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EFFECTS ON TEACHERS' MATHEMATICS CONTENT KNOWLEDGE
OF A PROFESSIONAL LEARNING COMMUNITY

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Education
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2011

Major Professor: Jeffrey Kaplan

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ABSTRACT

The purpose of this research was to study the implementation of a professional learning community comprised of one group of third-grade teachers in a Florida elementary school where the emphasis was on research-based practices in the teaching of mathematics. Investigated were the growth of teachers' content knowledge in mathematics, specifically in the areas of multiplication and division, and the effects of their professional learning within their classrooms. Specifically this study looked at whether or not the participation of a group of third grade teachers in a professional learning community PLC improved the mathematical content knowledge of the participants of the study. This research design called for the research to be conducted in three phases.

In Phase I, the researcher interviewed all participants using a researcher-designed interview guide. A researcher-adapted survey, based upon previously released items Ball (2008) was administered as a pre-test of mathematical content knowledge,. In Phase II of the study, the researcher documented the activities that occurred within a 10-week long professional learning community (PLC) of third-grade teachers. In Phase III of the research, a post-study interview was conducted with each of the participants by an independent observer to elicit participants' perceptions and observations based on their participation in the PLC. A post-test of content knowledge was also administered to the participants.

Several themes were identified in the research study. These themes led to recommendations for practice and future research. Themes were related to the lack of

mathematical understanding experienced by some teachers and the lack of professional development specifically related to mathematics, the value of the professional learning community, and the benefits of sharing current research and best practices. During this study, the participants were able to read and share examples of research-based best practices in mathematics, and participants then used this new information and additional mathematics content knowledge in their classrooms in teaching their students.

Dedicated to my family

To my husband Jay, who is my best friend, forever, and loves me just as I am.

To my children, Stephen, Daniel, and Elisabeth who are the lights of my life

To Mom and Dad Price who have supported me and believed in me

To my extended family, especially John, Jeanne, and all of the Griffin clan

who have supported me and believed in me.

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“What we have to learn to do, we learn by doing.” Aristotle

This quote sums up my philosophy of education and the way in which I teach. Over the 23 years I have taught I have evolved as a teacher because I have been surrounded by amazing students and co-workers. I begin by acknowledging the most important members of my learning community, my students. I have been privileged to serve many over the course of my career, and it is they who make my job an amazing journey. I am also lucky enough to teach at the best school in the world with the best administration and faculty imaginable. I especially want to thank the members of my study group for your joining me each week. You are an amazing group of educators.

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CHAPTER 1 THE PROBLEM AND ITS CLARIFYING COMPONENTS

Introduction

This chapter provides an introduction to the study. It contains a statement of the problem, the purpose of the study, definitions, and the research question which guided the study. Also presented are the background for the study, an overview of the conceptual framework, assumptions, limitations and delimitations, the significance of the research, and the organization of the dissertation.

Statement of the Problem

The problem of this study was related to the needs of elementary school mathematics teachers in Florida and the fact that they have often arrived in their teaching positions without the basic content knowledge to be effective elementary school mathematics teachers . This deficit in their knowledge has been compounded by instructional strategies in mathematics that have not been aligned with Florida’s Next Generation Sunshine State Standards (NGSSS) and may, therefore, create gaps for students’ as they seek to master mathematics concepts. These “gaps” interfere with students’ abilities to synthesize and apply prior knowledge to the acquisition of new mathematics concepts. An additional compounding factor is the limited professional development time typically available to teachers. For many teachers in many school districts, time to address teachers’ needs has not been available in the school day, and contractual agreements have placed strict limitations on the extent to which teachers must

or are expected to participate in professional development. It was this problem that one Florida school district chose to address through school board action, a strategic plan, and the establishment of a professional learning community.

Purpose of the Study

Teaching more strategies for student success has been discussed by building administrators as one way to bridge the gap between state and national standards and test scores. One method that has been considered to be effective in this regard is through training and the implementation of Professional Learning Communities,(PLCs). Implementing PLCs should help increase teachers' abilities, implement research into their teaching practices, and in turn create "highly effective" teachers with the ultimate goal of improving student achievement.

The purpose of this research was to study the implementation of a professional learning community comprised of one group of third-grade teachers in a Florida elementary school where the emphasis was on research-based practices in the teaching of mathematics. Investigated were the growth of teachers' content knowledge in mathematics, specifically in the areas of multiplication and division, and the effects of their professional learning within their classrooms.

Definitions

Adequate Yearly Progress (AYP): a system of accountability established through Federal legislation, the No Child Let behind (NCLB) Act of 2001. The legislation

ensured that schools make academic progress each year with 100% of students achieving minimal expectations on standardized tests by the year 2014 (Garcia, 2008).

Florida Comprehensive Assessment Test (FCAT): the Florida Comprehensive Assessment Test is administered to students in grades 3-12 in the spring of each school year to determine academic growth.

Florida School Recognition Program (FSRP): Schools that earn an A or improve by two letter grades are eligible to receive financial rewards from the state of Florida.

National Center for Educational Statistics (NCES): an organization that studies educational trends on national and state levels.

Next Generation Sunshine State Standards (NGSSS): mathematics standards that were created based upon the National Council of Teachers of Mathematics (NCTM) mathematics standards currently in place.

No Child Left Behind (NCLB): legislation that ensured that schools make academic progress each year with 100% of students achieving minimal expectations on standardized tests by the year 2014.

Professional Learning Communities (PLC): schools in which interaction among teachers is frequent and teachers' actions are governed by shared norms focused on the practice and improvement of teaching and learning (Garcia, 2008). Those formal and informal structures that encourage teachers to work together to examine current practice and to improve practice in the pursuit of a common, shared organizational vision (Eaker et al., 2002, p.3, Garcia, 2008).

Background of the Problem

During the 1950s when the United States was in the “Space Race” with its Russian adversary, schools were pushed into action to prepare students to compete on all levels and in essence “beat” the Soviets at their own game (Garrett, 2008). This was very successful, and science and mathematics programs produced many scientists capable of great discoveries such as the Apollo and Space Shuttle programs (Garrett). At the time of the present study, American students have been judged to consistently perform poorly in mathematics and science. According to Rose (2008), reasons for this decline have been lack of resources, lack of qualified teachers, cuts in funding, and the accountability requirements of the Public Law 107–110 enacted by the 107th Congress otherwise known as No Child Left Behind (NCLB) Act (2001) (Rose, 2008).

Thus, state and national pressures for higher student achievement had increased tremendously by the beginning of the 21st century, and the effectiveness of classroom teachers was being challenged more than ever before (Rose, 2004). Teachers were scrutinized, criticized, and challenged as to whether they were adequately teaching children (Doolittle, Sudeck, & Rattigan, 2008). Legislators called for increased accountability for teachers and higher achievement for students in a time of declining state and federal resources available to schools. (Labaree, 2004; Manna, 2009; McKim, 2006).

The achievement of students overall was being determined, for the most part, based on the results of standardized tests, most often administered on one day of the year (Darling-Hammond, 2005). Social problems such as domestic violence, homelessness,

and lack of parental supervision received little attention or consideration from politicians as legitimate reasons for poor test scores. School personnel, mainly teachers, seemed to be bearing the brunt of the criticism for what was considered a lack of progress for many children with little consideration for socio-economic variables that might contribute to the problem (Hazi & Rucinski, 2009; Houston, 2007; Packer, 2007).

NCLB (2001) has led to numerous reforms in the nation's schools. Schools have been required to hire only teachers that are "highly qualified" individuals (Darling-Hammond, 2005). However, with dramatic budget cuts, low socio-economic districts have lowered standards for their teachers to fill the positions that are available in their schools (Darling-Hammond, 2005). As many as 50,00 individuals have entered the teaching profession without training, and most of these individuals are in schools with the highest needs students (Darling-Hammond, 2005).

All states have begun to require students to be tested in the intermediate elementary grades in mathematics, language arts, and science, and in some states even social studies (Anderson, 2009). Thus, it is no surprise that intermediate elementary teachers have perhaps borne the greatest burden of educational accountability. Teachers have stated that this accountability has affected the way that they teach, what they teach, and how they teach (Anderson, 2009). It has been alarming, however, to think that the burden of this educational accountability for America rests with children who are merely eight through twelve years of age. It has also been alarming and somewhat surprising that very little research has been conducted on the impact of this increased accountability on students, teachers, and schools (Anderson, 2009).

Contextual Framework

The Impact of Accountability Initiatives in Florida

In keeping with the quest for accountability, some states have decided to hold teachers accountable by using their evaluations and students' test scores to determine teachers' pay. This has not necessarily been successful anywhere, yet, but the stakes have been and continue to be high. The legislatures of many states want to see results in return for their education spending.

In January 2001 the NCLB was signed into law. This legislation was put into place to answer the call for reform in education and the standards of schools (Rose, 2004). In essence NCLB is the reauthorization of the 1965 Elementary and Secondary Act (ESEA). In answer to this legislation, states had to produce some sort of testing scenario that would meet the requirements of the NCLB (2001). Florida responded with the Florida Comprehensive Assessment Test (FCAT) which had been initiated on a small scale in the state in the early 1970s, but was now to be administered to all students in grades 3-12 in its public schools (Florida Department of Education, 2009).

This FCAT testing legislation and administration has led to the restructuring of the standards to be taught to all students in the state of Florida. These standards, initially titled the Sunshine State Standards, have been revised at various times over the years. In 2007, the standards were modified (Florida Department of Education, 2007) to reflect a more stringent curriculum with more specific requirements of the state's schools. These newest standards, the Next Generation Sunshine State Standards, reflected further

specificity as to what students should master at each grade level (Florida Department of Education, 2009).

FCAT testing has definitely led to a great deal of accountability for the state's teachers. Under FCAT guidelines, each school is evaluated based upon its performance on the FCAT and is given a grade ranking from an A (making excellent progress) to an F (failure to make adequate progress) (Florida Department of Education, 2009). As of 2005, each school's grade was based on FCAT scores, student attendance, dropout rate, school discipline information, graduation rate, and student readiness for college (Florida Department of Education, 2009).

Schools that earn an A or improve by two letter grades are eligible to receive financial rewards through the Florida School Recognition Program (FSRP) that can be disbursed at the discretion of the school's staff and its advisory council (Florida Department of Education, 2009). Any school that earns a D or F ranking is eligible to receive assistance to improve their performance. If, however, the school does not improve within two years, students are eligible for state vouchers to attend private schools or higher performing schools (Gayles, 2007).

Some school districts in the state have gone so far as to involuntarily moved highly qualified teachers to poor performing schools. Highly qualified teachers, in this example, are those who produced excellent scores at their previous schools. They have been moved in hopes that they would provide the assistance to help students achieve at a higher level (Florida Department of Education, 2009). This action and the financial benefits of being an A rated school, have been extremely controversial among the state's

teachers, administrators and the general public (Gayles, 2007). Within Florida school districts, teachers and staff at these schools have also been under pressure to produce “passing” schools (Gayles, 2007; Rose, 2004).

Gayles (2007), in his research, stated that FSRP has contributed to inequality within Florida schools rather than alleviating it. The economic status of the country in 2010 has not helped to make any of the accountability actions palatable to teachers, many of whom have had to face pay cuts or no pay raises for the last few years as districts try to retain teachers and demonstrate high levels of achievement as to meet state and national standards set by by FCAT and NCLB, respectively.

Teacher Preparation in Mathematics

Researchers have affirmed that K-6 students often have not learned mathematics because their teachers’ basic knowledge has been inadequate. (Ball, 2000; Darling-Hammond, Berry, & Thoreson (2001). Wei et al., 2009). Traditionally, mathematics content courses and methods courses in colleges and universities have been distinctly separate (Ball, 2000), and they have been concerned with concepts and procedures. With little attention to mathematics content studied to discover and gain insight into the mathematics content which they would be expected to deliver, prospective teachers were left with a content knowledge gap. For this reason, many teachers arrive in their assigned classrooms lacking the basic strategies to help their students explain the processes they went through in order to solve mathematics problems (Ball, Hill, & Bass, 2005).

Professional Development and Professional Learning Communities (PLCs)

In regard to a recent 20-country study, Darling-Hammond (2008) stated that nations recognized as leaders in terms of their educational system realized that “(a) the right people need to become teachers, (b) these individuals must be developed into effective teachers, and (c) the educational system of leading countries must give their children the best instruction and equal access to it” (Darling-Hammond, 2008, p. 731).

Furthermore, this study also showed that teachers who receive effective research-based professional development were much more successful at producing successful students who performed well on standardized tests versus students of teachers who did not receive research-based professional learning (Darling-Hammond, 2009). Hill cited the problem with professional development for teachers in the United States as needing to be reevaluated in terms of content and delivery (Hill, 2009).

Darling-Hammond, Dozer, Johnston, and Rogers (2006). also discussed the amount of professional development received by teachers. For many countries in the world, the amount of professional development that teachers received was far beyond that of their American counterparts, and that this has made an immense difference in the achievement of students when tested. Researchers have also found that when effective research-based professional development has been offered to teachers, teacher expertise grows as does commitment to the profession and students. This, in turn, improves student achievement (Darling-Hammond, 2006; Hill, 2009; Houston, 2007). Hill (2009) stated that teachers in the United States typically participate in the minimal amount of professional development required by their state or district each year. Most states have

required an average of 15 days over a five-year period for recertification, and NCES reported that that was the case with the majority of the teachers answering their survey (Hill, 2009). Hill also reported that based on the NCES survey, teachers believed that a majority of the professional development that they attended had little or no benefit to their current teaching practices and usually merely reinforced what they already did rather than change it in any way that could improve their students' learning (Hill, 2009).

Many researchers (Ball, 2000; Darling-Hammond et al., 2001; Wei et al., 2009) have suggested that when professional development is focused upon current research "best practices" for use in their classrooms every day, teachers benefit greatly. If these teachers are to be effective, or "highly qualified," they must be able to participate in professional learning that can improve their skills and involve the use of the most recent research development in their subject area. Researchers have also shown that professional development requiring collaboration within a school is far more likely to focus on student progress and, in turn, improve student-learning gains (Darling-Hammond, 2002). Professional Learning Communities (PLCs) provide one response to meeting the professional development needs of teachers. The development and implementation of PLCs has emerged as a growing national trend designed to increase teachers' abilities to implement research into their teaching practices, to be "highly effective" and ultimately improve test scores (Eaker, DuFour, & DuFour, 2002; Wood, 2004). Legislation such as the No Child Left behind Act (NCLB, 2001) has brought about many changes in the public school system. New responsibilities and additional demands of their time accompanied by tight budgets have forced teachers to assume new and more

responsibilities (Eaker et al., 2002). PLCs have been viewed by some researchers as one way in which to help teachers meet the requirements brought on by changing standards and reforms (Eaker et al., 2002; Wood, 2004).

Professional Development in Mathematics in the Targeted District

In its Strategic Plan of August, 2009-10, the Seminole County Public School district called for continuous improvement and the school board adopted the following key strategies in mathematics:

1. Fully implement and monitor the targeted district's mathematics framework.
2. Align instruction of district supported intensive math programs with each program's implementation requirements.
3. Assign an assistant principal at each secondary school with the responsibility of overseeing implementation of the K-12 Mathematics Framework.
4. Expand the elementary "Math Super Stars" volunteer program.
5. Provide advanced curriculum leadership through professional development in leadership seminars and elementary curriculum meetings. (*The Future is Now*, 2009, p. 5)

Because professional development time was limited for all teachers, the targeted district negotiated a change in the contract of the teachers with their union to allow for increased planning time for their teachers (Official Agreement, 2009). Plan time, as put forth in the contract (Official Agreement, 2009) provided for each teacher being given two 40 minute time slots of uninterrupted planning time per day in elementary schools. In high schools, teachers received one uninterrupted plan period per day. One of these blocks, for elementary school teachers, was reserved for teachers to plan for the school day. The other block was devoted to tasks assigned by the principal or other administrators and included attending required team or grade level meetings, data review,

student study and team activities to be determined at each grade level (Official Agreement, 2009). These required collaborative activities were not designated as professional development time. The reserved time, however, opened the door for the development of professional learning communities engaging in focused professional development in mathematics which would lead to improved mathematics test scores for children. One of the elementary schools in the targeted district was the site in which the researcher conducted her study.

Research Question

This research was conducted to explore the following research question:

To what extent does participation in a professional learning community comprised of elementary grade level teachers in one central Florida elementary school influence teachers' mathematical understanding of basic multiplication and division strategies?

Methodology

This methodology used in the study was qualitative in nature. The study was conducted in three phases over a time period of ten weeks in the fall term of 2010. The participants in the study were six third-grade teachers in one central Florida, suburban elementary school. Phase I of the study began with a pre-test of participants to determine their baseline mathematics content knowledge prior to their participation in a professional learning community (PLC). Pre-study interviews were also conducted with participants to obtain background information related to knowledge and attitudes as learners and

teachers of mathematics and to elicit their perceptions regarding mathematics learning and teaching. In Phase II of the research, the group participated in a PLC for a time period of ten weeks with the goal of developing better understanding in the areas of teaching multiplication and division to their third grade classes. In Phase III, a post-test of content knowledge was administered to all participants, and post-study interviews were conducted with each of them to determine growth of mathematics content knowledge and the perceptions of teachers in regard to the value and benefit of the experience.

Assumptions

It was assumed that the instruments developed for use in the study were appropriate for use in acquiring information related to the participants as learners and teachers.

It was assumed that teachers participating in the study would respond honestly, and with professional integrity, to any of the items on the survey.

It was assumed that the development of a professional learning community would be beneficial to the participants as a form of professional development that could enhance teachers' knowledge and benefit their students.

Delimitations and Limitations

This study was delimited to a group of six regular education, third-grade teachers at one public elementary school. It was also delimited to the professional learning community activities that occurred over a ten-week period. Because of the small

population and the short time period over which the study was conducted, the findings were applicable only to the participants. Any attempt to generalize the results beyond the population involved in this study should be undertaken only after the similarity of teachers and the school setting has been determined.

Significance of the Study

The benefits of this study were able to be observed most directly as they related to the teachers participating in the study. Teachers had the opportunity to gain essential content knowledge in the area of mathematics and to enhance their teaching of multiplication and division. Also, it was anticipated that this study might be useful in providing a model emphasizing mathematics content knowledge in the professional development of teachers. This increased knowledge could ultimately result in students' improving their understanding of basic mathematics in the areas of multiplication and division and thus increasing their ability to improve their standardized test scores.

Summary

This chapter has provided an introduction to the study. The problem, purpose, and definitions have been stated, and the conceptual framework for the study has been briefly discussed. Also presented was the research question which guided the study and an overview of the methodology. Concluding the chapter were assumptions, delimitations and limitations and a statement regarding the significance of the study.

Chapter 2 contains a review of the literature and related research. Chapters 3 and 4 present the methodology and findings of the study. Chapter 5, the concluding chapter, is comprised of a summary and discussion of the findings, implications for practice and recommendations for future research.

CHAPTER 2 REVIEW OF LITERATURE AND RELATED RESEARCH

Introduction

This chapter has been organized to review the literature and research related to professional development for teachers with specific emphasis on professional learning communities (PLCs). In the first section, federal and state school reform initiatives are reviewed, and the resultant emphasis on professional development at the school district level in one central Florida district is discussed. The increased emphasis on accountability and impact of high-stakes testing is also presented. Teacher preparation and professional development, specifically professional learning communities, are subsequent topics which have been explored in the chapter.

Educational Reform Initiatives

Federal--ESEA

The Elementary and Secondary Education Act, Public Law 89-10 (ESEA) was enacted in 1965 under the presidency of Lyndon B. Johnson. Until 1965, the federal government had targeted funding for special interests, e.g., land, special education, but had not interjected itself into state control of education (Standerfer, 2006; Thomas & Brady, 2005). The main thrust of the ESEA was to give substantial funds to schools for programs such as bilingual education and Head Start through Title I and was the first time that economically depressed children's needs were addressed and funded. Private, as

well as public, schools were eligible to receive Title I funding, and this was met with some resistance by the National Education Association (NEA). Children having difficulty academically, but not meeting the criteria for child poverty, were eligible to receive help through Title I funding (Parker, 2005; Thomas & Brady, 2005). Thus, by the 1970s, 94% of all schools nationwide were being directly funded in some way by ESEA.

This turn of events was not without debate. The ESEA came under a great deal of scrutiny by Congress when it discovered that funds from this legislation were misappropriated, and that economically disadvantaged children were not necessarily receiving the funding that they should under the law. Congress actually ended ESEA on four occasions between 1965 and 1980, only to reenact it again and again for more academically disadvantaged children from low socio-economic families (Parker, 2005; Thomas & Brady 2005).

The election of President Ronald Reagan in 1980 brought about a reduction in funding for the ESEA, and Reagan worked to reduce the role of the Federal Government in public education (Parker, 2005; Standerfer, 2006; Thomas & Brady 2005). The publication of *A Nation at Risk* in 1983 highlighted the poor performance of public schools (Parker, 2005; Standerfer, 2006; Thomas & Brady 2005). It described a picture of public schools, as below par and stated that if corrective measures were not implemented, the United States would not be able to compete in the global job market.

The report called for higher standards academically, longer school days, more stringent course requirements, and better training for teachers (Thomas & Brady, 2005). Due to the report, 41 states implemented higher standards for high school graduation, and

29 states implemented mandatory testing for educators before they could work in public schools (Thomas & Brady, 2005). As a result of these new standards and requirements by the states, the National Center for Education Statistics reported that the funding for public schools decreased by as much as 21% between 1980 and 1985 (Parker, 2005; Standerfer, 2006; Thomas & Brady 2005).

In the mid 1980s, then Secretary of Education Bennett commissioned the Alexander-James study group to look at how testing could be used to compare states and increase accountability for schools (Thomas & Brady, 2005). In 1988, the National Governors' Association decided that a national set of standards should be devised for each core subject. During William Jefferson Clinton's presidency, this goal was continued. The ESEA was reauthorized in 1988 as PL 100-297 known as America's School Act and renamed in 1994 by the Clinton administration as the Educate America Act (Thomas & Brady, 2005).

Goals 2000: Educate America Act

This new form of the ESEA had four main components: (a) student achievement; (b) academic standards with specific knowledge and skill levels; (c) requirements for all students, even those considered at risk; (d) monitoring reforms through testing (Thomas & Brady, 2005). In 1994, ESEA was reauthorized with the Improving America's Schools Act (IASA). The IASA's intent was to imbue schools with the ability to provide children with the means to acquire knowledge and skills on state mandated tests. IASA was also the first time "adequate yearly progress" was introduced, and steps were required by the

states to demonstrate improvement (Thomas & Brady, 2005). The IASA stated that Title I funds would not be given to states unless educational goals, intellectual potential, and curricular opportunities were outlined. Also requirements had to be similar for all children regardless of their socio-economic status or educational disability (Thomas & Brady, 2005).

The IASA was not taken seriously by the legislatures at either the state or federal level, and the minimal efforts of both were frustrating to the congressional members who wanted to see the achievement of all students improve (Shaul & Ganson, 2005). The National Assessment of Educational Progress (NAEP) then reported that though the gap between black and white students had decreased significantly in the 1970s and 1980s, there had been little improvement since and was at a standstill in the first decade of the 21st century (Shaul & Ganson, 2005).

Teacher qualifications were also the subject of a great deal of research at this time. Much of the research on teacher certification indicated that in poorer schools teachers were quite often not adequately qualified and lacked the knowledge they needed to be effective in the classroom (Shaul & Ganson, 2005; Thomas & Brady, 2005).

Schools were also reported as having difficulty coming up with strategies and methods to help struggling schools become successful (Shaul & Ganson, 2005). In response, Congress' existing requirements were strengthened. New requirements were established, and actions that would be taken if schools did meet annual yearly progress (AYP) criteria were clearly stated (Shaul & Ganson, 2005).

The following are highlights of the 1994 law that were updated:

- Deadlines were given as to when all students should be 100% proficient;
- Graduation rates were added so that as many students as possible would be tested.
- All grades tested would be tested in language arts and mathematics and in some grades science were added.
- Participation in NAEP was required by the states.
- If a Title I school does not meet the requirement or AYP then action would be taken.
- Scientifically research-based strategies would be implemented.
- Teachers must meet the definitions of “highly qualified” (Shaul & Ganson, 2005, p. 152).

Additional funding was earmarked for the states to implement these requirements, as Congress wanted to be sure that all students were required to meet the same levels of academic performance (Shaul & Ganson, 2005; Thomas & Brady, 2005).

NCLB

On January 8, 2002, Public Law 107–110 was signed into effect by the 107th Congress “to close the achievement gap with accountability, flexibility, and choice, so that no child is left behind (p. xx). The intent of No Child Left Behind (NCLB) was to move K12 schooling to a higher level with a more focused and direct approach than had been used in the past (Rose, 2004; Shaul & Ganson, 2005; Thomas & Brady, 2005). This act required schools to demonstrate Annual Yearly Progress (AYP) toward a particular goal: universal student achievement of standards established by each state” (Rose, 2004). Schools that did not make AYP for two years in a row faced penalties which included a loss of federal funding, termination of staff, and dissolution of the school district (Rose, 2004; Shaul & Ganson, 2005; Thomas & Brady, 2005). This federal legislation held

much promise when first adopted, but its chances for success came under increased scrutiny due to a lack of funding to support the legislation.

Rose (2004) stated that, realistically, the NCLB was a reauthorization of the 1965 Elementary and Secondary Education Act (ESEA). This legislation was in many ways the answer to political calls for reform in education and the standards of the nation's schools. Rose (2004) also stated that NCLB had strengths and forced educators to look at student achievement and the disparities between various groups and their achievement levels. Many educators and researchers alike considered the goal of the NCLB legislations, that all children would achieve at the same level within 12 years as absurd considering that all children did not start at the same level, and each subgroup was dealing with various issues, e.g., poverty, race, and education systems, that affect their achievement levels (Rose, 2004; Shaul & Ganson, 2005; Thomas & Brady, 2005). NCLB also required that each state implement annual assessments for grades 3-8 and at least once in grades 10-12. In addition, tests in the areas of science were to be given at least once in grades 3-5, 6-9, and 10-12 (Thomas & Brady, 2005).

NCLB stated that each state must develop its own standards of achievement for what every child must know in the area of mathematics and science and that all children must achieve these skills (Rose, 2004; Shaul & Ganson, 2005; Thomas & Brady, 2005). The NCLB legislation also mandated a "more rigorous mathematics and science curricula that are aligned with challenging state and local academic content standards, and with the standards expected for postsecondary study in engineering, mathematics, and science" (No Child Left Behind, 2001).

State of Florida

In 1968, Section 229.551 of the Florida Statutes was enacted with the purpose of expanding educational services and improving the quality of education in the state of Florida. In order to effectively carry out the statute, the Florida Board of Education in August of 1969 outlined the following principles:

- (1) The establishment of state educational objectives in priority order, (2) provision of sound financial support, (3) creation of minimum standards for achievement and quality controls, (4) assistance to districts for evaluating results, (5) creation of information system, and (6) efficient use of funds. (Florida Department of Education, 2011, p. 1)

In 1970-71, an educational research and development department was also created with appropriation to support it. This department then began working on preliminary objectives and test items for assessment of Florida students. The Florida Legislature enacted Chapter 7-399, laws of Florida, the purpose of which was to evaluate the effectiveness of educational programs within the state. The goal of this legislation was to give each school district relevant data to evaluate its education programs. In 1971, the legislature adopted the plan enacting the Educational Accountability Act (Section 229.57, Florida statutes). When these goals were reevaluated in 1975, the state made clear the importance of every child in its schools acquiring essential skills.

In 1971, The Florida Statewide Assessment Program was created with the following responsibilities:

1. Yearly establishment of statewide objectives;
2. Assessment of student achievement of these objectives;
3. Public reporting of results for the State, each district, and each school;
4. Testing basic skills in reading, writing, and mathematics, and

5. Development of cost-effectiveness plan. (Florida Department of Education, 2011, p. 1)

Florida students were tested for the first time in reading in the 1971-72 school year, and their second assessment was in 1972-73. In 1974, The Educational Accountability Act was revised so that districts had to report their scores to the Commissioner of Education. The 1974 Act added that all students in grades 3-6 would be tested in the areas of reading, writing, and mathematics by 1976. However, a decision was also made that Florida would comply and duplicate the reading and mathematics portions of the National Assessment of Educational progress test in 1974-75 (Florida Department of Education, 2011).

In 1976, the Educational Accountability Act was put into place by the legislature. Two key amendments were added. The first required that all students graduating in 1978-79 must pass a state literacy test in order to earn a high school diploma. The second amendment added to the 1974 Act was that minimum standards with specific skills for subject areas would also be implemented over a three-five year period beginning in April 1977 (Florida Department of Education, 2011).

In 1979, State Board Rule 6A-1.843 was initiated. This rule stated specific modifications for exceptional education students during testing. Examples of these modifications and accommodations were flexible scheduling, flexible setting, recording answers, revised format, and audio presentation. This rule remained in place in 2011. (Florida Department of Education, 2011).

Over the years, Florida updated its testing methods, added various exceptionalities to be tested, and experienced several legal challenges to its testing procedures. As of October 1985, a total of 103,113 third graders, 101,987 fifth graders, and 117, 145 eighth graders were being tested. The most controversial part of Florida's new testing program was that if 12th graders did not meet the require pass score, they would not earn a high school diploma. In *Debra P. v. Turlington*, (Florida Department of Education, 2011), a legal challenge was brought against the Florida high school test in regard to whether or not the material on the high school competency test was actually taught in the classrooms of the state's high schools. The state prevailed, and the class of 1983 was required to pass the test to earn a regular diploma (Florida Department of Education, 2011).

In 1995, the Commission for Education in Florida focused on increasing expectations for student achievement, thereby assisting graduates in competing for jobs in the global market. Because of this initiative by the commission, curriculum frameworks, the Sunshine State Standards (SSS), were adopted by the state of Florida (Florida Department of Education, 2011). Emerging from the strands, standards, and benchmarks for the SSS, the Florida Comprehensive Assessment Test posed testing for students in the "context of real-world applications" (Florida Department of Education, 2011, p. 1). Initially the FCAT was designed to test only four grade levels in mathematics, reading, and writing. However, with Governor Bush's A+ plan in 1999, the FCAT was "expanded to include grades 3-10" (Florida Department of Education, 2011. p. 1). In 2001, the results of the FCAT were reported for the first time and it was decided that the FCAT

would be required for high school graduating classes of 2003 (Florida Department of Education, 2011).

Sunshine State Standards (SSS)

In answer to the ESEA, Florida adopted the Sunshine State Standards (SSS) in 1996 under the direction of then governor, Lawton Chiles. The standards were adopted so that in all core areas minimal standards were established for all students. Each core subject was divided into four-grade clusters (PreK-2, 3-5, 6-8, and 9-12) (Florida Department of Education, 2009). Over the years, these standards became more clearly defined at each grade level as well as within the grade clusters.

Next Generation Sunshine State Standards (NGSSS)

The Next Generation Sunshine State Standards (NGSSS) were adopted in 2006 so that the skills and benchmarks for each grade level were more explicit and presented a broader perspective than ever before. The new standards were to be in place and tested in grade three in the State of Florida for the 2009-2011 school year (Florida Department of Education, 2009). When looking at the two from a teacher's perspective, it is clear that the new standards are based on an in-depth understanding (Rose, 2004; Shaul & Ganson, 2005; Thomas & Brady, 2005). The current standards were less definitive and required students to know a great deal more in a shorter period of time. These new standards provided for time to better understand the basics, which in turn related to many other areas of mathematical understanding, resulting in a better foundation for more complex mathematics later in middle school (Florida Department of Education, 2009). The

standards have shifted many skills either earlier or later, and then created a much improved, developmentally improved focus for students (Tzur & Simon, 2004).

The Targeted Public School District (TPSD)

Strategic Plan

In response to the NCLB legislation and Florida state adoption of the NGSSS, the policies and procedures for mathematics instruction in the Seminole County Public Schools (SCPS) have been modified. The strategic plan developed by the district called for continuous improvement, and the SCPS Board of Education adopted the following key strategies in mathematics:

1. Fully implement and monitor the [targeted public school district] Mathematics Framework.
2. Align instruction of district supported intensive math programs with each program's implementation requirements.
3. Assign an assistant principal at each secondary school with the responsibility of overseeing implementation of the K-12 Mathematics Framework.
4. Expand the elementary "Math Super Stars" volunteer program.
5. Provide advanced curriculum leadership through professional development in Leadership Seminars and Elementary Curriculum Meetings. (*The Future is Now*, p. 5)

In response to NCLB and FCAT, "highly effective teachers" have become the new buzzwords (Darling-Hammond, 2005), and school districts have had to strengthen teacher training opportunities with more professional development. In 2009, SCPS initiated its Strategic Plan, which called for "the provision of advanced curriculum

leadership through professional development in leadership seminars and elementary curriculum updates” (*The Future is Now*, p. 9).

Securing sufficient time for teachers to engage in worthwhile professional development has always been a challenge, and the constraints on teachers’ time have limited what can be accomplished (Darling-Hammond, 2005). To address this element of time, SCPS therefore, negotiated a change in the contract of the teachers with their union, the Seminole County Education Association (SEA), to allow for increased planning time for their teachers (Official Agreement, 2009). Plan time, discussed in Article X, section G and H, stated that each teacher will be given two 40-minute slots of uninterrupted planning time per day in elementary schools, and high schools teachers will receive one uninterrupted plan period per day as well. One of these blocks for elementary school teachers will be for the teacher to plan for their school day, the other will be devoted to tasks assigned by the principal or other administration including required team or grade level meetings, data review, student study and team activities to be determined by each grade level.

Although this agreement specifically stated that professional development could not happen at this time (and only team activities could occur), this was quite different from any planning time that the SEA negotiated for teachers prior to this date (Official Agreement, 2009). In past years, SCPS elementary teachers only had one 40-minute block of time; anything scheduled during this time could include team meetings, student study, and various other activities. The new contract specifically stated that the second block of 40 minutes could be used for various activities including team meetings and

student study (Official Agreement, 2009). It has been referred to by building administrators as “team time,” referring to the notion that teams should be working together to improve their instruction in FCAT-tested curriculum areas.

Assistant principals were designated as the “go to” persons for these team times and for Wednesday afternoon professional development activities to be conducted along with other school personnel such as reading and math coaches ((*The Future is Now*, 2009). Team time during the 2009-2010 school year was to be used for the development of Professional Learning Communities (PLC’s) which in turn would hopefully lead to improved test scores (*The Future is Now*, 2009). In preparation for their roles, assistant principals attended three-day training sessions, based on the work of DuFour, DuFour and Eaker (2005), designed to increase their knowledge regarding PLCs and their implementation at the school level (TPSD, 2009). Administrators were also provided a copy of *Professional Learning Communities at Work* (Eaker et al., 2002) and attended several meetings throughout the year.

This training and implementation of PLCs was in answer to the growing national trend of using PLCs to help increase teachers’ ability to infuse research and best practices into their teaching so as to be “highly effective.” Ultimately, the goal of SCPS was to improve test scores (Eaker, et al., 2002; *The Future is Now*, 2009; Wood, 2004). Legislation, such as the No Child Left behind Act (NCLB, 2001), has brought about many changes for public school systems. The impact on teachers has been to call on them to assume different responsibilities in their roles as teachers (Eaker et al., 2002). Professional learning communities (PLCs) have been viewed by some researchers as one

way in which to help teachers with the new standards and reforms they have been required to address (Eaker et al., 2002; Wood, 2004).

However, little research has actually been done to show how teachers perceive PLCs and how they affect what teachers actually do in their classroom as a result of being involved in them (Eaker et al., 2002; Wood, 2004). Researchers have shown a correlation between PLCs and teacher instructional practices. This study was conducted to further contribute to the body of knowledge by further investigating teachers' perceptions of their involvement in a PLC and its impact on their instructional practices. If PLC participation was found to impact teachers' daily instructional practices, it would authenticate the existing research indicating that PLCs do affect students' achievement.

Accountability

High-Stakes Testing: Florida Comprehensive Assessment Test (FCAT)

In 1972, the Florida Comprehensive Assessment Test (FCAT) was initiated. Its format was quite different from that of the present day. At that time the FCAT was used to measure only a sample of students and to test their competency on minimum competency skills (Florida Department of Education, 2009). This quickly changed to include all students in selected grade levels. In 1976, the Florida Legislature enacted a new accountability act that targeted grades 3, 5, 8, and 11 for assessment (Florida Department of Education, 2009). The state also implemented the nation's first required high school graduation test in October 1977. This high school competency test was quite

controversial and was challenged in Federal Court before it was implemented, becoming a requirement in the state in 1983 (FDOE, 2009). Subsequently, in 1995, The Florida Commission on Education Reform and Accountability began reconceptualizing the FCAT, and it was first administered in 1998 in close to its present-day form (Florida Department of Education, 2009).

The State Board of Education adopted recommendations for assessment in four broad areas of the curriculum: reading, writing, mathematics, and creative and critical thinking (Florida Department of Education, 2009). The design committee also adopted the Florida curriculum frameworks, the Sunshine State Standards (SSS). These standards established guidelines and a statewide system that incorporated assessment, accountability, and in-service training as a part of this framework as well (Florida Department of Education, 2009). In 1996, the State Board of Education approved the Sunshine State Standards as Florida's new academic standards and, in that year, all grade levels 3-10 participated in the testing (Florida Department of Education, 2009).

Teacher Preparation

Teacher Preparation in Mathematics

Ball (2000) confirmed, in her study of mathematics content knowledge at the University of Michigan, that new teachers found it difficult to stray from their own traditional models of teaching mathematics. Traditional images of teachers teaching not only shaped how these young teachers learned, but how they taught as well. Teachers

were more likely to teach as they were taught as opposed to adopting the methods presented in undergraduate methods of teaching classes (Ball, 2000; Seed, A. H. (2008).

Teachers, once on the job, have had little support and very little professional development, yet the expectation that they will learn new curriculum has always been present (Ball, 2000; Darling-Hammond, 2001; Kikas, Peets, Palu, & Afanasjev, 2009; Wei et al., 2009). These authors have noted that teachers have found the challenges of learning the curriculum and adjusting to the changes to be daunting. As a result many have been overwhelmed and stressed. Teachers in this predicament have often reverted to their comfort level and what they know, which, in many cases, is the teaching they received themselves (Ball, 2000; Darling-Hammond, 2001; Kikas et al., 2009; Wei et al., 2009). All too often what those teachers have learned is that lessons are divided into two parts: (a) teachers demonstrate the lesson as students observe, and (b) students practice the lesson (Ball, 2000; Darling-Hammond, 2001; Wei et al., 2009). Despite research to the contrary, this method of instruction has continued to be prevalent throughout the United States. (Darling-Hammond, 2001; Ma, 1999; Wei et al., 2009;). When Ma (1999) studied the teachers of America and China, she found that Chinese teachers had a better conceptual understanding of the mathematics that they taught. In comparison, American teachers had very little conceptual understanding of the mathematics they were teaching their students. Chinese teachers had many strategies for their students who struggled, but their American counterparts had very little in the way of strategies to help failing students (Ma, 1999). Chinese teachers allowed the students to solve problems with multiple

approaches and steps. American teachers stuck to the traditional approach and presented only one way to solve a problem.

Researchers have affirmed that K-6 students often do not learn mathematics because their teachers' basic knowledge is inadequate (Ball, 2000; Darling-Hammond, 2001; Kikas et al., 2009; Seed, 2008; Wei et al., 2009). In the past, teacher education programs followed a format in which mathematics content courses and methods courses were taught separately (Ball, 2000). More times than not these courses addressed concepts and procedures rather than mathematics content in which a teacher could discover and gain insight into the type of mathematics instruction he/she was expected to teach (Ball et al., 2005; Kikas et al., 2009; Seed, 2008). The fact that the basics of content knowledge have been neglected in the education of teachers has left a gap in the way these teachers deliver the content to their students. Countless teachers lack the basic strategies to help their students explain the processes they went through in order to solve their mathematics problems (Ball et al., 2005).

That teachers have this deficit could be an explanation for the drop in mathematics achievement, specifically in algebra, in the later grades (Ball et al., 2005). However, many of the instructors of mathematics methods courses have automatically assumed that the requisite mathematics content has already been taught. Thus, though many pre-service teachers need further instruction, there has been insufficient time in these courses to address deficits (Burton, Daane, & Giesen, 2008). This, then explains why teachers may arrive in classrooms with little background knowledge or support, and

little knowledge about how to teach the content (Ball, 2000; Kikas et al., 2009; Seed, 2008).

Welsh (2008) commented on the findings of a study by the Center on Education Policy and indicated that, in general, state math scores had improved since 2002. In the study, however, it was also noted that mathematics proficiency had declined as students transitioned from elementary school through high school. In most states, the mathematics curriculum is too broad, and a more in-depth understanding is needed in order for students to be successful in their college math classes (Welsh, 2008).

Welsh (2008) further observed that The National Mathematics Advisory Panel (NMPA) had commented in March 2008 that “Students lack a deep understanding of basic skills in mathematics, including a grasp of whole numbers and fractions. students who complete algebra II are more likely to graduate college when comparing students with less mathematical preparation” (p. 13). Many students, according to Welsh, are placed in upper level math classes but do not know how to add, subtract, multiply, or divide unless they use a calculator, and they are at a complete loss when it comes to fractions. Fractions and a student’s ability to solve them is the basis for how many children learn to solve algebraic equations. Fractions are said to be the most complex of operations that an elementary age child learns. More specifically the division of fractions is considered the most difficult topic in mathematics operations (Bulgar, 2003). Welsh (2008) commented further on the increased emphasis on having students take algebra by seventh grade when, in fact, over 90% of them are not at a stage developmentally where they can think abstractly.

Policy and practices in the field of elementary school mathematics have undergone many changes over the past 30 years (Burton et al., 2008; Katz, 2007; Lowenberg-Ball, Hill, & Bass, 2005). Research conducted on how the brain processes the information required to become proficient at mathematics has greatly expanded the knowledge of how to best help students who are learning mathematics (Sutton, 2002). Although scientists and researchers nationwide have produced an abundance of studies on best practices in mathematics instruction, the persistent issue of bringing research to scale has impeded full implementation of these results in classrooms (Burton et al., 2008; Katz, 2007). When looking at the research in teacher education, it is clear that many have questioned the ability of elementary mathematics teachers and the ability of students to understand such crucial concepts as fractions (Tirosh, 2000; Tsao, 2005; Simon, 1993).

Katz (2007), in his research, defined algebra using the words of Euler, “The science which teaches how to determine unknown quantities by means of those that are known” (p. 185), and he considered the study of algebra at the secondary level to be generalized and not a tool for describing and using mathematical systems. Katz posited that this method of using and teaching algebra has not been pedagogically successful and barely teaches a set of skills which are then useable only in certain mathematical situations. He expressed the belief that algebra needs to be taught as a problem-solving methodology that is consistent with both mathematical development and a child’s developmental stages of learning. He discussed at length the fact that students are unprepared in the area of algebraic thinking because these types of concepts are not taught correctly at an early age. Students need to have mastered completely basic

geometric and fraction concepts in order to be successful in algebra later on in their academic careers (Katz, 2007).

In their work on stages of mathematical learning, Tzur and Simon (2004) discussed two main theoretical frameworks for learning mathematical concepts: (a) Dubinsky's APOS (action, process, object, and schema) theory; and (b) Sfard's reification theory. Also, in discussing learning as a constructive activity, they related their research to Piaget's work in epistemological and psychological position.

Researchers (Simon, 1993; Tzur & Simon, 2004) have emphasized two areas of mathematical understanding: (a) process (operational) and (b) object (structural). Researchers believed that these two separate areas of mathematics were dramatically different yet inseparable when it comes to the understanding of mathematics content (Katz, 2007). Based on Piaget's theories, Tzur and Simon, focused on the need for learners to actively participate in the actual lessons at hand in order to be able to construct a mathematical understanding. They also concluded, based on their understanding of Sfard's work, that students did not accomplish an objective or refined level of understanding; specifically, they did not transition from the concrete operational stage of learning to the abstract stage of learning successfully in mathematics (Simon, 1993; Tzur & Simon, 2004).

According to Piaget's theories (1985), assimilation means the organization of sensory motor input by available conceptual structures. What individuals learn is based upon what they perceive and is limited by what they conceptualize (Cobb & Bauersfeld, 1995; Tzur, Simon, Heintz, & Kinzel (2001)). In order for a new concept to be learned

the prior knowledge of the skill needs to be learned, each concepts builds on the one before. A students ability to understand and put together mathematical ideas and concepts is basically not possible if they cannot recall prior knowledge and a total understanding of concepts already learned (Tzur & Simon, 2004). Learners can only add to their “inventory” of concepts when they have learned and can conceptualize the thing that they have learned previously. Learners actually reflect on what they already know and identify patterns and relationships in order to understand the new concepts (Piaget, 1985;Tzur & Simon, 2004).

Researchers have shown that males tend to be mathematically challenged by their teachers and girls tend to challenged in the area of reading. Boys have also been found to lag behind in reading with national test scores 10 points below those of their female counterparts. Although the gap in mathematics between girls and boys has lessened somewhat over the years, researchers have indicated that more males than females tend to go into fields requiring mathematical backgrounds and that females tend to feel less comfortable with mathematical content (Fretzel, Pekrun, & Goetz, 2007; Kikas et al., 2009; Seed, 2008).

This gap between girls and boys in mathematical understanding has been studied in many ways over the years. At the time of the present study, it had been determined by researchers that there was a direct relationship between the methods of instruction teachers use with boys and girls and the extent of their success in mathematics (Fretzel et al., 2007; Herbert & Stipek, 2005). The differences in course work taken by boys and girls at the high school and college levels taken by boys and girls has been regarded as a

perceptual issue on the part of the female population. Women tend to believe that they are not as adept at mathematics and therefore shy away from more difficult mathematics classes (Fretzel et al., 2007; Herbert & Stipek, 2005).

Although progress has been made in the education of girls and in providing encouragement for them to take more mathematics classes, there is still an underlying belief held by both parents and educators. Fretzel et al.(2007) stated the problem clearly when they advocated for “more efforts to promote positive effect, and to prevent anxiety, hopelessness, and shame experienced by females in mathematics” (p. 509) Researchers have also addressed the need for interventions to be in place no later than late elementary school. According to Fretzel et al (2007 and Herbert and Stipek (2005), positive interventions should be in place in the context of social environments in order to achieve a lessening of inferiority feelings in girls verses boys.

For Cobb and Bauersfeld (1995), learning was perceived as a series of actions and standards that are put into use within the context of one’s learning community. Therefore, in order for something to be known by learners, they must already have an arrangement into which something can be assimilated (Tzur et al., 2001). Knowledge is perceived as the conceptual structures for individuals, and operations are used to make sense and organize their experiential worlds (Cobb & Bauersfeld, 1995; Tzur et al., 2001).

From the perspective of a teacher’s responsibility in the learning process, teachers must work to help their students develop mathematical concepts (Cobb & Bauersfeld, 1995; Tzur et al., 2001). The assumption has been made that teachers understand the difference between their own knowledge and content knowledge. In addition, teachers

should possess knowledge of their students so that they can present information and concepts based upon those students' basic knowledge. Teachers' understanding of what their students understand is crucial to their ability to teach, and their students' ability to become successful in learning mathematical concepts (Simon, 1993; Tzur et al., 2001). Teachers' perspectives of their students' abilities vary greatly and are based on the many aspects of teaching their specific students on a day-to-day basis. Tzur et al. (2001) stated that help was needed in teacher education classes so that teachers can separate what they know versus what their children know about the subject of mathematics. According to Cobb & Bauersfeld (1995), these findings demonstrated how crucial it is for teacher development to take place in the area of mathematical concepts.

In order to be effective, teachers must know the subject they teach. Ball et al. (2009) questioned whether simply knowing a subject well was sufficient for teaching it. They claimed that knowing how a process in math works was not enough for an effective teacher of mathematics, and that educators must be able to analyze student work, represent mathematical problems in many distinctive ways, and teach to many modalities of students. They further commented that subject matter courses in undergraduate schools had a tendency to be academic in nature and quite distant from the real world of teaching.

Professional Development

Professional Learning Communities

As a result of legislation such as the No Child Left Behind Act (NCLB, 2001), many school reforms have been instituted. As a consequence, teachers have been inundated with many new tasks that take their focus away from their instructional time (Doolittle et al., 2008; Vescio, Ross, & Adams, 2008). To be effective, teachers should be absorbed in the subjects they teach, be able to communicate that knowledge to their students as well as develop higher level thinking skills and problem solving for their students (Garet et al., 2001). These authors expressed the belief that the traditional approach to teaching, i.e., the memorization of facts without a more in-depth understanding of subject matter, had no place in the reform-driven school system of the 21st century.

Garet et al. (2001) wrote that teachers must learn more about the subjects that they teach and, in turn, how their students learn these subjects. They suggested that when professional development is continuous and meaningful, rather than short term and irrelevant, it is far more effective and useful to teachers. They also noted that when teachers are engaged in professional learning communities (PLCs) that focuses on specific subject areas, they can use a hands-on approach. If professional development is a part of their daily school routines, it is more likely to be used by them in their classrooms. In their California study, Hill and Loewenberg-Ball (2004) suggested that professional development focused on specific content area was more beneficial to learners. They

stressed that focusing on a specific subject area such as mathematics in the context of a single professional development activity could benefit teachers. This is in contrast to published reports regarding the value of PLCs.

PLCs have been suggested in the literature as a way for teachers to work together to accomplish some professional development tasks. Darling- Hammond (1998) indicated that teachers could change their instructional approach with members of PLCs and thereby directly impact student achievement. A learning community involves collaboration between teachers at the highest level. Because of this, the needs of students can be addressed in a much more effective manner. The resources that are available to the teachers within a school can also be maximized when a group of teachers come together to form a collaborative group and focus on the learning rather than the teaching (Darling-Hammond, 1998; Doolittle et al., 2008; DuFour, DuFour, Eaker, & Karhanek, 2004)

Darling-Hammond (1998) developed the following list of characteristics of effective professional development. She believed that professional development should have the following set of characteristics in order for it to be effective: Staff development , to her way of thinking, should be “interactive, allowing teachers to participate in real tasks of teaching and learning with colleagues; include observation of students with a focus on student improvement and the use of data; based on research; sustained over time; and include collaboration with colleagues” (Darling-Hammond, 1998, p. 9).

In order for PLCs to be effective teachers need to meet on a regular basis to plan the curriculum and share research-based strategies and relevant data to make those curricular decisions (DuFour et al., 2004). The change from traditional team planning to

PLCs will require many people to be leaders at their schools so that the PLCs can be effectively facilitated and managed with clear curricular goals in mind (DuFour et al., 2004).

In reviewing Darling-Hammond's (2007) research on PLCs, it was indicated that teachers would implement curriculum that extends what they already know. If the teachers are extending what they know, they can easily integrate new knowledge into their personal repertoire. In contrast, if the knowledge is a great deal more than teachers already know, it is far more difficult to integrate it successfully, as they have to learn it as well. Fogarty and Pete (2009) cited several essential understandings for successful PLCs. The most important is that adult learners, if they are supported by their peers and administration, will take charge of their own learning. DuFour et al. (2004) spoke of the importance of a PLC either involving the entire staff or various grade levels so as to enable faculty to work together to build their students' skills and strategies. According to DuFour et al. (2004), very few teachers actually share students' work or plan with the next grade level in mind. PLCs give teachers this opportunity. By working together and using all resources, teachers are better able to see where students are not achieving specific academic skills. (DuFour et al., 2004).

DuFour and Eaker (1998) defined professional learning communities in a 1998 publication. According to these authors, the "professional" is someone who is considered an expert, or has an advanced degree or training, and is always current on what is new and innovative in his or her "field." A school is a "learning" environment where all of the inhabitants are actively engaged in the learning process, and "community" suggests that

all participants in this school are working together to better educate the students and achieve better results than they would if they were to go about it all alone. Wenzlaff and Wieseiman (2004) observed that teacher beliefs, teacher learning, and teacher knowledge of content matter were all crucial to the learning that takes place within classrooms. Teachers' beliefs in their capabilities to effectively teach students is critical to their success in the classroom (Fogarty & Pete, 2009; Wenzlaff & Wieseiman, 2004).

Wenzlaff and Wieseiman (2004) suggested that teachers who participate in large group professional development do not relate in any way to what they do on a day-to-day basis. They advocated for finding better ways to facilitate the learning that is offered to teachers, so that it is considered to be valuable by them.

In conclusion, DuFour and Eaker (1998) stated that the general model for American schools was outdated and was modeled after the industrial model of the 19th and 20th centuries. The 21st century society is technological. PLCs are more appropriate to the needs of 21st century teachers and students and what teachers need to do to prepare their students for a future in a technological society (DuFour & Eaker, 1998; Wei et al., 2009). Educators need to understand that the "traditional model" may not meet the needs of 21st century students and that not everything they believe about teaching may be valid. PLCs are a way in which teachers can work together and shape the new future of the teaching profession in American schools (DuFour & Eaker, 1998).

Foundations of a Professional Learning Community

DuFour and Eaker (1998) stated that the success of PLCs is contingent upon “four pillars”--mission, values, vision, and goals. When describing mission, they look at why the school and teachers exist, the purpose toward which teachers strive, and the clear focus in regard to the purpose (DuFour, DuFour, Eaker, & Many, 2006). Vision requires looking to the future to determine what direction must be taken to accomplish this purpose (DuFour & Eaker, 1998). Values addresses how teachers go about achieving the mission, what they are committed to do to reach their goals, and what guides their behavior (DuFour & Eaker, 1998; Wei et al., 2009). Goals set timelines and priorities so that progress can be determined (Darling-Hammond, 2008; DuFour et al., 2006;).

DuFour and Eaker (1998) stated that the foundation of PLCs needs to be the mission and purpose of the group. The group should be looking at their reasons for forming the group and the motivation behind it. They should be looking at what can be done to improve or focus on the learning taking place (Darling-Hammond, 2009; DuFour & Eaker, 1998). Most schools have a mission statement; however, that statement is usually the same throughout the country and not unique to any state, district, or specific school (DuFour & Eaker, 1998). Ideally, each of these mission statements is created to ensure that success for every student is the goal.

DuFour and Eaker (1998) and Darling-Hammond (2008) also stressed the importance of vision as it gives the school and its faculty a sense of purpose. It gives them a goal to strive toward and provides a picture for both students and faculty of what the school should be. What has been difficult for educators when it comes to vision is that

legislators and critics of education have had their own vision of what the school and its students should be accomplishing (DuFour & Eaker, 1998). Such things as more coursework, more school days, more homework, and a greater degree of mastery are often emphasized--and that is just for high school graduation.

Cwikla, (2004) discussed professional development for educators as a career-long journey of learning. Teachers who are effective engage in the learning process and student's ability to think and learn throughout their entire careers. Ball (1996) and Cwikla proposed that teacher learning should take place in a collegial environment and that it should be based upon teacher collaboration and peer support in order for student learning to take place. All too often, teachers are asked to implement programs without enough processing time or professional development. In order for teachers to effectively teach the material, they need to be able to process it and learn how to effectively bring that information to their students. As with most adults, change is difficult for teachers. Teachers who have received the appropriate support from their peers and professional community in terms of processing time or professional development are more likely to have implemented new curricular ideas effectively (Cwikla, 2004).

Characteristics of a Professional Learning Community

DuFour and Eaker (1998) outlined the characteristics of PLCs as

“(a) shared mission, vision, and value where the collective beliefs of the group are the same, (b) collective inquiry in which members of the group work together to discover and ask questions about their teaching and methodology, (c) collaborative teams that share a common purpose and utilize the skills of members of the group toward a common purpose, (d) Action, orientation, and

experimentation where all work together toward a common goal regardless of whether the methods tried are successful and learn from failure or inconclusive results as well as successes, (e) Continuous improvement in which questions regarding purpose, achievements, strategies, assessment are posed to ensure a results orientation. (DuFour & Eaker, 1998, p.25-28).

DuFour et al. (2006) also stated that individual team “norms” should be used to help teams focus on the mission. These norms are not beliefs but ways to act. They should be reviewed regularly, and only a minimum number of norms should be put into place as too many will defeat the purpose of the PLC.

Eaker et al. (2002) also stated that the process of learning, rather than teaching, needs to be addressed. They suggested three aspects on which to concentrate: “(a) What do we expect students to learn? (b) How will we know what they have learned? (c). How will we respond when students do not learn? (Eaker et al., 2002, p.19).”

Three main ideas were found in the work of DuFour et al. (2005). The first idea called for educators to focus on the learning process rather than the teaching process, since this can be the difference between a high achieving school and a non-achieving school. The second idea involved the process of a PLC that encouraged collaboration and in turn improved teachers’ abilities. This was related to the sharing of student data so that teachers can reflect on the methodology they are using and adjust it based upon what they are learning together. One of the crucial elements of this process was that teachers be given the time to share and work with each other in order for results to occur (DuFour et al., 2005). The third main idea was that results have to be examined so that goals can be

set for teachers to share and analyze each other's teaching and strategies. According to the authors, attending to these three main ideas will create better results for the school.

Eaker et al. (2002) stated that a PLC should be divided into developmental stages along a continuum. They mapped the following four stages of a collaborative culture. First, teachers initially teach alone and rarely know what each other is doing. Next, is the initiation stage when teachers realize that their peers are all teaching similar curriculum but do not share what they are doing. The third stage is one of development which occurs when teachers sometimes work together and come up with some assessment or goals that are common among them all. The final stage is one of sustaining when teachers work together consistently and share curriculum and goals (Eaker et al. 2002).

Darling-Hammond (2006) stated that NCLB has drawn awareness to the fact that in order to have highly qualified teachers as mandated by legislation, many conditions at the national and state levels have to change. Some states such as Ohio and California have increased the number of highly qualified teachers through professional development and assistance programs to ensure success on both the certification tests and through the first year of teaching however, urban schools have had difficulty retaining well educated and capable teachers and have offered very little in the way of professional development (Darling-Hammond, 2006).

As part of the national Staff Development Council, Wei et al. (2009) investigated the professional development of teachers in high achieving nations such as Finland, Sweden, and the United Kingdom. They determined that the common threads among other countries were that (a) teachers' days needed to have time built in for collaboration

and professional development; (b) professional development of teachers should be continuous and concentrate upon what subject matter they teach; (c) teachers should have many opportunities for professional development, (d) beginning teachers should have an extensive support system; and (e) teachers should participate in the selection of curriculum materials and decision that involve their instruction of the students.

In comparing professional development of teachers in the United States, the authors found very little professional development built into the work week of teachers. Most professional development activities were typically limited to one or two days as opposed to a continuing initiative (Wei et al., 2009).

Summary

Literature has been reviewed in this chapter related to educational reform issues at the federal, state, and school district levels. Accountability initiatives and high-stakes testing initiatives have been discussed as they have impacted teacher preparation and professional development and most specifically the development of professional learning communities (PLCs).

The researcher looked at the work of DuFour et al. (2005), Darling-Hammond (2005), and Hord (1997) who have studied PLCs and addressed in numerous works the need for them as a viable way to improve student learning gains. Hord (1997) cited the following five components of professional learning communities: (a) supportive and shared leadership, (b) shared values and vision, (c) collective creativity, (d) shared practice, and (e) supportive conditions. The professional learning community formed for

this research consisted of a small number of individuals, and this framework was considered appropriate for larger groups. Still, the components were considered and were helpful in establishing the norms that were used as the basis of the professional development initiative, i.e., the professional learning community, among a small group of teachers.

CHAPTER 3 METHODOLOGY

Introduction

This chapter present presents the methodology and procedures used in the three phases of this research study. The purpose of the study is restated, and the school setting and population are described. The research question, the research design, and the research timeline are detailed. The sources of data are identified, and the procedures used in accessing those sources of data are explained.

Purpose of the Study

The purpose of this research was to study the implementation of a professional learning community comprised of one group of third-grade teachers in a Florida elementary school where the emphasis was on research-based practices in the teaching of mathematics. Investigated were the growth of teachers' content knowledge in mathematics, specifically in the areas of multiplication and division, and the effects of their professional learning within their classrooms.

The School Setting

The setting for this study was a large Florida suburban elementary school where 26% of the students received free and/or reduced lunch. At the time of the study, the school was in the fifth year of operation with a total enrollment at just over 880 students, of which 159 were in the fifth grade. Racial demographics for the school were as follows:

66% White, 14% Hispanic, 9% Black, 4% Asian, and 7% Multiracial for a total minority rate of 34%. All classes were taught by teachers certified by the state of Florida Department of Education, and 39.6% of the total 61 teachers held Master's degrees.

In the previous school year, all third -grade students were tested using the 2010 Florida Comprehensive Assessment Test (FCAT), and 78% demonstrated proficiency in Mathematics by scoring a. This rate of proficiency represented an increasing trend for the school since 73% of third graders were proficient in Mathematics in 2009, and only 70% were proficient in 2008.

This school was rated an "A" school by the Florida Department of Education during the 2009--2010 school year. The school did not make adequate yearly progress (AYP).

Study Participants

Third-Grade Teachers

The third-grade team consisted of seven teachers in seven general education classrooms with 18 or fewer students in each. One of the teachers elected not to participate in the study due to prior constraints on her time. Thus, the final group was comprised of six teachers. These teachers were assisted by one specific learning disabilities teacher who also provided services to two other grade levels. Additional assistance to this teaching team was provided by one reading specialist and three non-

degreed instructional assistants, all of whom also provided assistance to five other grade levels.

The six participants who were chosen for this study had taught in the same school and constituted a “team” of teachers who had worked together for between three and six years. This team of third grade teachers had expertise in the following fields: (a) mathematics, (b) reading, (c) social studies, (d) science, and (e) language arts. The participants in this study had all received the minimal amount of pre-service training that was required by the colleges where they completed their elementary education degrees. Hill and Ball (2009) found that most elementary teachers receive little more than an equivalent of grade 13 mathematics in their undergraduate classes. This group of third grade teachers was typical in that they had attended very little mathematical professional development in their years in the profession. All of the teachers in the study had students with similar backgrounds, and all participants believed strongly in the importance of their work as educators. Additionally, all six used the same district-approved Houghton Mifflin Harcourt *Go Math* curriculum in their inclusive math classrooms. It was this group of six teachers who constituted the professional learning community.

The Researcher as Facilitator

The researcher served as the facilitator for the professional learning community that was the subject of this study. Her present assignment was as an inclusion teacher for children with disabilities, a position she has held for seven years. She was a highly qualified teacher in the school and was dual-certified in both elementary education and

early childhood education. She held reading and ESOL (English for Speakers of Other Languages) endorsements and was a National Board Certified Teacher in the area of Middle Childhood Generalist. The researcher had also earned a master's degree in technology and media and had 22 years of teaching experience in the areas of kindergarten, first, fourth, and fifth grades. At the time of this study, she was a curriculum and instruction doctoral candidate.

The researcher was well known by the participants and has been recognized as a mentor or group leader for professional development. She has been a mentor to many beginning teachers as well as teachers who needed extra help with classroom discipline or curriculum issues. The researcher has also served as a supervising teacher for senior and junior interns from the local university for over 20 years. The researcher's background and experience were important in preparing her to conduct this research. Her experiences as a mentor and supervisor of interns as well as an inclusion specialist gave her insight into the importance of experience and professional development. Her work in these areas has given her a drive to achieve and learn. In turn, it was her desire to share her expertise with a group of individuals who were willing to step out of their comfort zones and put forth the effort to improve their abilities to teach these two simple mathematics concepts using strategies which were new to them.

This project has benefited the PLC members as evidenced by the changes in attitude and growth in content knowledge. The researcher has also learned and believes that her ability to work with teachers in professional development settings has been enhanced. The changes in attitudes of the participants and the growth in content

knowledge via the PLC were evident and encouraging first steps which can lead to further collaborative learning. The PLC, itself, provided a potential model for further professional development initiatives in the school. The researcher has already discussed with the building administrator the idea of leading some PLC groups for next year involving other grade levels and other mathematical topics.

Independent Observer

An independent observer was used in this research study as an advisor to the researcher and as an objective professional not involved in the actual professional learning community. The observer had two primary roles in the research: (a) she assisted with the scoring of the participants' pre- and post-tests of content knowledge, and (b) she conducted the post-study interviews with participants. The observer was trained by the researcher in the procedures expected to be used in conducting the post-study interviews. Though the study could have been completed without this individual, the researcher wished to ensure the fidelity of scoring procedures on the pre- and post-tests of content knowledge by having a second professional review and discuss the test results with her. It was believed that participants in the study may have been more candid in conveying their perceptions regarding the PLC if an individual other than the researcher conducted the post-study interviews.

The independent observer for this research study was an individual who held a master's degree in elementary education and a doctoral degree in exceptional education. She had taught first and third grades for 12 years and also served as a reading

interventionist and mathematics coach. According to the requirements of the Institutional Review Board of the University of Central Florida, the observer successfully completed coursework in the protection of human research subjects.

Research Question

This research explored the following research question:

To what extent does participation in a professional learning community comprised of elementary grade level teachers in one central Florida elementary school influence teachers' mathematical understanding of basic multiplication and division strategies?

Research Design

This study was a mixed methods study employing qualitative and quantitative methods of research to study one group of teachers at an elementary school. The focus was on the groups' instructional practices and the use of research based materials in the context of a professional learning community and their membership in it. The researcher employed multiple data collection techniques: pre- and post-study interviews, pre- and post-tests of content knowledge, observation, and document analyses to study the effects of the professional learning community (PLC). Guba, (1981) suggested the use of observations, interviews, and document analyses as an appropriate methodology for research. The researcher examined a variety of documents, i.e., pre- and post-study interview documentation and pre- and post-tests of mathematical content knowledge to determine growth of teachers in the areas of multiplication and division. (Hancock &

Algozzine, 2006). The researcher also investigated whether the implementation of a PLC focused on the use of research-based practices in the teaching of mathematics improved teacher understanding which could, in turn, contribute to increased student achievement.

This research design called for the research to be conducted in three phases. In Phase I, the researcher interviewed all participants using a researcher-designed interview guide (Appendix A) to elicit information from the participants regarding (a) their pre-existing feelings as mathematics learners, (b) their pre-existing feelings as mathematics teachers, and (c) their perceptions about mathematics learning and teaching.

Phase I of the research also included the administration to the participants of a researcher-adapted survey, based upon previously released items studied by Ball (2008). This survey was administered as a pre-test (Appendix B) to determine mathematical content knowledge of the participants of the professional development study group prior to the formation of the PLC. Permission for use of the items was attained and is noted in Appendix C of this document.

In Phase II of the study, the researcher documented the activities that occurred within the professional learning community of third-grade teachers. The professional learning community was conducted over a period of 10 weeks with a group meeting of approximately 40-60 minutes each week. During these meetings, field notes and discussions were recorded by the researcher in a notebook. These meetings were originally scheduled to be conducted primarily during the teachers "duty time" which is allocated for professional development and various other teacher functions. Some of the meetings were conducted after school as county meetings or administrative meetings

were later scheduled during the planned meeting times for the group. The group was flexible and determined that the necessity of the meetings was worth staying beyond the school day on some days.

In Phase III of the research, a post-study interview (Appendix D) was conducted with each of the participants by the independent observer to elicit participants' perceptions and observations based on their participation in the PLC. The independent observer was used to conduct the interviews in order to ensure, so much as possible, the candor of PLC participants in discussing their experiences, their attitudes, and their perceived professional development as a result of the PLC.

A post-test of content knowledge was also administered to the participants. The same instrument administered as a pre-test was again administered to the participants as a post-test of their mathematics content knowledge (Appendix B). Data from the pre- and post-tests were compared for growth of participants' content knowledge based on their participation in the PLC.

Phase I: Sources of Baseline and Background Data

Pre- and Post-Test of Mathematics Content Knowledge

The researcher constructed a 10-item survey instrument (Appendix B) which served as both a pre- and post-test of mathematics content knowledge for participants. The survey was based on a series of questions designed by Ball (2008) in her University of Michigan research. These questions were used to determine mathematics content

knowledge of the participants of the professional development study group prior to their participation in the professional learning community. The researcher selected 10 pre-released items from Ball's (2008) work for use in the survey. Five of the questions served as the data points for the study. The remaining five items were "fillers" and had no bearing on the survey results. Each of the five selected questions for which data were collected were correlated with three of the benchmarks related to multiplication and division in Florida's Next Generation Sunshine State Standards (NGSSS) as indicated in Table 1.

Table 1

Relationship of Pre- and Post-Test Items to Overall Objective and Benchmarks

Overall Objective: Develop understandings of multiplication and division and strategies for basic multiplication facts and related division facts.

Benchmark (MA.3.A.1.1). Model multiplication and division including problems presented in context: repeated addition, multiplication comparison, array, how many combinations, measurement, and partitioning.

Survey Question 3. 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:

How does each students method reflect his or her understanding of the two digit multiplication process?

Survey Question 5. 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:

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

What does his method say about Todd's understanding of place value?

Benchmark (MA.3.A.1.2). Solve multiplication and division fact problems by using strategies that result from applying number properties.

Survey Question 4. 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.

Survey Question 2. 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 strategy demonstrates that the student understands the concept of prime numbers? Explain your 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.

Benchmark (MA.3.A.1.3). Identify, describe, and apply division and multiplication as inverse operations

Survey Question 7. Mr. Garrett's students were working on strategies for finding the answers to multiplication problems. Which of the following strategies would you expect to see some elementary school students using to find the answer to 8×8 ?

- a) They might multiply $8 \times 4 = 32$ and then double that by doing $32 \times 2 = 64$.
- b) They might multiply $10 \times 10 = 100$ and then subtract 36 to get 64.
- c) They might multiply $8 \times 10 = 80$ and then subtract 8×2 from 80: $80 - 16 = 64$.
- d) They might multiply $8 \times 5 = 40$ and then count up by 8's: 48, 56, 64.

Why would some of Mr. Garrett's students select strategy B?

Participant Interviews

Participants in the PLC were also interviewed as a part of the study to determine basic demographic information as well as their mathematical background, their professional development background, what sort of courses they took at the secondary and college level for mathematics, the colleges they attended and degrees they attained. The interview guide (Appendix A) developed by the researcher contained 36 open-ended questions. These questions were used to gather information from respondents regarding (a) their pre-existing feelings as mathematics learners in Section 1, (b) their pre-existing feelings as mathematics teachers in Section 2, and (c) their perceptions about mathematics learning and teaching in Section 3.

Teachers were initially provided with the instrument and permitted to complete their paper and pencil responses individually. Responses were returned to the researcher who then interviewed each of the teachers individually to seek further clarification if needed or permit teachers to expand on their written responses. The researcher took notes during the interview and recorded additional data, i.e., responses to probing questions or

clarification of earlier responses. These follow-up interviews were later transcribed. These data supplemented the written responses of teachers and were reviewed in order to develop a profile of each of the participants and to determine anomalies, errors, inconsistencies, and irrelevant data.

Phase II: The Professional Learning Community

Phase II of the research, consisting of the formation and conduct of the professional learning community (PLC), occurred over the ten-week period between September 7, 2010 and November 9, 2010. Participation in the PLC was intended to provide participants with additional mathematics content knowledge in the specific areas of division and multiplication and to assist them in their mathematics instruction. It was anticipated that this could have a direct impact on the learning gains of third-grade students in mathematics.

Each meeting for the PLC was conducted in a third classroom at the school in which the participants taught. The PLC required few additional resources. Configured as a study group, the PLC met every Tuesday for a period of 10 weeks from 10:20-11:00 am on the following dates: September 7, 21, October 12, 19, and November 2. The other meetings were conducted from 3:30-4:30 pm on the following dates; September 14, 28, October 5, 26, and November 9. The researcher participated in all sessions and was active in demonstrating mathematics strategies as part of the study group's activities.

The format for these meetings included using and viewing professional development demonstrations and podcasts designed by Houghton Mifflin Harcourt as a

part of their *Go Math!* series. Meeting discussions were dependent on several factors and included, but were not limited to, mathematics material, pedagogy, student performance, or program use.

The group decided on topics for the meetings based upon the NGSSS in the areas of multiplication and division, third grade level, and the needs of their students. At each meeting, the group looked at lessons for the upcoming week and decided as a group which lessons would be appropriate for their study based on their classes' success from the previous week. The group then looked at resources and materials from the *Go Math!* series that had been recently adopted by the school district to determine which ones would be helpful to them. Finally, various other resources were shared to show alternative methods, materials, and ways in which children could gain mathematics knowledge from available materials.

At each session, participants reviewed a podcast provided by *Go Math!* (2010), that was relevant to the topic they had selected for the week, and discussed as a group what they saw and understood from the podcast. Throughout this process, the researcher, who was also a participant in the group, observed the group to further assess teachers' understanding of how children learn mathematics. Originally, this research study was based upon a protocol for meeting that did not allow for a great deal of personal interaction and sharing. However, once the group met, it was decided that because a new mathematics series had been adopted and implemented in their classrooms, more room needed to be added into the schedule for sharing and problem solving related to the new series.

Protocol for Facilitation of the PLC

Since the researcher had a dual role as both facilitator and participant in the PLC, she was responsible for numerous tasks including: documenting progress of the group, looking for and presenting ideas for the group to use in their classrooms, sharing ideas, and learning from the group. The researcher was mindful, in all of her group and individual interactions, that her role was to facilitate the teachers' learning so that they gained mathematics content knowledge within the professional learning community setting. This knowledge needed to be that which they, not necessarily the researcher, believed was needed for their individual classes.

It was also important that the teachers stay interested throughout the study and were actively focused on their own learning as opposed to increased student achievement. This research allowed ongoing opportunities to learn that included access to research articles, books, and videotapes. The teachers and researcher designed their professional development with these resources and used them as a stimulus for discussion and reflection.

The researcher's role in this process was to be reflective in her approach to her facilitator role. As such it was important to consider the events from one PLC meeting to the next to consider what might be most appropriate in facilitating subsequent activities of the group. Usually, that reflection resulted in decisions around the resources and research that could be provided to teachers to assist them in gaining additional mathematics knowledge needed for their particular classroom and students. The researcher actively participated in teachers' conversations but tried to avoid influencing

their thought processes when they tried something new or different. She did, however, monitor group and individual reactions using questioning techniques. She queried the participants by asking questions about the choices the teachers made, the designs of lessons, the use of manipulatives, and the strategies employed in teaching the lessons. This process helped the researcher to understand the context in which decisions were made and why certain mathematics lessons were selected over others. Some of the questions asked may, therefore, have influenced teachers' participation in the group and their thinking about a certain concept. The researcher did her utmost to answer questions in a complete manner but to always refer the questioner to appropriate research and resources. She also was careful to be nonjudgmental in her responses to questions so as to avoid providing responses based on her, not teachers' interpretation of the literature. This permitted the researcher to observe participants as they received information and put it to use with their students.

Document Review

Guba (1981) suggested the use of observations, interviews, and document analyses as an appropriate methodology for research. The researcher reviewed documents such as pre- and post-test of content knowledge results, and pre- and post-study interview notes and transcripts of audio taped PLC meetings. This review enabled determinations regarding the changes that had occurred in participants' mathematics content knowledge as a result of the PLC activities, i.e., research-based practices and their perceptions regarding participation in the PLC.

Phase III: Post-Study Interviews and Post-Test of Mathematics Content Knowledge

Between November 15 and 19, 2010, post-study interviews were conducted with each of the participants by the outside observer who was associated with the research. Five questions were used to guide the interviews. The questions focused on (a) changes in classroom practice as a result of the PLC, (b) new mathematics understandings as a result of the PLC, (c) changes which had occurred in group efficacy as a result of PLC activities, (d) descriptions of any changes that had occurred, and (e) an explanation--if changes had not occurred

Pre- and post-study interview data were compiled, and examined for trends in terms of participants perceptions of changes that were occurring (or not) in regard to their mathematics practice and content knowledge. The researcher and the independent observer then discussed the results of the analysis.

On November 16, 2010, a post-test of content knowledge, the pre-test of content knowledge repeated, was administered to all participants. Pre- and post-test results were displayed in tabular form for the six teachers and reviewed to determine the extent to which content knowledge had changed for the participants.

As a final step in Phase III, the researcher reviewed all of the data available from the three phases to determine trends and anomalies. In an effort to be thorough in the review of the documentation available, the results were reviewed and discussed with the independent observer.

Research Timeline

Institutional Review Board (IRB) permission to conduct the study was requested in July 2010, and permission was granted on July 8 of that same year (Appendix E). School district permission to conduct the study was also requested and granted in July 2010 (Appendix F). Once permission to conduct the study was received, informed consent to participate in the study was obtained from each of the participants (Appendix G).

On August 24, 2010, prior to the beginning of the PLC meetings, participants were surveyed regarding their mathematics content knowledge using the pre-test of content knowledge. Interviews with each of the teachers were conducted by the researcher from August 23-September 3, 2010. PLC meetings and activities occurred from September 7-November 9, 2010. The post-test of content knowledge was administered on November 16, 2010, after the official observation period of PLC activities had concluded. Post-study interviews were conducted by the independent observer from November 15-19, 2010. The time line for research activities is presented in Table 2

Table 2
Timeline for Research Activities

Dates	Sequence of Events/Activities	Data Gathered by Researcher
Phase I		
August 23-September 3, 2010	Pre-Study Interviews with participants	Demographic and Descriptive
August 24, 2010	Administration of pre-test of content knowledge	Establish prior knowledge of teachers
Phase II		
September 7, 14, 21, 28; October 5, 12, 19, 26; November 2, 9	Weekly PLC meetings	Meeting notes Audiotapes Field notes Examine problems with math series Themes and issues/share successes
Phase III		
November 16, 2010	Administration of post-test of content knowledge	Establish post-knowledge of teachers
November 15-19, 2010	Post-study interviews	Update participant perceptions

Fidelity of Implementation

In this study fidelity was established by having the same professional learning community leader at all meetings, as well as the interview and for the pre-study PLC questionnaire, and the pre- and post-tests of content knowledge. Additionally, an independent observer conducted the post interview and checked the fidelity on ratings of the participants pre- and post-test results.

Data Collection and Analysis

The unit of analysis for this project was the teachers. Pre- and post-study interviews with teachers were used to assess participants' perceptions of changes that were occurring (or not) in regard to their mathematics practice and content knowledge.

For this study, a comparison was made of the teacher's content knowledge in the area of multiplication and division mathematics strategies before and after their participation in the PLC. This study was conducted to determine if the six individuals changed their understanding of the teaching of mathematics based on their participation in the PLC. This understanding was determined by a pre- and post-test of teachers' content knowledge in mathematics, more specifically, in the areas of multiplication and division. The anonymity of participants was assured by using a pseudonym (Annie, Beth, Cathy, Dena, Emily, Fran) for each respondent. The codes, list of names, and any documentation associated with the PLC were maintained in a locked cabinet which was accessible only to the researcher. All electronic data was stored on a password- encrypted jump drive and maintained with all other data in a locked cabinet in the researcher's classroom. The disposition of documents, their storage, and period of retention are displayed in Table 3.

Table 3
Document Security, Storage, and Retention

Item	Contents	Who May Access	Storage	Record Retention
Participant list	Names of participants and corresponding code number	Researcher only	Researcher's locked file cabinet	5 years after study
Password encrypted USB jump drive	written documentation of participants' interviews audio recordings of PLC meetings	Researcher only	Researcher's locked file cabinet	5 years after study
Instruments (hard copies)	Interviews (pre and post) and any shared documents from PLC group	Researcher only	Researcher's locked file cabinet	5 years after study

The researcher used triangulation in the collection and analysis of data (Creswell, 1998). As a method of evaluating the data across multiple sources, it increased the credibility of the study and links were able to be shown between the participants' interviews, participants' questionnaire responses, and their participation in the PLCs.

PLC transcripts and field notes were transcribed to indicate instances of growth in mathematics understanding, growth in pedagogical content knowledge, and growth in the group as an effective professional learning community. The data were summarized, and the researcher noted differences between each of the six participants (Hancock & Algozzine, 2006). Trends were noted in transcripts and recorded as written notes, then summarized for the purpose of this research study.

Triangulation occurred in the data collection process through the use of interviews, audio transcripts, and field notes (Hancock & Algozzine, 2006; Moustakas,

1994). PLC meetings were audio taped, and the tapes were reviewed three times at the end of each session. In the first review, notes were taken. In the second review, general themes were identified. In the third review links were made between the field notes, learning community observations, and the interview notes.

Two major categories of observations were established based on the participants responses and interactions within the group each week: (a) pedagogical experiences with teaching and learning mathematics, and (b) experiences working with others in a professional learning community (Eaker et al., 2002) It was the initial intent of this research that any emerging themes would fit into these two categories. However, documentation of PLC activities was expanded to present an overview/agenda for the meeting followed by summaries of meeting activities and events using four categories that demonstrated (a) changes in practice, (b) new mathematics understandings, (c) changes in group efficacy, and (d) reasons for changes in group efficacy. Within the categories, themes were identified. Over the course of the research, each new set of observations was used to confirm existing themes or to suggest new ones (Eaker et al.,2002). These experiences were then examined and cross-referenced for the purpose of discussion in this research study. The researcher was looking for changes in the groups' work experience with others and any shifts in the "norms" of the teaching experiences that were discussed at each meeting.

Pre- and post-tests were administered so that the two surveys could be compared for knowledge of mathematics content area by evaluating the responses to the five questions that served as the data points for the study. The remaining five "filler" items,

which had no bearing on the survey results, were disregarded. Each of the five selected questions for which data were collected were correlated with three of the benchmarks related to multiplication and division in Florida's Next Generation Sunshine State Standards (NGSSS). They were correlated so that PLC activities could be directly related to the teaching of the new mathematics curriculum and standards across the state. The pre-tests and post-tests were scored independently and compared in Phase III of the research. Responses were assigned values ranging between 0 and 3 where 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation. Once the pre- and post-test responses for each of the five items were scored and recorded for each of the participants, it was possible to compare the results for all the participants' pre-and post-test responses. Tables and graphs accompanied by narrative explanations were used to present the pre- and post-test scores of mathematics content knowledge.

Summary

This research study was a mixed methods research study with an emphasis on increasing teachers' mathematics content knowledge in the areas of multiplication and division. This chapter has detailed the methods and procedures used to conduct the study. The research was conducted in three phases. In Phase I, participants were interviewed and completed a pre-study interview to provide demographic information and a pre-test of content knowledge. In Phase II, participants were actively engaged in a professional

learning community (PLC) in which the researcher served as facilitator. In Phase III, participants in a professional learning community (PLC) completed a post-test of content knowledge and a post-study interview. The triangulated data were reviewed and analyzed to determine patterns in teaching, themes, and teachers' instructional comfort with subject matter and content. Chapter 4 presents an analysis of the data collected to determine the extent to which participation in the professional learning community was successful in effecting growth in mathematics content knowledge and in positively influencing classroom practice in teaching mathematics.

CHAPTER 4 FINDINGS

Introduction

This chapter is divided into six sections. The chapter begins with a description of the participants. The following sections are used to report data gathered in (a) a pre-test of mathematics content knowledge, (b) pre-study interviews, (c) the 10 professional learning community meetings, (d) the post-test of mathematics content knowledge, and (e) the post-study interviews.

Participants

As previously mentioned in Chapter 3, the participants of this study consisted of a third-grade team of seven teachers in seven general education classrooms with 18 or fewer students in each. One of the teachers elected not to participate in the study due to prior constraints on her time. Thus, the final group was comprised of six teachers. These teachers were assisted by one specific learning disabilities teacher who also provided services to two other grade levels. Additional assistance to this teaching team was provided by one reading specialist and three non-degreed instructional assistants, all of whom also provided assistance to five other grade levels.

The six participants who were chosen for this study had taught in the same school and constituted a “team” of teachers who had worked together for between three and six years. This team of third grade teachers had expertise in the following fields: (a) mathematics, (b) reading, (c) social studies, (d) science, and (e) language arts. The

participants in this study had all received the minimal amount of pre-service training that was required by the colleges where they completed their elementary education degrees. Hill and Ball (2009) found that most elementary teachers receive little more than an equivalent of grade 13 mathematics in their undergraduate classes. This group of third grade teachers was typical in that they had attended very little mathematical professional development in their years in the profession. All of the teachers in the study had students with similar backgrounds, and all participants believed strongly in the importance of their work as educators. Additionally, all six used the same district-approved Houghton Mifflin Harcourt *Go Math* curriculum in their inclusive math classrooms. It was this group of six teachers who constituted the professional learning community.

Annie is a female Caucasian teacher with five years of experience in elementary education. She has a bachelor's degree in elementary education and her teaching has been exclusively at the third grade level. The highest levels of mathematics she completed in high school and college were Algebra II and Statistics, respectively.

Beth is a female Caucasian with six years of experience in elementary education. She has bachelor's and master's degrees in elementary education, and she has taught only third grade. Her highest level of mathematics in high school was Algebra I. In college, she completed Statistics.

Cathy is an African American female with six years of teaching experience in elementary education. She has a bachelor's degree in elementary education and has taught kindergarten and second, third, and fourth grades. The highest level of

mathematics she achieved in high school was Trigonometry. She also completed Statistics in college.

Dena is a female Caucasian with four years of experience in elementary education. She has a bachelor's degree in elementary education and has taught exclusively at the third grade level. The highest level of high school mathematics she completed in high school was Pre-calculus. In college, she completed Statistics.

Emily is a female Caucasian with three years of experience in elementary education. She has a bachelor's degree in organizational communication and elementary education and has only taught third grade. In high school, the highest level mathematics course she took was Algebra II. At the college level, she completed Algebra and Statistics.

Fran is the veteran of the group she is female with 17 years of experience in elementary education. Fran has a bachelor's degree in biology and a master's degree in exceptional education and elementary education. She has taught Grades 1-5 and both self-contained and inclusive exceptional education. The highest level of mathematics she achieved in high school was Pre-calculus. She completed Calculus and Statistics at the college level.

Pre-test of Participants' Mathematics Content Knowledge

The pre-test of content knowledge was used as a tool by the researcher to establish a base line of the participants' content knowledge, a way to gage their basic understandings of certain mathematical concepts and the teaching of those concepts to

their students (see Appendix B). The 10-item test was constructed by the researcher and was administered as both a pre- and post-test to make determinations of participants' mathematics content knowledge as it related to multiplication and division. Only five of the questions were scored as they were directly related to the study. The remaining five "filler" items, which had no bearing on the survey results, were disregarded. Each of the five selected questions for which data were collected were correlated with three of the benchmarks related to multiplication and division in Florida's Next Generation Sunshine State Standards (NGSSS). They were correlated so that PLC activities could be directly related to the teaching of the new mathematics curriculum and standards across the state.

The following is the rubric by which the participant's responses for the pre test were scored by: 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

Benchmark MA.3.A.1.1 I (Item 3)

Table 4 presents the data related to Benchmark MA.3.A.1.1 (Model multiplication and division including problems presented in context: repeated addition, multiplication comparison, array, how many combinations, measurement, and partitioning). The table displays the pre-test scores of respondents for item 3 and provides a description of the extent of participant understanding.

Item 3 requested that participants showed understanding of varying methods of solving a multiplication problem. The problem also determined whether or not they

understood that skills in multiplication and division could be solved in many ways and were open to their students' using varied methods of problem solving. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 4
Pre-test Scores of Participants' Mathematics Content Knowledge: Item 3

Participant	Score	Demonstrated Understanding and Explanation
Annie Pre-test	1	Demonstrated no understanding--gave an explanation.
Beth Pre-test	1	Demonstrated no understanding--gave an explanation but was incorrect
Cathy Pre-test	1	Demonstrated no understanding--gave an explanation
Dena Pre-test	0	Demonstrated no understanding--simply wrote "Not sure!"
Emily Pre-test	0	Demonstrated no understanding--gave no explanations
Fran Pre-test	1	Demonstrated no understanding--gave an explanation

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In the pre-test, Annie, Beth, and Cathy wrote responses after each choice but were incorrect in their mathematical reasoning. In the pre-test, Dena chose an incorrect answer and gave no explanation. This showed that she did not understand the mathematical reasoning behind the problem. Emily chose an answer and gave no explanation. This showed that she did not understand the mathematical reasoning behind her choice. Fran

chose an answer and gave the wrong explanation. This showed that she did not understand the mathematical reasoning behind her response. In summary for item 3, four teachers gave explanations on the pre-tests for each student's responses. Two of the participants wrote "not sure," or "I don't know" for their pre-test responses and explanation.

Benchmark MA.3.A.1.1 (Item 5)

Table 5 presents the data related to Benchmark MA.3.A.1.1 (Model multiplication and division including problems presented in context: repeated addition, multiplication comparison, array, how many combinations, measurement, and partitioning). The table displays the pre-test scores of respondents for item 5 and provides a description of the extent of participant understanding.

Item 5 requested that participants determine how the student solved the multiplication problem correctly without using the "traditional" algorithm in his thought processes. This question was used to aid the researcher in understanding the participants' understanding of teaching place value and the students' understanding of place value. The student may understand place value but not in the way the teacher "taught it". The participants needed to show that they understood this concept. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 5
Pre -test Scores of Participants' Mathematics Content Knowledge: Item 5

Participant	Score	Demonstrated Understanding and Explanation
Annie Pre-test	1	Demonstrated no understanding--gave an explanation.
Beth Pre-test	1	Demonstrated no understanding--gave an explanation.
Cathy Pre-test	0	Demonstrated no understanding--stated "I don't know," but had correct answer.
Dena Pre-test	0	Demonstrated no understanding--stated, "I don't know," but had correct answer.
Emily Pre-test	0	Demonstrated no understanding--no explanation
Fran Pre-test	1	Demonstrated no understanding--gave an explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In the pre-test, Annie chose an answer and gave an explanation but was not sure why. This showed that she did not understand the mathematical reasoning behind her response. Beth, on the pre-test, chose an answer and gave an incorrect explanation. This showed that she did not understand the mathematical reasoning behind her response. Cathy simply chose an answer and stated, "I don't know." This showed that she did not understand the mathematical reasoning behind her choice. Dena chose an incorrect answer on the pre-test. This showed that she did not understand the mathematical reasoning behind the problem. Emily chose an answer and gave no explanation indicating a lack of understanding of the mathematical reasoning behind the response. Fran chose an

answer and gave an explanation that showed she was trying to figure out how the student reasoned his place value.

In summary, for item 5, three of the participants chose, answered, and explained their responses on the pre-tests. However, their pre-test explanations showed a lack of mathematical understanding.

Benchmark MA.3.A.1.2 (Item 4)

Table 6 presents the data related to Benchmark MA.3.A.1.2 (Solve multiplication and division fact problems by using strategies that result from applying number properties). The table displays the pre-test scores of respondents for item 4 and provides a description of the extent of participant understanding. Item 4 requested that participants show understanding of the rules of divisibility for solving various division problems. This showed an understanding of patterns in numbers and an ability to understand those patterns in order to teach them to students. The table is accompanied by a narrative providing further detail concerning participant responses.

Table 6
Pre-test Scores of Participants' Mathematics Content Knowledge: Item 4

Participant	Score	Demonstrated Understanding and Explanation
Annie Pre-test	0	Demonstrate no understanding--chose an answer but did not know why
Beth Pre-test	1	Demonstrated no understanding--gave an explanation
Cathy Pre-test	1	Demonstrated no understanding--gave an explanation
Dena Pre-test	0	Demonstrated no understanding--gave an explanation
Emily Pre-test	1	Demonstrated no understanding--simply chose an answer.
Fran Pre-test	1	Demonstrated no understanding--gave an explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

For item 4 of the pre-test, Annie chose an answer and stated, "I do not know why." This showed that she did not understand the mathematical reasoning behind her response. Beth chose an answer and wrote, "Because C is the most likely answer." This showed that she did not understand the mathematical reasoning behind her response. Cathy provided an incorrect explanation. This showed that she did not understand the mathematical reasoning in the problem. Dena chose an incorrect answer and gave an explanation that was incorrect for item 4, demonstrating her lack of understanding of the mathematical reasoning. Emily chose an answer and gave an explanation that was partially correct in that she stated a divisibility rule, "It only works when the sum of the last two digits is an even number." This showed that she did not fully understand the

divisibility rules and the mathematical reasoning. Fran, in responding to pre-test item 4, chose an answer and gave the wrong explanation. This showed that she did not understand the mathematical reasoning.

In summary, for item 4, four teachers gave explanations on their pre-test responses. Two of the participants simply chose an answer but did not explain.

Benchmark MA.3.A.1.2 (Item 2)

Table 7 presents the data related to Benchmark MA.3.A.1.2 (Solve multiplication and division fact problems by using strategies that result from applying number properties). The table displays the pre-test scores of respondents for item 2 and provides a description of the extent of participant understanding. Item 2 requested that participants demonstrate their understanding of patterns in numbers and their importance in students' understanding of mathematical concepts for division and multiplication processes. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 7
Pre-test Scores of Participants' Mathematics Content Knowledge: Item 2

Participant	Score	Demonstrated Understanding and Explanation
Annie Pre-test	2	Demonstrated understanding--no explanation
Beth Pre-test	1	Demonstrated understanding --answer was not correct.
Cathy Pre-test	1	Demonstrated no understanding--gave an incorrect explanation
Dena Pre-test	2	Demonstrated understanding--answered correctly, did not give explanation
Emily Pre-test	0	Demonstrated no understanding-
Fran Pre-test	1	Demonstrated no understanding--incorrect answer and explanation

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In response to item 2 on the pre-test, Annie chose an answer from the four choices and could not explain why. This showed that she did not understand the mathematical reasoning behind the question. Beth, in her pre-test response to item 2, chose an answer from the four choices and she gave an explanation that was incorrect. This showed that she did not understand the mathematical reasoning she had used. Cathy chose an answer and provided an incorrect explanation indicating that she did not have an understanding of the mathematical reasoning. Dena chose a correct answer; however, she gave no explanation indicating a lack of understanding of the mathematical reasoning. Emily chose an answer but offered no explanation. This showed that she did not understand the mathematical reasoning. Fran chose an answer in response to item 2 on the pre-test but

gave the wrong explanation indicating a lack of understanding of the mathematical reasoning.

In summary, for item 2, all six teachers selected a response from the four choices. Two of the teachers could not give an explanation for their choices, but the other four justified their selections with an explanation that made mathematical sense.

Benchmark MA.3.A.1.3 (Item 7)

Table 8 presents the data related to Benchmark MA.3.A.1.3 (Identify, describe, and apply division and multiplication as inverse operations). The table displays the pre-test scores of respondents for item 7 and provides a description of the extent of participant understanding. Item 7 sought to determine that participants further understood that their students could use varying methods to solve multiplication and division problems by demonstrating understanding of place value through invented solution of mathematical problems. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 8
Pre-test Scores of Participants' Mathematics Content Knowledge: Item 7

Participant	Score	Demonstrated Understanding and Explanation
Annie Pre-test	1	Demonstrated no understanding--gave an explanation.
Beth Pre-test	1	Demonstrated no understanding--gave an explanation.
Cathy Pre-test	0	Demonstrated no understanding--gave an explanation.
Dena Pre-test	1	Demonstrated no understanding--gave an explanation.
Emily Pre-test	0	Demonstrated no understanding--gave an explanation.
Fran Pre-test	1	Demonstrated no understanding--gave an explanation

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In response to item 7 on the pre-test, Annie chose an answer and gave an explanation indicating that she was not sure why she had selected that response. This showed that she did not understand the mathematical reasoning used in her response. Beth and Cathy, in responding to item 7, both chose an answer and gave an incorrect explanation. Dena chose an incorrect response indicating a lack of understanding of mathematical reasoning. Emily chose an appropriate answer but provided an incorrect explanation. Fran chose an answer, but her incorrect explanation indicated her lack of understanding of the mathematical reasoning behind her response. In summary, for item

7, in the pre-test, four of the participants chose an answer and explained their choices. Their explanations were, however, incorrect in analyzing the students' work.

In summary, each item on the pre-test of content knowledge was linked directly to teacher NGSSS and what each student was required to understand with respect to a particular mathematical concept. All six participants showed little or no mathematical understanding of the five questions assessed as related to multiplication and division content knowledge. All teachers provided only minimal or no explanation for their answers on the pre-test of content knowledge, but all six participants stated in their pre-study interviews that they felt adequately prepared to teach mathematics in their classrooms. Thus, there was identified a definite gap between the pre-test of content knowledge and the perceptions of the teacher participants regarding their knowledge as determined in the pre-study interviews. Participants showed that they were, at the very least, not comfortable with their own ideas for strategies to teach these concepts. At the other end of the spectrum, participants' responses on the pre-test of content knowledge indicated they had little or no idea of how to demonstrate effective problem solving or to use mathematical strategies to solve mathematics problems as outlined in the NGSSS and required daily in their teaching.

Pre-Study Interviews with Participants

Pre-study interviews were conducted with each of the six teacher participants in the study. A researcher-developed instrument, comprised of three sections, was used to guide the interviews (see Appendix A). The following reports of the interviews have been

organized to develop a profile of each of the six participants using the following three categories corresponding to the interview guide: (a) the participant as a learner of mathematics, (b) the participant as a teacher of mathematics, and (c) the participant's perceptions of mathematics learning and teaching. Using these data, a profile was created for each of the participants.

Initially, the teacher participants in the study were somewhat nervous about participating in this study and were concerned that their anonymity be preserved. Thus, the researcher took steps to ensure their comfort as the study began. Prior to the interviews, teachers had an opportunity to review questions and provide some initial written responses which were returned to the researcher. Interviews were conducted (a) to further clarify the written responses, (b) to permit the researcher to seek further information if needed or (c) to provide an opportunity for participants to elaborate on their prior responses.

The researcher met individually with the six participating teachers between August 23 and September 3, 2010 in a typical third-grade classroom. She recorded additional observations representing expanded participant responses for use in developing the following profiles of the teachers participating in the study.

Annie

Annie as a Learner of Mathematics

Annie was a Caucasian female with five years of teaching experience and had always taught third-grade students. She held a bachelor's degree in elementary education. She had taken Algebra II and Pre-calculus in high school. The highest level of math she had taken in college was Statistics.

In looking at her own experiences in mathematics, she recalled difficulty in making sense of why she had to perform certain operations. She said she felt that she always performed the operations because she was taught to do so using certain parameters but never understood the “why” of the mathematics behind it (TR 1, p. 1). She stated that she had to learn, but not until later, that she needed to ask many questions. She also stated that most of her mathematics teachers were energetic and helpful. She did recall one geometry teacher who recommended she give up on mathematics because “she would most likely become a sign turner for a construction company, the guy that holds the sign that says ‘slow’ or ‘stop’” (TR 1, p. 2). Though she knew he was joking, the comment was remembered because, “I knew I wasn't the best math student, but realizing my teacher knew that too made me start second guessing in class” (TR 1, p. 1).

Annie stated that she liked mathematics classes the least and she felt that was because that was her weakest subject. She said that her Dad or a girlfriend helped her the most. When she looked back at her college math experiences, she recalled a College Algebra teacher that had over 300 hundred students in his class. She said she had a great

deal of difficulty paying attention. She also recalled that the professor of another college class was fired half way through the semester because most students received a D or and F at midterms. For the rest of the year, her class had a substitute. She indicated that all of her teachers taught mathematics from the front of the room, and everyone was expected to take “notes” (TR 1, p. 2). She elaborated and said that it was not until she taught elementary methods classes that she developed a better grasp on even basic concepts such as regrouping. She believed that her lack of hands-on approach to math all the way through school encouraged her to realize that students all learn differently and that she needed to accommodate every learning style so that students are given the chance to understand the mathematics concepts she is teaching.

Annie as a Teacher of Mathematics

Annie realized she wanted to become a teacher during her high school years. She realized at that time that she liked to teach others how to do things. When asked what subjects she needed in order to teach mathematics in elementary school, she responded with Algebra, Geometry, and Statistics. She indicated that she enjoyed and got the most out of her geometry class, because it involved hands-on experiences, and it was a tangible subject compared to Statistics or Algebra. Her greatest struggle in mathematics has been fractions, especially equivalent fractions.

In regard to her understanding the content she taught to her students, she responded affirmatively. She added that she preferred to teach multiplication and division but only when there were hands-on activities to engage children in the lessons. She

expressed the belief that many of her students were successful in mathematics, and that she liked to think it was because she gave them the right tools to understand the content. She, however, expressed some doubt indicating that she was “not 100% sure” that this occurred (TR 1 p. 2).

In discussing failures, Annie recalled one specific instance in which a female student had a difficult time with place value from the beginning of the year and never really did understand. She thought that she had failed the student because she did not find a way to correct the student’s mistakes and teach her the concept.

Annie’s Perceptions of Mathematics Learning and Teaching

Annie expressed clear viewpoints when asked to identify someone who she considered a “great” mathematics student and someone who was not particularly great. She referenced an engineer friend as being an excellent mathematics student and explained that he had to be a great mathematics student because he was an engineer. When citing someone who did not excel in mathematics, she chose her mother and shared her reasoning, “Because my mom is an assistant in an elementary school and she doesn’t need to know mathematics” (TR 1 p. 3).

When asked how she could better improve her mathematics instruction, Annie stated that she would like to be able to explain mathematics to her students in more than one way. She said that she was not comfortable seeking help from others because she needed “to be an expert on the things I teach” (TR 1 p. 3). When asked if others sought

assistance from her, she replied that a few times a year someone might ask her how she taught something in mathematics.

In discussing specific professional development in mathematics, Annie stated that she would “love” to have more professional development in mathematics (TR 1 p. 3). She also stated, however, that she felt the professional development that she did attend focused on the materials being used for the mathematics rather than the concepts; and her needs were in the area of better understanding concepts. She did not think there was sufficient support in the area of mathematics in her school system and that many times she thought that she was “left out on a limb” in teaching mathematics (TR 1 p. 3).

Beth

Beth as a Learner of Mathematics

Beth was a Caucasian female with six years of teaching experience, all with third-grade students. She held a bachelor’s and master’s degree in elementary education. Her highest levels of mathematics courses were Algebra II in high school and Statistics in college.

In reporting her experiences in mathematics, she recalled learning “good problem solving skills” (TR 2, p. 1). She believed her mathematics teachers were “pretty good,” at teaching mathematics and indicated that she enjoyed mathematics because she was always “good at it” (TR 2, p. 1). Beth did not recall any specific experiences in mathematics as a learner and could not really recall any specifics about any of the

mathematics classes she took in high school. She said that sometimes her older sister had helped with mathematics, but mostly she worked independently. She recalled that she took several college level mathematics classes including her elementary education methods classes. She particularly recalled a class she took in problem solving with a specific professor who required students to solve problems and actually explain their answers. This, at the time, was unusual for her. In contrasting her college experiences to her high school mathematics experiences, she believed that she became a better problem solver in college. When asked if she thought that high school and college mathematics helped her with the teaching of mathematics, she replied affirmatively, indicating that because she had been a successful math student, she felt confident in teaching mathematics to her students.

Beth as a Teacher of Mathematics

Beth realized early in her life that she loved children, and her decision to teach was made during her second year of college. When asked what subjects she needed in order to teach mathematics in elementary school, she cited Algebra II and indicated it was important because it “forces you to problem solve” (TR 2, p. 2).

In regard to her specific teaching preferences in mathematics, she responded that she preferred to teach data analysis and graphing to her students because they seemed to enjoy it more than other areas. When recalling a mathematics area she did not particularly like to teach, she indicated that she did not like any mathematics above the third grade level. She expressed the belief that her students were successful in mathematics, in part,

because she presented them with strategies and manipulatives to use. In discussing failures, Beth recalled that she had not been able to understand how students arrived at the correct answer, and this was frustrating to her. She did not recall any particular students' lack of understanding in her class in mathematics.

Beth's Perceptions of Mathematics Learning and Teaching

Beth expressed a clear viewpoint when asked to identify someone she considered to be a good mathematician and someone who was not particularly great. She referred to colleagues at a tutoring facility where she worked in addition to her regular teaching position as being "great" at mathematics (TR 2, p. 3). She explained that it was because they found mathematics "interesting" (TR 2, p. 3). She stated that she did not particularly know anyone who was not good at mathematics.

When asked how she could better improve her mathematics instruction, Beth indicated that she did not believe that she did a great job in the teaching of fractions and mixed numbers, but she said that she was comfortable seeking help from others because she felt comfortable with her "team mates" (TR 2, p. 3). She also stated that she would most likely seek advice on teaching mathematics, if needed, from her co-workers at the tutoring facility. She shared that other teachers did seek assistance from her and that she could and did explain concepts to them so that they understood.

In discussing specific professional development in mathematics, Beth stated that she would "love" to have professional development in mathematics (TR 2, p. 3) She stated that she had not had the opportunity to attend many professional development

sessions specifically devoted to mathematics because “there was not much available to her” but that any professional development she had attended had been helpful (TR 2, p. 3)

Cathy

Cathy as a Learner of Mathematics

Cathy was an African American female with six years of teaching experience and had taught kindergarten, second, third, and fourth grades. Her current teaching assignment was with third grade students. She held a bachelor’s degree in elementary education. Her highest level of mathematics in high school was Trigonometry and in college was College Algebra.

In looking at her personal learning experiences in mathematics, she recalled that her teachers in both college and high school were good teachers and that they were knowledgeable and helpful. She stated she learned in her mathematics classes that “If you want to be good at something, you have to practice” (TR 3, p. 1). She also stated that she enjoyed mathematics because her teachers knew the subject well. They knew how to teach mathematics, and made it more enjoyable for her as a student. She recalled that her mathematics teachers typically showed the class the “long way” first and then the “short way” so that students were able to fully understand the mathematics concepts (TR 3, p. 1). She said that she received the most help, as a student, from her teachers at school.

Cathy recalled that in a College Algebra class she had to solve and balance equations, use a scientific calculator for graphing, and complete proofs in geometry. She also stated that her college professors were helpful and knowledgeable. In general, they had made her college mathematics experience a positive one. She also reflected that her college and high school mathematics classes were similar and that because she had them, she was better able to understand the mathematics she teaches to her students.

Cathy as a Teacher of Mathematics

Cathy realized that she wanted to become a teacher when she was a junior in high school and recognized that she liked to help people. When asked what subjects she needed as preparation for teaching mathematics in elementary school, she responded with Algebra I, II, and Geometry. She indicated that she did not really have a favorite area of mathematics, because she believed that her “knowledge of most math concepts is equal” (TR 3, p. 2). Likewise, she stated that there was not a particular area of mathematics that she disliked. She explained that this, in her opinion, was because, “A lot of people that hate a particular area in math usually didn’t get enough practice in that area” (TR 3, p. 2).

In regard to her understanding of the content she taught her students, she believed that she had the most trouble with the way some word problems were phrased, and this made it difficult to explain appropriate methods of problem solving to her students. She added that she preferred to teach place value and geometry because there were many manipulative and hands-on activities that could be used. She expressed the belief that all of her students have had some success in mathematics. She liked to think it was because

“they wanted to understand the material” (TR 3, p. 2). She added that she tells her students that their success “comes from themselves” and that she is just their guide” (TR 3, p. 2)

In discussing failures, Cathy stated, that if her students failed it was because of a lack of effort. “They did not do their homework, did not pay attention in class, or they missed too much school” (TR 3, p. 2).

Cathy’s Perceptions of Mathematics Learning and Teaching

Cathy cited her fiancé as a person she believed was excellent in mathematics. She attributed his excellence to his work in “route sales” and to his knowledge of basic mathematics which she described as “quick and precise” (TR 3, p. 3). When citing someone who did not excel in mathematics, she chose her mother and shared her reasoning, “Because she is old school, and due to the time period and the place that she grew up in, it was a rural area, she could never achieve success in mathematics” (TR 3, p. 3).

When asked how she could improve her mathematics instruction, Cathy voiced her wish to be able to better explain percentages and decimals. She said she was comfortable seeking help from her co-workers and that they usually did not judge when she did not understand something. When asked if others sought her out for assistance, she replied “yes,” indicated that she was comfortable assisting when asked, and that co-workers had been very appreciative of her help (TR 3, p. 3).

In discussing specific professional development in mathematics, Cathy stated that she would be willing to attend professional development in mathematics. She also reported that she had not attended much professional development in mathematics because of several factors: (a) cost, (b) timing, and (c) the inappropriate level of the staff development being offered for the grade she taught.

Dena

Dena as a Learner of Mathematics

Dena was a Caucasian female with six years of teaching experience who had taught third grade exclusively. She held a bachelor's degree in elementary education, had taken Pre-calculus and the prerequisites in high school and Statistics in college.

In reporting her learning experiences in mathematics, she recalled having difficulty in making sense of long division. She said that as she got older, she learned many rules and formulas that helped her in mastering mathematics concepts. She stated that her mathematics teachers throughout school were, in her opinion, average and that she had one good teacher in middle school and another in high school. She remarked that she liked her mathematics classes because they challenged her. When she thought about her high school mathematics classes, she recalled, "We learned a LOT of rules in geometry" (TR 4, p. 1). She also remembered having to "memorize formulas for Algebra and Calculus." She said that both her parents, but primarily her father, assisted when she needed help in mathematics. When looking back at her college experiences with

mathematics she remembered taking College Algebra and Statistics but could not remember exactly what she studied. She did state that she recalled that she had to take long quizzes online and complete weekly homework assignments. She also stated that her classes in college were large and held in auditoriums, so it was “pretty much sink or swim,” and there was little opportunity to get individual attention if one did not understand something (TR 4, p. 1). When asked whether or not her mathematics classes in high school or college helped her with the teaching of mathematics, she stated “In some ways, “yes,” but in a lot of ways no” (TR 4, p. 1). She reported that, “A lot of my mathematics skills are rote, and I never truly learned the reasons behind the things I was taught” (TR 4, p. 1).

Dena as the Teacher of Mathematics

Dena realized that she wanted to become a teacher during her freshman and sophomore years of college. When asked what subjects she needed in order to be prepared to teach elementary mathematics she responded, “You do not really need a high level of mathematics, but you need a deep understanding of mathematics” (TR 4, p. 2). She stated that she responded this way because “I do not understand the reasons behind a lot of my mathematics knowledge. I just do what I was taught.” (TR 4, p. 2). She indicated that she most enjoyed Algebra, because it was all formulas. She described herself as being fairly “black and white” when it came to learning and that Algebra was similar in that there were not too many gray areas. (TR 4, p. 2). Her greatest struggle in mathematics was in Geometry, yet she enjoyed teaching it.

In regard to her understanding of the content she taught to her students, she responded that she enjoyed teaching multiplication, “because it makes sense to the children. I also like it because manipulatives are used, and it makes it easier to learn.” (TR 4, p. 2). She added that she did not like teaching estimation strategies for addition and subtraction because they needed to be taught using a method different from the one she had used in learning. When examining her successes in mathematics, she recalled a third-grade girl who came to her class with very few mathematics skills. The student made substantial progress due to her extra support and tutoring during the year.

In discussing failures, Dena recalled one specific instance of a female child who came to her class with very poor skills in all areas of mathematics, particularly money. She improved during the year, but was still not at grade level. She commented, “I don’t necessarily feel responsible. I guess it’s all of her teachers’ responsibility” (TR 4, p. 2).

Dena’s Perceptions of Mathematics Learning and Teaching

Dena expressed a clear viewpoint when asked to identify someone who she considered to be a “great” mathematics student and someone who was not particularly great (TR 4, p. 3). She referred to a mathematics coach who was assigned to her school as being an excellent mathematics. She explained that she was “great” at explaining things in different ways (TR 4, p. 3). When citing someone who did not excel in mathematics, she chose a close friend and shared her reasoning, “She is an office manager in a medical office. I’m not really sure why she has trouble with it, but I know she has a learning disability” (TR 4, p. 3).

When asked how she could better improve her mathematics instruction, Dena indicated that she would like to be able to better differentiate her instruction. She stated, “I do not know alternate ways of presenting ideas” (TR 4, p. 3). She said she was comfortable seeking help from others and when asked if others sought her out for help with mathematics she could not recall anyone asking her for assistance. She stated that she would rather ask a person who was not a co-worker for help as they “would not be as judgmental” (TR 4, p. 3).

In discussing specific professional development in mathematics, Dena stated that she would like more professional development in mathematics. She also stated that she had never attended professional development in mathematics as there was more focus on reading and writing; and there were few staff development offerings devoted to mathematics.

Emily

Emily as a Learner of Mathematics

Emily was a Caucasian female with four years of third-grade teaching experience. She held a bachelor’s degree in communication and elementary education. The highest levels of mathematics she had taken in high school and college were Algebra II and Statistics respectively.

In examining her personal experiences as a mathematics learner, she recalled a sense of frustration because she could not connect to real world applications. She said she

believed she completed procedures because she was taught the procedure and not the concept. She stated that her elementary teachers were “blackboard” teachers, and “We wrote what they wrote” (TR 5, p. 1). She also reported that she had a great experience in her eighth grade class with a teacher who “helped her understand the world of numbers and how to look at them differently” (TR 5, p. 1).

Emily stated that because of her insecurity with the subject, she disliked a majority of the mathematics classes she took. An experience that Emily recalled from college mathematics was that she had a professor who taught mathematics differently than she had seen it taught previously. She stated that he was “energized and did not move on from [one] skill until everyone got it. He helped me understand how it related to my work, and that wasn’t until I was a college student” (TR 5, p. 1).

She also indicated that for most of middle school she was tutored and that her tutor was actually better than most of her teachers. In college, she recalled that she took College Algebra and Statistics. She stated that she enjoyed Statistics and “hated geometry as I was horrible at it” (TR 5, p. 1). Emily described her transition from high school to college mathematics as a positive one because the teachers were better. When asked if her experiences in high school and college mathematics prepared her to teach mathematics in elementary school, she stated that the answer had to be “no” (TR 5, p. 1). She shared that, because of her history as a student, she was afraid to teach mathematics when she began her teaching career. This changed when a co-worker asked her to lead a mathematics lesson. She believed that because of this co-worker she grew more confident

and had learned to love teaching mathematics. She expressed the desire to give children an experience completely different from her own.

Emily as a Teacher of Mathematics

Emily realized she wanted to become a teacher when she helped her daughter learn to read just seven years ago. She stated that she became fascinated with the learning process and how amazing it was to see someone actually learn. “I knew then, I wanted to do that daily” (TR 5, p. 2). When asked what subjects she had needed in order to be prepared to teach mathematics in elementary school, she responded “I don’t think I had the best experiences in mathematics” (TR 5, p. 2). She expressed her belief in the importance of individual teachers and what they are willing to “put into their students” (TR 5, p. 2). She indicated that she enjoyed teaching geometry and attributed this to students’ starting with concrete understanding of blocks and moving to abstract understandings. She also added that she believed special learning was the most difficult for students. She also commented that, when teaching geometry, the teaching of angles was not her “strong suit” (TR 5, p. 2).

Emily reported that her greatest struggle in mathematics has been higher order thinking questions as she felt she was a “surface” thinker (TR 5, p. 2). She stated that she did enjoy teaching number sense to her students as students learn to see numbers in different ways. In describing a student’s success, she recalled a student who grew to know and understand multiplication. She described students’ success as being related to their being given the time and opportunity to understand concepts; that the learning was

not just a memorization procedure but also a process of understanding why. She, however, gave herself little credit for students' success, explaining that "I just gave them an opportunity to learn the concept in different ways" (TR 5, p. 2).

In discussing failures, Emily recalled that many of her students have not understood the concept of money. She stated that "It is a developmentally difficult skill, and students in third grade are not necessarily exposed to the concept enough to solidify the skill" (TR 5, p. 2).

Emily's Perceptions of Mathematics Learning and Teaching

Emily expressed her views clearly when asked to identify someone who she considered to be an excellent mathematics student and someone who was not particularly in that category. She referred to her father as being an excellent student of mathematics, explaining that he had an engineering degree, and often tutored her throughout her school life. When citing someone who did not excel in mathematics, she chose her mother. Her reasoning for this choice was that her mother worked in a county office for 25 years, and her job did not require higher level mathematics skills. She also stated, "Mom only finished junior college. She is the more creative type versus the analytical mathematical type. She has strong written language skills, great reading ability, and is very artistic. However, at the moment she is helping me tutor my daughter in middle school advanced mathematics" (TR 5, p. 3).

When asked how she could better improve her mathematics instruction, Emily indicated that she would like to be able to teach counting back money because "It's a

nightmare! I have the store, the money, the cashier, and it is still difficult” (TR 5, p. 3).

She said she was comfortable asking a co-worker for help and that she would much rather understand what she was doing than to “let her pride get in the way” (TR 5, p. 3). When asked if a co-worker ever sought her assistance, she simply stated that she had not been approached.

In discussing professional development in mathematics, Emily stated that she would “love” to have more professional development in mathematics. (TR 5, p. 3). She also said that she had not attended any professional development in mathematics because she felt that what was offered was not particularly applicable to her. She did not think there was sufficient support in the area of mathematics in her school system and often believed that there was no help at all.

Fran

Fran as a Learner of Mathematics

Fran was a Caucasian female with 17 years of teaching experience and had teaching experience in grades 1-5. Her current teaching assignment was with third-grade students. She held a bachelor’s degree in biology and a master’s degree in exceptional education and elementary education. She had completed Algebra I, II, and Geometry in high school and Pre-calculus and Statistics in college.

In describing her personal experiences in learning mathematics, she recalled that she loved to solve hard problems and that there were always ways to solve a problem.

She stated that she liked her mathematics classes because she believed that, “one part of my brain could relax while the other parts worked. I did not have to figure out mysterious people and their motives” (TR 6, p. 1). She believed that numbers “behaved” themselves and were more predictable (TR 6, p. 1). She also stated that most of her teachers were nuns with a “bad” attitude, but she did not let that bother her (TR 6, p. 1). She described numbers as feeling like “music in my head” (TR 6, p. 1).

Fran stated that in high school she took typical mathematics classes such as Algebra II, Trigonometry, and Pre-calculus. She recalled that these classes dealt with functions, graphs, and calculations of curvy areas. She said that no one in her home really helped her with mathematics, as neither of her parents were very good at mathematics or they did not care. When she looked back at her college experiences in mathematics, she recalled that she took Calculus and Statistics. She said she loved Calculus and hated Statistics. She also remembered some of her professors in mathematics as being more “down to earth” than others (TR 6, p. 1). She indicated that college was the first place she did not like mathematics. When asked if her background in mathematics had helped her with the teaching of mathematics she expressed uncertainty. She stated that she still loved mathematics despite a few college professors that had terrible attitudes. She even recalled one particular professor who advised the class that “Those of you with the least mathematics experience will be the best educators” (TR 6, p. 1). She stated that he was not a great mentor and was never sure what he meant by that.

Fran as a Teacher of Mathematics

Fran realized she wanted to be a teacher at age 29. She stated that she always ended up teaching someone and was told by many, “you should become a teacher” and that “After years of fighting it, I decided I might as well; and I’ve never been happier” (TR 6, p. 2). When asked what subjects she believed were needed to be prepared to teach elementary mathematics, she responded with, “Not sure because I use stuff I learned in advanced classes” (TR 6, p. 2). She indicated that she most benefited from Geometry because it “reminded her of things in nature, culture, and art” (TR 6, p. 2). Her greatest struggle in mathematics was Statistics. She expressed the belief that statistics “can be prostituted” (TR 6, p. 2). She elaborated on that comment, saying, “Career politicians use statistics to make things appear to be one way and try to trick ignorant people” (TR 6, p. 2). She stated that she would like to learn more about a condition called “dyscalculia” so that she could help students who suffer from it (TR 6, p. 2).

Concerning her understanding of the content she taught to her students, she responded affirmatively. She added that she liked to teach graphing, geometry, number patterns, fact families, and multiples because she could use art projects to reinforce them. She expressed the belief that many of her students were successful in mathematics and that she liked to think it was because she teaches them to enjoy the subject. She discussed students’ experiencing mathematics by doing it, talking about it, drawing, painting, and manipulating mathematics. She also shared her belief that not all of this can be measured on the state mandated test.

In discussing failures, Fran recalled one specific student who failed the state mandated test, had multiple disabilities, and came from a non-English speaking household. She said, “That really bugged me--don’t know what else I could have done... adopted her maybe. . .” (TR 6, p. 2).

Fran’s Perceptions of Mathematics Learning and Teaching

Fran provided specific examples when asked to identify someone who she considered good at mathematics and someone who was not particularly great at it. She referred to an engineer friend who she stated, “is fascinating” (TR 6, p. 3). She indicated that he actually knows about mathematics applications in everyday problems, “Like he had to move his shed, and he was figuring out angles, weight distribution, and pulleys” (TR 6, p. 3). We all laughed at him, but he got the job done with “minimal exertion” (TR 6, p. 3). When citing someone who did not excel in mathematics, she cited her daughter and shared the following reasons, “Because she is very artistic, loves literature. I keep trying to help her, but when she starts whining, it gets me mad so I back off” (TR 6, p. 3).

When asked how she could better improve her mathematics instruction, Fran indicated that she would do more hands-on projects, building things, art, gardening, and small business. She replied that she was comfortable asking for help, and that “If you are in earshot, you’re fair game” (TR 6, p. 3). When asked if others sought assistance from her, she replied that several people had, and that she especially liked discussing mathematics with adults in front of her class as, “It is really neat for kids to see adults think out loud” (TR 6, p. 3).

In discussing specific professional development in mathematics, Fran stated that she was always open to new ideas and that she would welcome professional development in mathematics. She also stated that she has not attended much, if any, mathematics professional development in the past “probably because I have been busy with reading and writing, testing pressure” (TR 6, p. 3). She also commented that if she did take any professional development, it could not have been that remarkable or she would have remembered it. She did not think there was sufficient support in the area of mathematics in her school system and that there seemed to be more pressure to “fix reading and writing” (TR 6, p. 3).

Professional Learning Community (PLC) Meetings

The six teachers comprising the professional learning community, the researcher and the outside observer met weekly between September 7 and November 9, 2010 in meetings of approximately one hour in duration. The meetings were tape recorded so that the researcher could reflect on the events and activities occurring at each of the meetings and learn of (a) changes in teachers’ mathematical content knowledge as a result of the weekly PLC activities, i.e., research-based practices and (b) their perceptions regarding participation in the PLC. The overall objective for the professional learning community was to use the weekly meetings as a vehicle with which to guide participants using various strategies, resources, and mathematical discussions. The sharing of instructional methods by participants, to develop additional competency in mathematical knowledge and to benefit from the structure of a professional learning community, were desired

outcomes. The PLC Meetings took place on the following dates: September 7, 14, 21, 28; October 5, 12, 19, 26; and November 2, 9

PLC Meeting 1 (September 7, 2010)

This meeting took place in Room 214 at the participants' school site from 10:20 am to 11 am. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, researcher, and the outside observer (for the purpose of this study, she will be referred to as Mary). Mathematical concepts discussed at this meeting related to the adoption of a new mathematics series, *Go Math*, within the participant's school district. The main topic of discussion for this meeting, beyond the new mathematics adoption was the ability level that each participant felt when it came to the teaching and understanding mathematical concepts. As a group, the prior preparation for teaching mathematics was fairly typical of mathematics teachers throughout the nation (Ball, 1996, 2005, 2008) with their highest level of college mathematics being courses such as trigonometry, Algebra II or Pre-calculus.

The group chose to focus on multiplication and division concepts and lessons for the duration of the PLC as that was the focus of the new mathematics series for the first two months of the school year. The discussion centered upon the fact that new adoption in mathematics called for teacher's assuming students' perspectives in teaching using a problem solving approach to mathematics. All members indicated this was a completely different method for both them and their students. In this first session, the group agreed that the goal of this professional learning community (PLC) would be focused on

mathematics. As a group, they stated that they understood that division and multiplication would be taught in unison in the new series, which apparently was something none of them had ever seen before.

Since the teachers were currently using the newly adopted *Go Math!* series in their county, they believed that they needed some assistance in teaching the new content more effectively. The new curriculum called for a more in-depth approach to learning mathematics and required students to think differently about the content being presented than they had previously. In turn, teachers were also required to teach differently. The group saw the PLC as providing an opportunity for them to improve both their students' learning and the quality of their teaching. The teachers decided that as a group they would like to improve their overall teaching of multiplication and division for their third grade students. It was their hope that if they developed a better understanding of the new mathematics content related to multiplication and division, their students would benefit and better understand the concepts being taught. All participants agreed that the focus of the district, when it came to professional development, had been on literacy for quite some time, leaving little time or money for mathematics training. This first meeting afforded the teachers opportunities to share their beliefs and values about mathematics. They discussed what was important to them in the teaching of mathematics and how they could best help their students. Annie, Dena, and Emily were outspoken at this meeting. Though they did not dominate the conversation, they contributed more than the rest of the group. Cathy was the quietest member of this group. She spent her time actively listening.

Only after this new math series was introduced to their students and difficulties with basic competencies arose did they realize that they lacked understanding. Now, each member was struggling with the fact that their students could not problem solve to the depth that the mathematics series required and they knew very little about how to help them. They all agreed that the primary purpose and focus of the PLC for them needed to be on helping students make gains and develop increased capacity to learn mathematics. Several of the group also expressed concerns about the new series as it pertained to exceptional education students and those generally weak mathematics students in their classes.

PLC Meeting 2 (September 14, 2010)

This meeting took place in Room 214 at the participants' school site from 3:30 pm to 4:30 pm. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and the researcher. The first item on the agenda was a short podcast talking about the number line, multiplication and division and their relationship. Participants briefly discussed what they learned from the podcast, what they thought was valid, and what they thought was not realistic for them or did not apply to their situation.

The focus of the podcast was using a number line, ten frames, and hundred charts. A majority of the group had not previously used these tools as the basis of their teaching, and they were particularly intrigued by the use of thinking strategies that were emphasized in the podcast. These strategies were used within the constructs of the *Go Math!* series as well as topics discussed in the research-based math resources literature

that they had shared since the prior meeting. During this meeting, a conversation also ensued about the correct use of mathematics vocabulary and the fact that words that had been considered as the norm for elementary school, e.g., minus versus take-away, integer versus number, were now passé.

PLC Meeting 3 (September 21, 2010)

This meeting took place in Room 214 at the participants' school site from 10:20 am to 11 am. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and the researcher. This school was fortunate in having one of the authors of the newly adopted mathematics series, *Go Math!*, 2010, as a parent of children attending the school. She had volunteered to share her expertise and assist with the implementation of the mathematics series. She had been on campus several times and held curriculum and informational meetings for individual grade levels, teams, intermediate grades 3-5, primary (k-2) teachers, and the entire staff. She was very comfortable with mathematics and was eager for the school to embrace the "new" strategies presented in *Go Math!*

The PLC's third meeting occurred soon after the author had presented a staff development for the entire faculty. The group, therefore, began its meeting with a discussion of her visit and the information she had shared with the faculty. One thing that seemed to be of concern to all the participants was their ability to manage their time: "How can I fit all this into one day?" (TR 15, p. 1) In dealing with the whole faculty, the author had responded, "You cannot. You have to look at what the objective for the lesson is and teach to that objective." (TR 15, p.1) Thus, she was encouraging teachers to use

their judgment in determining how many, and which, practice and homework problems were required to master the concepts. She did, however, stress that a large amount of problem solving practice was crucial; that in order to master the NGSSS, the students had to be able to understand and work through these problems.

Annie, Beth, and Cathy commented that the researcher had also made this point in the last meeting. Participants also shared their concerns that not doing “everything” would result in administrator criticism. (TR 15, p. 1) The researcher reminded them that at the meeting of the entire faculty their administrator had concurred with the author’s recommendation to be selective. Another opinion expressed on this topic was that some teachers believed that their students should complete all of the problems, that students needed additional practice, and that the publishers would not have included problems in texts if they had not intended for students to solve them.

It was surprising to the researcher that even after being encouraged to be selective in regard to problem selection by stating the benchmark and then choosing problems for practice that best fit the learning of that benchmark, participants were reluctant to do so. When queried about this, there was no real answer offered. It appeared, to the researcher, that teachers were uncomfortable sharing their reasons either with the group or with the researcher.

PLC Meeting 4 (September 28, 2010)

This meeting took place in Room 214 at the participants’ school site from 3:30 pm to 4:30 pm. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and

the researcher. The fourth meeting of the PLC seemed to provide a defining moment for the group. All of the teachers came to this meeting with an elevated sense of frustration with the new curriculum and wanted to discuss their feelings with the group. All members of the group felt that they were not being effective when it came to teaching the new series and wanted to know if other group members felt the same way..

As facilitator for the group, the researcher felt that even though she had certain goals in mind for the group, she wanted them to leave the PLC with positive experiences. She also wanted participants to have a valuable learning experience in which they gained knowledge that was useful to them in the teaching of mathematics. Therefore, at this meeting the group discussed their problems with the series and used the time available to them to arrive at some strategies that might assist them. Some suggested strategies that were discussed were counting on, making ten, and using a number line. Annie, Emily, and Fran were especially outspoken at this meeting and offered words of advice for the group through their own experiences. The researcher offered advice and comments when asked but largely let the participants take the lead in the discussion.

PLC Meeting 5 (October 5, 2010)

This meeting took place in Room 214 at the participants' school site from 3:30 pm to 4:30 pm. Present at this meeting were Annie, Beth, Emily, Fran, and the researcher. Cathy and Dena missed this meeting due to a conflict in their schedules. It was apparent, during this fifth meeting, that the participants' understanding of mathematics was expanding along with their understanding of each other and their

students. Members of the group shared that they were seeing success in their students, and they attributed this to the PLC activities and discussions. Annie and Beth shared at this meeting that their students were “talking mathematics” with more frequency, participating, and using problem solving strategies with more ease as well. (TR 17, p. 1)

The researcher introduced *Student Centered Mathematics* (Van de Walle, 2006), to the group and used it as a source of information about manipulatives and their potential use in participants’ classrooms. This book proved to be an invaluable resource for both the participants and the researcher, and discussion during much of this meeting centered on the use of manipulatives. The group also initiated discussion about their own learning experiences as mathematics students and the types of “tools” that had been made available to them in their schooling. Fran and Annie seemed especially interested in the conversation and had the most to say. Fran seemed to visibly gain confidence at this meeting and was emerging as a leader.

PLC Meeting 6 (October 12, 2010)

This meeting took place in Room 214 at the participants’ school site from 10:20 am to 11:00 am. Present at this meeting were Annie, Beth, Emily, Fran, and the researcher. Cathy and Dena were not in attendance due to a conflict in their schedules. Because of the success at the last meeting with the use of the Van de Walle (2006) resource, the researcher brought several copies of Ma’s (1999) *Knowing and Teaching Mathematics*. This book had initially been made available to faculty by a previous math coach at this school site. All faculty had been encouraged to read the book, but the text’s

language was a little more difficult, and the book had languished on a shelf since the coach had left the year before. The researcher presented the book to the group with a plan to have teachers read excerpts from the book over the course of the next week and share their thoughts with their colleagues at Meeting 7.

A majority of this meeting was devoted to sharing successes/problems associated with new strategies, mainly manipulatives. All members expressed frustration at trying to change the way that they used manipulatives with their students. Members of the group offered more examples of both successes and failures as well as suggestions for each other when it came to the teaching of mathematics. It was also noted by the researcher that group members' were more open in sharing comments with her.

PLC Meeting 7 (October 19, 2010)

This meeting took place in Room 214 at the participants' school site from 10:20 am to 11 am. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and the researcher. This meeting began with a group discussion about students and the fact that the new math series' approach to teaching mathematics, with an emphasis on teaching students to problem solve, was completely different from the previous trend which had been to teach students to pass tests. The group discussed at length their frustration with the state of Florida, and Fran was especially vocal on this matter. Beth also expressed frustration at state testing and mandates that were put into place by the state that were not necessarily in the best interests of their students.

After the initial discussion this meeting was largely devoted to discussing Ma's (1999) work and sharing perceptions regarding the various strategies that were presented in his text. Teachers, in their discussion, focused on Ma's emphasis on the use of various strategies to learn mathematics and the multiple approaches that can be used to solve mathematics problems. Emily and Fran seemed especially interested in Ma's work and expressed some definite thoughts to the group about her work, which sparked conversations about American students and their abilities in mathematics. Annie, Beth, and Fran also discussed with the group that they were noticing their students were more engaged and using more "math talk" in class. This sparked more conversation about the use of different approaches to teaching mathematics. Teachers indicated that by allowing students to work together and talk about mathematics they were seeing differences in their classrooms. Dena and Cathy did not participate in the discussions as much as did their peers.

PLC Meeting 8 (October 26, 2010)

This meeting took place in Room 214 at the participants' school site from 3:30 pm to 4:30 pm. Present at this meeting were Annie, Beth, , Emily, Fran, and the researcher. The focus of this meeting shifted back to the original objective of the PLC. The new *Go Math!* series called for teaching multiplication and division. The concerns of the participants emerged during this meeting, as division had not been taught in the third grade prior to this time. This week's PLC was a teaching meeting. The researcher shared some basic information about division such as divisibility rules and their function in

mathematics. Fran was also vocal at this meeting in that she talked at length about her own misconceptions in mathematics. This led the rest of the group to think about their ideas in mathematics. Curriculum choices and professional judgment were also issues that Fran brought to the group as valid concerns for her in regard to her teaching.

PLC Meeting 9 (November 2, 2010)

This meeting took place in Room 214 at the participants' school site from 10:20 am to 11:00 am. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and the researcher. Teachers continued to share some of their experiences they were having with new strategies in their classrooms and were somewhat reflective in describing their own growth in comfort level. The researcher also shared examples of various fraction activities that could be used in the future by teachers in introducing fractions to third-grade students.

Annie was especially vocal at this meeting and she was anxious to share her experiences with colleagues around her school. She also discussed the dynamics that were occurring in her classroom. This sparked further discussion within the group. The researcher also brought a fraction activity to the group. It involved equivalent fractions and students' making manipulatives to show equivalency. Approximately one-third of the meeting was spent working on this manipulative activity.

PLC Meeting 10 (November 9, 2010)

This meeting took place in Room 214 at the participants' school site from 3:30 pm to 4:30 pm. Present at this meeting were Annie, Beth, Cathy, Dena, Emily, Fran, and the researcher. Meeting 10 was the last scheduled meeting of the PLC. Participants completed the post-test of mathematics content knowledge and had a discussion regarding the value of the PLC to them as individuals and the possibility of continuing the group.

Post-Test of Participants' Mathematics Content Knowledge

As previously stated in the description of the pre-test of participants mathematics content knowledge section, the 10-item post-test (see Appendix B) was constructed by the researcher and was administered as both a pre- and post-test to make determinations of participants' mathematics' content knowledge as it related to multiplication and division. Only five of the questions were scored as they were directly related to the study. The remaining five "filler" items, which had no bearing on the results, were disregarded. Each of the five selected questions for which data were collected were correlated with three of the benchmarks related to multiplication and division in Florida's Next Generation Sunshine State Standards (NGSSS). They were correlated so that PLC activities could be directly related to the teaching of the new mathematics curriculum and standards across the state. The post-test was administered by the researcher at the end of the study to determine growth in the participants' mathematics content knowledge. The results served as one source of data in gauging whether the PLC had been successful in

changing basic understandings of certain mathematical concepts and the teaching of those concepts to their students.

Benchmark MA.3.A.1.1 (Item 3)

Table 9 presents the data related to Benchmark MA.3.A.1.1 (Model multiplication and division including problems presented in context: repeated addition, multiplication comparison, array, how many combinations, measurement, and partitioning). The table displays the post-test scores of respondents for item 3 and provides a description of the extent of participant understanding. item 3 requested that participants showed understanding of varying methods of solving a multiplication problem. The problem also determined whether or not they understood that skills in multiplication and division could be solved in many ways and were open to their students' using varied methods of problem solving. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 9
Post-test Scores of Participants' Mathematics Content Knowledge: Item 3

Participant	Score	Demonstrated Understanding and Explanation
Annie Post-test	3	Demonstrated understanding--gave more specific answers”
Beth Post-test	3	Demonstrated understanding--answered correctly with explanation.
Cathy Post-test	3	Demonstrated understanding--gave an explanation
Dena Post-test	3	Demonstrated understanding--gave an explanation
Emily Post-test	3	Demonstrated understanding--gave an explanation.
Fran Post-test	3	Demonstrated understanding--gave an explanation

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In the post-test, Annie chose to do the same thing, but she explained each answer with more specific mathematical reasoning. In the post-test, Beth chose to do the same thing, but she explained each answer with more specific mathematical reasoning. In the post-test, Annie chose to do the same thing, but she explained each answer with more specific mathematical reasoning. In the post-test, Dena gave the correct answer and provided an explanation that showed sound mathematical reasoning. In the post-test, Emily gave the correct answer and explained using mathematical reasoning. In the post-test, Fran gave the correct answer and explained, “All three students show understanding of place value and the distributive property of multiplication.”

In summary for item 3, four teachers gave explanations on the post-tests for each student's responses. In the post-test, all six participants wrote an explanation for their answers. This showed mathematical understanding on the part of the participants, as their explanations were detailed and accurate.

Benchmark MA.3.A.1.1 (Item 5)

Table 10 presents the data related to Benchmark MA.3.A.1.1 (Model multiplication and division including problems presented in context: repeated addition, multiplication comparison, array, how many combinations, measurement, and partitioning). The table displays the post-test scores of respondents for item 5 and provides a description of the extent of participant understanding. Item 5 requested that participants determine how the student solved the multiplication problem correctly without using the "traditional" algorithm in his thought processes. This question was used to aid the researcher in understanding the participants' understanding of teaching place value and the students' understanding of place value. The student may understand place value but not in the way the teacher "taught it". The participants needed to show that they understood this concept. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 10
Post-test Scores of Participants' Mathematics Content Knowledge: Item 5

Participant	Score	Demonstrated Understanding and Explanation
Annie Post-test	3	Demonstrated understanding--gave an explanation.
Beth Post-test	3	Demonstrated understanding--gave an explanation
Cathy Post-test	3	Demonstrated understanding--gave an explanation.
Dena Post-test	3	Demonstrated understanding--gave an explanation.
Emily Post-test	3	Demonstrated understanding--gave an explanation.
Fran Post-test	2	Demonstrated understanding--gave no explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In responding to item 5 on the post-test, Annie chose her answer and wrote, “He has the understanding of place value. When multiplying 6 ones by 3 ones, he wrote 8 in the ones place and 10 below. As long as the numbers are in the correct place value the correct answer can be found.” This answer showed an understanding of the necessary mathematical reasoning. Beth chose the correct answer and showed mathematical understanding with her response, “He understands the digits and their place value.” Cathy chose the correct answer and her explanation stated, “Todd understands place value. He needs to line up his numbers correctly.” This showed mathematical reasoning and understanding on the part of Cathy.

Dena gave the correct answer to item 5 and stated, “Todd understands the values of each digit.” Emily chose a correct answer and explained with “Todd has a strong understanding of place value.” Fran gave the correct answer and simply stated, “It works for him. He understands place value.” This did not really show an understanding of mathematical reasoning on her part.

In summary, for post-test item 5, three of the participants chose, answered, and explained their responses. For the post-test, five of the six participants chose the correct responses and explained their responses. Only one respondent, however, provided a complete response demonstrating a clear understanding of the student's approach in solving the mathematical concept.

Benchmark MA.3.A.1.2 (Item 4)

Table 11 presents the data related to Benchmark MA.3.A.1.2 (Solve multiplication and division fact problems by using strategies that result from applying number properties). The table displays the post-test scores of respondents for survey item 4 and provides a description of the extent of participant understanding. Item 4 requested that participants show understanding of the rules of divisibility for solving various division problems. This showed an understanding of patterns in numbers and an ability to understand those patterns in order to teach them to students. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 11
Post-test Scores of Participants' Mathematics Content Knowledge: Item 4

Participant	Score	Demonstrated Understanding and Explanation
Annie		
Post-test	3	Demonstrated understanding--gave an explanation
Beth		
Post-test	3	Demonstrated understanding--gave an explanation.
Cathy		
Post-test	2	Demonstrated understanding, but gave no explanation.
Dena		
Post-test	2	Demonstrated understanding--but gave no explanation, simply chose answer C.
Emily		
Post-test	3	Demonstrated understanding--gave an explanation.
Fran		
Post-test	3	Demonstrated understanding--gave an explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In her post-test response to item 4, Annie chose a different answer and explained, “You need to look at the ones and tens place.” This showed an understanding of the needed mathematical reasoning. Beth chose the correct answer and showed mathematical understanding with her explanation, “If you look at the last two digits, the numbers should be divisible by 4. You do not have to look at the hundreds because every hundred is divisible by 4.”

Cathy chose the correct answer in response to item 4, but her explanation did not have the correct mathematical reasoning behind it. Dena gave the correct answer and did not offer an explanation. Emily gave the correct answer and explained using mathematical reasoning worded in a similar way to her first response: “She looked at the

last two digits to imply use of divisibility rules.” This showed a more specific understanding of mathematical reasoning. Fran gave the correct answer and explained, “I chose B because 4 divides evenly into 100 and multiples of 100, you need only check the last two digits.” This answer showed understanding of mathematical reasoning behind the divisibility rules.

In summary, for item 4, four teachers gave explanations in post-test responses. Two of the participants, in their post-test responses, chose an answer without explanation, and four of the participants explained their choices. This showed mathematical understanding on the part of the four participants who chose an answer and gave explanations. The provided explanations were, however, minimal and demonstrated only partial understanding of the mathematical concept.

Benchmark MA.3.A.1.2 (Item 2)

Table 12 presents the data related to Benchmark MA.3.A.1.2 (Solve multiplication and division fact problems by using strategies that result from applying number properties). The table displays the post-test scores of respondents for item 2 and provides a description of the extent of participant understanding. Item 2 requested that participants demonstrate their understanding of patterns in numbers and their importance in students’ understanding of mathematical concepts for division and multiplication processes. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 12
Post-test Scores of Participants' Mathematics Content Knowledge: Item 2

Participant	Score	Demonstrated Understanding and Explanation
Annie Post-test	3	Demonstrated understanding--chose the same answer, but explained why
Beth Post-test	3	Demonstrated understanding--chose the correct answer and explained,
Cathy Post-test	2	Demonstrated understanding--answered correctly, without explanation
Dena Post-test	2	Demonstrated understanding--answered correctly, did not give explanation..
Emily Post-test	3	Demonstrated understanding --gave correct choice and explanation.
Fran Post-test	3	Demonstrated understanding--chose correct answer and gave explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In the post-test, Annie chose a correct response for item 2 and explained that “If it [the number] is divisible by any of these numbers, it is not prime.” Beth also selected the correct response and explained, “If is a prime number it is only divisible by one and itself.” Cathy, though arriving at a correct response, explained, “I’m not sure. I do know that a prime number is divisible by itself and one.” Dena provided a correct answer but offered no explanation. In the post test, Emily gave the correct answer and explained, “I’m not sure, I know that Prime number are divisible by itself and 1.” Fran gave the correct answer and explained, “371 is not a prime number--primes are only divisible by 1 and itself. B and D do not make sense.”

In summary, for item 2 on the post-test, all six teachers chose from the four choices. Two of the teachers could not explain their choices, but the other four justified their selections with an explanation that made mathematical sense. Four of the participants selected the appropriate responses and provided very elementary explanations for their choices, which showed partial understanding of the mathematical concept. No participants provided a detailed explanation for this item. They stated the divisibility rule as their explanation.

Benchmark MA.3.A.1.3 (Item 7)

Table 13 presents the data related to Benchmark MA.3.A.1.3 (Identify, describe, and apply division and multiplication as inverse operations). The table displays the post-test scores of respondents for item 7 and provides a description of the extent of participant understanding. Item 7 sought to determine that participants further understood that their students could use varying methods to solve multiplication and division problems by demonstrating understanding of place value through invented solution of mathematical problems. The table is accompanied by a narrative providing further detail in regard to participant responses.

Table 13
Post-test Scores of Participants' Mathematics Content Knowledge: Item 7

Participant	Score	Demonstrated Understanding and Explanation
Annie Post-test	3	Demonstrated understanding--gave an explanation.
Beth Post-test	3	Demonstrated understanding--gave an explanation.
Cathy Post-test	3	Demonstrated understanding--gave an explanation.”
Dena Post-test	3	Demonstrated understanding--gave an explanation.
Emily Post-test	3	Demonstrated understanding--gave an explanation.
Fran Post-test	3	Demonstrated understanding--gave an explanation.

Note. 0 = no response or I do not know; 1 = demonstrated no understanding--incorrect answer with explanation; 2 = demonstrated understanding--correct answer with no explanation; and 3 = demonstrated understanding--correct answer and explanation.

In responding to item 7 on her post-test, Annie selected choice B and explained, “By using an array to show 10×10 would equal 100. They would count $8 \times 8 = 64$ $100 - 36 = 64$.” This showed an understanding of the mathematical reasoning. Beth chose the correct answer and showed mathematical understanding with her explanation, “According to what I have learned in PLC math group, I believe the students would choose A or D. I have taught them the strategy of round up numbers. The student could have drawn an array for 10×10 . Draw a box around 8×8 . Then what is left is 2×8 and 2×10 . This would mean to subtract 36 from 100.” This explanation demonstrated understanding of mathematical reasoning. Cathy chose the correct answer for item 7 and

stated in her explanation, “Mr. Garrett must have taught the class how to multiply with ten and subtract.” This showed an understanding of correct mathematical reasoning.

In responding to item 7 on the post-test, Dena gave the correct answer and demonstrated her understanding of mathematical reasoning in the following explanation: “If they use an array of 10×10 which is 100, they can subtract the 36 to make the array of 8×8 which is 64. She chose A.” Emily chose the correct answer and stated, “The student may have chosen to draw an array of what he knew 10×10 , then frame out the equation (8×8) then add the remaining array of $(2 \times 10$ and $2 \times 8) = 36$ then subtract from 100.” This showed an understanding of mathematical reasoning. Fran gave the correct answer and simply stated, “They used an array of $10 \times 10 = 100$ subtracted $2 \times 10 = 20$ and then subtracted $8 \times 2 = 16$.” This showed understanding of mathematical reasoning. In summary, all six participants provided accurate responses and complete descriptive statements demonstrating a clear understanding of the students’ approaches in solving the mathematical concept.

Post-Study Interviews with Participants

Post-study interviews were conducted with each of the six teacher participants in the study. The independent observer met individually in a typical third-grade classroom with each of the participants between November 15 and November 19, 2010. At the conclusion of each interview, the independent observer recorded her observations, which were later shared and discussed with the researcher prior to preparing written statements regarding the interviews for the present study. The independent observer also reviewed

the written statements for clarity in ensuring that the researcher had accurately reported the observations of the independent observer. The following reports for each of the six teachers have been organized around their responses to four questions which were central in the analysis of PLC meetings: Because the purpose of this study was to investigate the growth of teachers' content knowledge in mathematics, specifically in the areas of multiplication and division, and the effects of their professional learning within their classrooms, the four questions centered on teachers' perceptions of (a) changes in their practice; (b) new understandings; (c) changes in group efficacy; and (d) reasons for changes in group efficacy. By linking the pre-study interviews and pre-test of content knowledge responses with the post study interviews and post-test of content knowledge questions, the researcher was able to obtain a more complete picture of participants' levels of understanding and their perceptions about mathematics prior to and at the conclusion of the PLC experience. In essence, the various research activities gave the researcher background and insight into the individual participants' attitudes and knowledge levels that she would not otherwise have gained. These four elements, supplemented by the evidence provided in the post-test of mathematics content knowledge provided the basis from which themes, implications, and recommendations emerged in the discussion in Chapter 5

Annie

Changes in Practice

When answering the first question concerning what, if any, changes occurred in the practices of her classroom because she participated in the professional learning community, Annie stated that she now does more addition practice. She also stated that she used more games and strategies with her students. She went on to explain that she works more diligently to arrive at differentiated instructional strategies in mathematics and that she also stresses to her student that many times there is more than one way to solve a problem.

New Understandings

In regard to new understandings, Annie indicated that she had a better understanding of the distributive property, addition and subtraction, and multiplication and division. She also believed that she better understood some of the on-line components of the new *Go Math!* series.

Changes in Group Efficacy

Annie stated that she believed that the group became more comfortable with each other as they progressed through the weekly meetings. She also thought that, as the group members grew more comfortable with each other, they shared more and were less afraid to express their lack of understanding of any part of group discussions.

Reasons for Changes in Group Efficacy and Why or Why Not?

Annie stated that as the study progressed, group members seemed to be able to talk more about their deficits in teaching mathematics. She believed that they had learned to trust and rely on each other.

Beth

Changes in Practice

In responding to the first interview question as to the changes made in her classroom practices because she participated in the professional learning community, Beth stated that she believed her team shared more by talking about mathematics. She added that her students also talked more about mathematics and that the additional conversation was benefiting them in their everyday practice in mathematics class.

New Understandings

In regard to new understandings, Beth indicated that she had a better understanding of number sense and being able to separate numbers to multiply them. She stated that because of this, her students were learning more than one way to multiply numbers and gaining confidence in their ability.

Changes in Group Efficacy

Beth was positive in expressing that all of the different strategies she learned in the professional learning community were very helpful to her and her understanding of mathematics. She cited the group discussions as being helpful and saw the results of those discussions, as they were applied in her classroom, directly benefiting students in improving their understanding of mathematics.

Reasons for Changes in Group Efficacy and Why or Why Not?

Beth stated that as the study progressed, she had grown in her knowledge of mathematics and teaching it. She revealed that she had not known what to expect when the study started, but that it was definitely a “doable” experience for any teacher (TR 8, p. 1).

Cathy

Changes in Practice

In discussing changes in her classroom practice because of her participation in the professional learning community, Cathy stated that she believed that she was incorporating what she learned in the PLC in her classroom. Cathy also indicated that she used “drops in a bucket” type strategies such as having the students count in 3s, starting with 4, while they are in line or transitioning from one thing to another (TR 9, p.1). She

explained that she uses more intervention strategies from the new *Go Math!* series than she would have if she had not had the training in the professional learning community.

New Understandings

In regard to new understandings, Cathy indicated that she now understood more about comprehension skills in mathematics. She elaborated by commenting on the importance of reading comprehension. Her belief was stronger than ever that students needed to be able to comprehend what they were reading in order to produce results in their mathematics work.

Changes in Group Efficacy

Cathy commented on the value of some of the activities in the PLC meetings. She indicated that without being shown what to do, she probably would not have initiated some of the activities she was currently using, as she felt she lacked background in mathematics. She also stated that the “hands-on” instruction really benefited her, and that because of it she was looking at mathematics differently.

Reasons for Changes in Group Efficacy and Why or Why Not?

Cathy stated that as the study progressed, that she believed that she was becoming a better instructor. She further explained this, indicating that she was better able to address the needs of her lower quartile students, not just her high performing students.

Dena

Changes in Practice

When answering the first question concerning changes that may have occurred in her classroom practice because she participated in the professional learning community, Dena stated that she felt that she had found “more room” in her instruction for alternate explanations in mathematics (TR 10, p. 1). She also stated that she was making a conscious effort to try to differentiate her instruction more and use other aspects of the mathematics program (the *Go Math!* series) that she might not have used prior to the PLC activity.

New Understandings

In regard to new understandings, Dena indicated that she learned different ways to multiply, more ways than she ever knew possible. She also stated that because of her new understanding of multiplication, she allowed her students to explore more alternatives and that they, in turn, were becoming better students in mathematics.

Changes in Group Efficacy

Dena stated, that she saw a difference in the group as the weekly meetings progressed in that members talked more and more each week. She elaborated, explaining that she saw her peers sharing ideas and “talking math” more throughout the duration of

the study (TR 10, p. 2). She believed that the different activities opened up dialogue within the group and made members less afraid to share.

Reasons for Changes in Group Efficacy and Why or Why Not?

Dena stated that as the study progressed, it lead to more mathematics discussions within her classroom as well as within the study group. She also stated that sharing and working together was very important, as it made participating teachers better at teaching their students.

Emily

Changes in Practice

When answering the first question concerning changes that may have occurred in her classroom practice because of her participation in the professional learning community, Emily stated that she had begun using more problem solving with her students both individually and in groups. She indicated that she had noticed that both she and her students were walking through “steps” to solve word problems rather than just being afraid to take on the challenge (TR 11, p. 1).

New Understandings

In regard to new understandings, Emily indicated that she had not realized how important reading comprehension was in the understanding of mathematics. She also

commented that because the group had completed so much work with multiplication, division, and problem solving she was more comfortable teaching these topics to her students.

Changes in Group Efficacy

Emily stated, that she believed she was allowing her students more tactile involvement in mathematics because of her participation in the study group. She further explained that the current instruction in her class was leading to a depth of understanding that her students had not previously exhibited.

Reasons for Changes in Group Efficacy and Why or Why Not?

Emily stated that as the study progressed, that she has used a larger variety of mathematics strategies than she ever had before. She indicated that she had noticed a difference in her students' attitudes toward mathematics because of her personal change in attitude toward the subject.

Fran

Changes in Practice

When answering the first question concerning changes that may have occurred in classroom practice because of participation in the professional learning community, Fran stated that she has increased the amount of student-directed instruction with her class

rather than teacher-directed instruction. She supported this in her statements about problem solving and the fact that she had students talking about and sharing their ideas. She expressed the belief that these changes were giving her students more confidence in mathematics.

New Understandings

In regard to new understandings, Fran indicated that her participation in the study reinforced what she thought was the “right” track in teaching mathematics (TR 12, p. 1). She explained that participation in the group had also led to her using more exploratory activities in the classroom with her students as well.

Changes in Group Efficacy

Fran stated that she felt that as the group became more comfortable with each other, they became increasingly comfortable sharing and discussing mathematics. She noted that as the group’s comfort level increased, they became more open. As a result, they were not afraid to share their “downfalls” in mathematics as well as their successes (TR 12, p. 2).

Reasons for Changes in Group Efficacy and Why or Why Not?

Fran stated that, as the study progressed, she became less afraid to explore the new mathematics curriculum and make educated decisions about what and how she should approach mathematics lessons. She further stated that overall, the group was a

good experience, and she thinks that all of the members received something positive from the experience.

Summary

The chapter has presented the findings of the study related to the three phases of the research. Data were presented which were gathered from multiple sources including (a) a pre-test of mathematics content knowledge, (b) pre-study interviews, (c) 10 professional learning community meetings, (d) the post-test of mathematics content knowledge, and (e) post-study interviews. Chapter 5 contains a summary and discussion of the findings presented in Chapter 4 along with recommendations for practice and future research.

CHAPTER 5 ANALYSIS, SUMMARY, AND RECOMMENDATIONS

Introduction

This research study was conducted to examine the influence of participation in a professional learning community and its impact on the learning of its participants. The study was guided by the following single research question:

To what extent does participation in a professional learning community comprised of elementary grade level teachers in one central Florida elementary school influence teachers' mathematical understanding of basic multiplication and division strategies?

This chapter is divided into seven sections. The findings of the study are summarized and discussed as follows: (a) the pre-study interviews with participants, (b) the pre-test of content knowledge administered to assess participants' levels of multiplication and division content knowledge related specifically to the New Generation Sunshine State Standards (NGSSS), (c) the progress and events/activities of the 10-week professional learning community, (d) a post-test of content knowledge (the pre-test repeated), and (e) post-study interviews. Additional sections of the chapter offer recommendations for practice, and recommendations for future research.

Analysis of Pre-Study Interviews

Pre-study interviews were conducted to better familiarize the researcher with the participants. Initially, the participating teachers completed a questionnaire requesting demographic and attitudinal information. They were queried as to their prior experiences

as learners and teachers of mathematics. They were also questioned about their present attitudes about teaching and learning mathematics. The pre-study interviews that were conducted were based on the completed questionnaires and were intended to assist the researcher in preparing to work with the group as a facilitator in a professional learning community. Following are summaries for the three areas of interest in the pre-study interviews:

Teachers as Learners of Mathematics

In the teachers' responses to the questions posed in the interviews, there were many similarities and some obvious differences. In considering the teacher as a learner of mathematics, each teacher had similar mathematics courses at the college level with Fran having had Pre-calculus, the highest level of mathematics taken, and Cathy having had only College Algebra, the lowest level of mathematics taken as their primary mathematics courses in college. All other participants had statistics course as their highest level of mathematics. Researchers have shown that the level of mathematics courses taken in college has had a direct impact upon the teacher's ability to understand mathematics content knowledge (Ball, 2000; Ball et al., 2005; Burton et al., 2008; Darling-Hammond, 2001; Katz, 2007; Simon, 1993; Tzur & Simon, 2004).

All participants cited different comfort levels as math learners, but one common thread in the interviews was that all cited a lack of teaching using manipulatives. The participants also indicated that not having been shown more than one way of approaching problems was a serious deficit when they learned mathematics Ball (2000) and Seed

(2008) stated in regard to their research that teachers were prone to teach in the way that they were taught. They further stated, in regard to manipulatives, that simply exposing teachers to their use was insufficient. Teachers need to be instructed in their use as tools. If they are permitted to use manipulatives in their college methods classes with students in the wrong way, the purpose will be defeated for the use of the tools in the classroom (Ball, 2000; Seed, 2008).

Fran was the only participant who seemed to have a positive attitude toward mathematics throughout her life experiences as a learner. Annie, Dena, and Emily indicated negative experiences in mathematics and a lack of ability on the part of their teachers throughout school to teach them the subject. All of the participants recalled rote learning or a teacher “in the front of the room” stating facts with little interaction with students.

Beth, Cathy, and Fran recalled positive experiences in mathematics throughout their schooling and cited different teachers or professors that they felt helped them to develop a better understanding of mathematics because of the different methodologies that were used in their teaching. Researchers have concurred that many students of mathematics throughout their school experiences, have very little confidence in their abilities in mathematics. In particular, researchers have noted that females especially have a poor comfort level in mathematics, and that they have generally been the first to teach the nation’s children (Fretzel et al., 2007; Kikas et al., 2009; Seed, 2008; Wei et al., 2009)

Teacher as a Teacher of Mathematics

In reviewing the teacher interviews from a teaching perspective, each participant seemed to have differing views regarding their ability to teach and in what specific areas of teaching they excelled. All expressed some frustration with some area of teaching mathematics. Annie, Cathy, Dena, Emily, and Fran indicated that they liked teaching geometry over any other mathematics, because of the hands-on approach that could be used. These teachers reflected what researchers have acknowledged, that mathematics preparation for teachers is marginal at best and that they only feel comfortable teaching what they know well (Fretzel et al., 2007; Kikas et al., 2009; Seed, 2008).

Geometry was a prime example of mathematics with which participants were comfortable in school. More complicated mathematical problem solving was generally noted by participants as difficult to teach and achieve understanding by students. This preference of the participants was supported by mathematics researchers have observed that teachers of mathematics in elementary schools are prone to be more comfortable with concepts taught in geometry rather more complex problem solving because they had more experience with geometry in a hands on environment (Ball, 2000; Ball et al., 2005; Kikas et al., 2009; Seed, 2008)

Teacher Perceptions of Mathematics Learning and Teaching

In reviewing interviews regarding teacher perceptions of mathematics learning and teaching, all six participants named a male, often in a career with science/math preparation when naming a person who might assist them or who they thought was

“excellent” in regard to their mathematics knowledge. In contrast, they all cited a female as a person they felt was “not very good” at mathematics. Their reasons usually were because “they did not need to be,” or because “they did not need to be [good in math] in their job.” Researchers have shown that males tend to be mathematically challenged by their teachers, and girls tend to be challenged in the area of reading. The fact that males have been cited as lagging some 10 points below their female counterparts in reading on national test scores provides some evidence acknowledging the disparity (Fretzel et al., 2007; Kikas et al., 2009; Seed, 2008).

Although the gap in mathematics between girls and boys has lessened somewhat over the years, researchers have verified that more males than females tend to go into fields that require mathematical background and that females tend to feel less comfortable with mathematical content. (Fretzel, 2007; Kikas, 2009; Seed, 2008).

All participants also cited a lack of focus on mathematics within their district as well as a lack of in-service offered in the area of mathematics throughout their careers. This issue has also been discussed at length by researchers and authors. Teachers who do not receive the curricular support and targeted in-service tend to teach the same way that they have been teaching or were taught as students as a direct result of this lack of support (Ball, 2000; Ball et.al. 2005; Cwikla, 2004; Darling-Hammond, 2001, 2008; Wei et al., 2009).

In-service and current best practices that support the teacher continually are crucial for the success of the classroom teacher and most importantly for their students. Mathematics is an area that has not been the focus of national attention, until recently,

when it has been noted that currently the United States is lagging behind many other countries in the world on students' performance on standardized testing. This has been leading to a deficit in preparation of students for the job market, e.g., engineers and scientists (Ball, 2000; Ball et.al. 2005 Cwikla, 2004; Darling-Hammond, 2001, 2008; Wei et al., 2009).

Analysis of Pre-Test of Mathematics Content Knowledge

The content knowledge pre-test was administered by the researcher to gain insight as to the understanding of the participants for five mathematical benchmarks that were taught in third grade in the school district. For each of the content knowledge items, the participants were asked to determine an example of a student's understanding of multiplication and division strategies in various forms. Teachers were also asked to determine if a student used a "different" method of solving a mathematical problem than was "traditionally" accepted and if the student's problem solving strategy was correct. For all the pre-test items, participants showed little understanding of the five content knowledge problems that were developed by Ball (2009) to determine understanding of mathematical content by teachers of mathematics at the elementary level.

As previously noted by the researcher these items were released items that Ball was no longer using in her data study, but were made available to the researcher so long as they were used in open ended format for participants rather than testing format. The items were scored for the purposes of the research based on a rubric ranging from 0 to 3 indicating levels of no understanding to more than adequate understanding for pre-test

responses and explanations. All responses for pre test items 1-5 either were answered with a “do not know” response or demonstrated very limited understanding by all participants, Annie, Beth, Cathy, Dena, Emily, and Fran.

The only exception was that Annie and Dena responded to item 2 with understanding and gave the correct answer, but without an explanation. The problem presented in item 2 requested that participants demonstrate their understanding of patterns in numbers and their importance in students’ understanding of mathematical concepts for division and multiplication processes. Annie and Dena were participants who expressed, throughout the research, a greater understanding of mathematics, and had also stated on many occasions throughout the research study that they felt comfortable with the teaching of mathematics. They indicated, however, that they were confident in using the ways they had been taught which was primarily “rote” facts and very little explanation.

It was the conclusion of this researcher that this was due to the fact that these two participants had expressed that they both enjoyed teaching multiplication and division and that these were mathematical concepts that they believed were based on the way they had learned mathematics. The fact that they did respond correctly, but with no explanations showed their inability to teach outside of a fairly limited frame of reference when it comes to mathematics. Their own conceptual knowledge of these skills was limited to the “rote” methods that they were taught as students. Researchers have concurred that this is the case with a majority of teachers, and that this lack of ability to show differing strategies in mathematics leads to students who share the same

characteristic regarding problem solving (Ball, 2000; Ball et.al., 2005; Cwikla, 2004; Darling-Hammond, 2001, 2008; Wei et al., 2009).

Analysis of the Professional Learning Community

The overall objective for the professional learning community was to use the weekly meetings as a vehicle with which to guide participants using various strategies, resources, and mathematical discussions. The sharing of instructional methods by participants, so as to develop additional competency in mathematical knowledge and to benefit from the structure of a professional learning community, were desired outcomes. Professional Learning Community meetings were documented throughout the 10-week period using four categories that demonstrated (a) changes in practice, (b) new mathematics understandings, (c) changes in group efficacy, and (d) reasons for changes in group efficacy. These same four categories have been used in this chapter to organize the presentation of the analysis, discussion and summary of the data.

Analysis of PLC Meeting 1 (September 7, 2010)

Changes in Practice

The teachers chose to focus on multiplication and division as the skill set for the PLC. Dena expressed the reality of her situation by saying that in her college math courses, she had not been taught the strategies she needed to successfully teach her students strategies and that some of her students learned facts, half of which were

forgotten by the next lesson. All of the teachers in the group expressed similar concerns about what they did on a day-to-day basis in mathematics. They also discussed concerns about the inadequacy of training related to the mathematics series being implemented for the 2010-2011 school year and their lack of understanding of the training they did receive.

New Understandings

It was clear from the beginning that the teachers were intimidated by the fact that, in the new math series, students were expected to begin with more complex subject matter in mathematics. The teachers also voiced concerns that until recently, there had been little depth in the mathematics curriculum. It had been an extremely “wide” curriculum with very little room for problems solving and learning of strategies. The new curriculum and the Next Generation Sunshine State Standards (NGSSS) were far broader in scope and teachers needed a much broader understanding of the subject matter in order to effectively teach it.

One theme that ran across this first meeting was that participants felt that the students did not come to them ready for third grade. They questioned how students who were struggling with addition and subtraction could possibly multiply and divide. A substantial part of the first meeting was devoted to discussing (a) ways in which teachers could assist students, (b) how teachers can teach mathematics to a class where at least one third of the students do not have the foundations of the lesson, (c) how and where additional materials and help for these students can be accessed. All members of the

group expressed their frustration that their students did not understand basic mathematic number sense skills such as place value, numeration, and repeated addition. The entire group stressed that these skills are expected to be understood by their students with the implementation of the new math series. Each needed suggestions as to how to “fill in the gaps” of their students knowledge and effectively teach the material that was expected to be covered for the current school year.

What also became obvious in the interactions of the entire group was the isolation of individual teachers in their own classrooms on a daily basis. They came to professional development with their own set of beliefs about the way teaching should occur within the confines of their individual classrooms. This first meeting established a “safe” climate for teachers in which they had opportunities to share their beliefs. This enabled group members to hear other viewpoints and test their own beliefs against those of their colleagues.

Changes in Group Efficacy

Since this was the first meeting of the group, it was not possible to look at changes that occurred in group efficacy; however, several observations were made regarding the group. It was clear that the teachers were able to make decisions about what they believed needed to be addressed as far as curriculum choices within the PLC. They were also able to work things out together as a group, and they were extremely motivated to make this experience a positive one. It was also quite evident that there were some misconceptions about teaching mathematics that most likely stemmed from the earlier

learning of participants through their mathematics experience as students in high school and college. Some believed that multiplication and division should be taught separately from each other, that facts should be memorized, and that lack of fluency in mathematics was the reason for so many computational errors.

Reasons for Changes in Group Efficacy and Why or Why Not?

This first meeting of the group was used to introduce the concept of the professional learning community as a tool by which teachers could work together to improve outcomes for students. Thus, it was a meeting at which the overall goal for the group was established and preliminary understandings were shared.

Dena, Emily, and Annie all questioned the expectation that children who could not use a number line correctly could be expected to solve word problems. Some well founded observations were offered by group members in regard to the benefits of students' use of drawing in solving problems. The teachers, however, did not express their own beliefs as to a "right way" to teach mathematics, nor did they share any thoughts on the implementation of the new NGSSS. (TR 13, p. 4)

It also became apparent in this first discussion that members of the group had not previously used a great deal of problem solving in their instructional practices. This was clearly an issue for all of them as the new math series' primary focus was on problem solving. The new *Go Math!* series called for students to learn mathematics by working together, using manipulatives and various mathematical strategies to solve mathematics problems. Time management also emerged as a huge issue. The new mathematics series

contained a daily average of four practice pages and two additional homework pages. Teachers reported struggling with utilizing all of this material in the single 70-minute mathematics period available to them.

In summary, this initial meeting was exploratory in nature. Teachers shared their thoughts in regard to specific topics they wished to explore and specific problems with which they were dealing. They did not really know what to expect from their participation in the PLC but indicated interest in becoming more knowledgeable in regard to the new mathematics series.

Analysis of PLC Meeting 2 (September 14, 2010)

Changes in Practice

The group realized at this session that trying to explain and practice the entire *Go Math!* strategies with their students would be impossible. Cathy stated that she believed she should just try one strategy in her class. Only after she had been successful with that strategy would she be comfortable moving on to another. Fran stated that she used some of these strategies, but not on a regular basis. Cathy and Dena indicated their beliefs that it seemed to take too much work to use these “thinking” strategies and that the old way seemed simpler. (TR 14, p. 1) Fran then stated that perhaps they should simply try a strategy that seemed easiest for both them and their students. The teachers agreed that they would try one strategy in the next week in their classes, choosing the strategy that they believed fit the needs of their students.

New Understandings

Not many new understandings were observed at this meeting. The participants were still uncertain as to how this study (the professional learning community) was going to benefit them and their students, if at all. More elements related to the new mathematics curriculum were discussed. All six team members reiterated that they were having a difficult time “fitting in” all of the new series’ required material. (TR 14, p. 3) The researcher shared with the group that completing all the practice and homework problems was not necessarily what the writers of the curriculum had in mind and that teachers should use problems directly related to the essential skill being taught. She also suggested that teachers, in previewing word problems, might begin using a strategy with their students that would help students divide the problem into component parts.

The teachers agreed that they had, in their concern to “cover” the material, not really looked to see which problems focused on the skill being taught and were receptive to the idea of being more selective in choosing practice and homework materials. (TR 14, p. 3) The problem-solving advice offered by the researcher was not acknowledged or explored further within the group.

Changes in Group Efficacy

It was noticeable in the meeting that group members did not really listen to each other when they talked. The focus appeared to be more about the sharing and telling than listening to learn what strategies were and were not successful. Group members had a history together in terms of team planning time, sharing ideas and school information in

required meetings. They were not used to functioning together in a professional development setting targeted to them.

Reasons for Changes in Group Efficacy and Why or Why Not?

It appeared to the researcher that group members were trying to determine one another's comfort level in mathematics and the teaching of it. They were eager to share experiences or strategies that were successful, but they did not share any experiences that might have indicated a lower comfort level with mathematics content or their understanding.

Analysis of PLC Meeting 3 (September 21, 2010)

Changes in Practice

The group decided to discuss some of the highlights of the in-service presentation by the textbook author at the meeting of the entire faculty. Beth then shared the author's strategy of making ten using one's fingers. She described the strategy as follows:

You hold up two fingers and say make ten. The class has to focus on you and hold up the right number of fingers to match yours and make ten. Although this seems simple, the children did not find it easy and their responses were very slow when they started doing it. (TR 15, p. 2)

She further explained that she did this for several facts daily and then continued with her mathematics lesson. She proceeded to do this every day for a week. The children responded well and improved their ability to respond with the correct number of fingers.

Beth also stated that she planned to keep doing this to help students master their facts.

New Understandings

What struck the researcher in this meeting as far as new understandings was that the group listened to Beth share, and all acknowledged that this was something that they had heard as well. Several then stated that since Beth had been successful, they might be wise to start using the strategy as well. The researcher found this interesting because though they had not chosen to implement the strategy as presented by the textbook author, they were receptive to the success of one of their peers.

Changes in Group Efficacy

In this session, the participants' efficacy was not 100% evident, but there was an inclination demonstrated to work together by using the "make ten" strategy. Group members were willing to listen to each other and to share and try out each other's ideas. There was still some resistance on the part of some of the participants to listen to the "experts," but they were definitely more willing to listen to each other.

Reasons for Changes in Group Efficacy and Why or Why Not?

Group members were still functioning in their traditional team model rather than as a community of learners. It appeared to the researcher that members were uncertain as to the contributions that they could make to the group. The group had not yet had sufficient time to develop an identity and a trust level.

Analysis of PLC Meeting 4 (September 28, 2010)

Changes in Practice

For this meeting, the group decided that they would like to share results and failures from their classroom. Annie stated that she had been using some “counting on” strategies, and that she had noticed that the children were paying more attention and having more success than in prior weeks. (TR 16, p. 1) When asked to explain this change, she indicated that she believed it was her understanding of what a difference the strategy could make. She thought that students were noticing her enthusiasm for the process and that it was having a positive impact on their efforts. Beth stated that she had tried the “making 10” strategies with her class whenever she wanted their attention and that she had seen a difference in their participation. (TR 16, p. 1) When the researcher queried her as to students’ success, she indicated there had been no measurable increase at this point, but that she believed it would come with time.

Fran stated that she had been using a number line for the first time with her class and that some of her students were successful, and some were not. She indicated that she believed both she and her students needed more experience with the strategy to be successful.

New Understandings

Beth, Dena, and Cathy voiced their beliefs that teaching multiplication and division in isolation was a better approach, but did admit that using this approach left

students unable to solve the problems. Fran was willing to try the teaching of the two together and was positive about her entire experience with this approach. She believed that having the children see the relationship between the two operations early in the learning was beneficial.

Emily shared her struggle with the use of a number line in complicated mathematics. Her students were having difficulty because they had never seen a number line in mathematics that exceeded 10. She also discussed her success with the “counting on” strategy. After hearing about the strategy at a prior meeting, she tried a strategy that involved counting on by 2s, but she had adapted the strategy to start with 5s. She used the strategy frequently, e.g., hall time, idle classroom moments. After a few weeks, she changed from basic number of 5 to 3. She was amazed at how much the children learned and how quickly they became engaged with the process.

Changes in Group Efficacy

The biggest change this week was in the area of group efficacy. The group arrived at the meeting very frustrated and concerned that the lessons they were teaching were not effective because neither they nor their students understood what they were doing. The researcher asked someone from the group to provide a specific example of the frustration, and Annie volunteered. She talked about teaching the distributive property and her inability to help her children understand it. She stated that when teaching them this property, they understood that the idea was to break the number apart so that the children could do the math without knowing their tables. An example would be as follows:

Problem: Mark bought 6 new fish for his aquarium. He paid \$7 for each fish. How much did he spend in all? (Math Counts, 2010).

$6 \times 7 =$ could be written $6 \times (5 + 2)$

Think of seven as $5 + 2$.

Then $6 \times 7 = (6 \times 5) + (6 \times 2)$ Multiply each addend by 6

$6 \times 7 =$ _____ + _____ Add the products

$6 \times 7 =$

Therefore, Mark spent \$ ___ for his new fish.

Annie cited the above example and said that her students could show it with an array but could not show it using the distributive property. She also shared that just the use of the phrase, “distributive property” intimidated her students. The researcher suggested that perhaps the phrase need not be used so as to avoid students being so focused on the phrase that it inhibited their ability to actually understand its meaning. The researcher also suggested the use of manipulatives such as bear counters or chips to demonstrate the mathematics of the problem. This example and suggested solutions also provided an opportune time to remind teachers of some of the truly amazing features involving the use of technology in the new series that could be accessed using classroom tools such as white boards and computer television presenters.

In contrast to prior meetings, group members seemed to really listen to one another during this meeting. Participants tried to problem solve and help each other understand their dilemmas, e.g., how to “teach” the distributive property. In essence, they had to teach each other as none had a clear understanding of how the property actually worked at the level they taught.

Reasons for Changes in Group Efficacy and Why or Why Not?

The most likely reason for the change in efficacy this week was the recognition/admission by individuals of their inability to understand and teach a mathematical concept at a level that they personally felt was acceptable. Each member showed some degree of frustration. The mathematical concept they struggled with was not particularly difficult, but it was an entirely different approach from their prior teaching of rote memorization of facts. Using the new math series, they were required to help children separate numbers in order to better solve the problem .

Analysis of PLC Meeting 5 (October 5, 2010)

Changes in Practice

Manipulatives and their use had been a topic of discussion in prior discussions of the group. Participants had some concerns about their appropriate usage during mathematics lessons, i.e., at the beginning or during the lessons. Van de Walle's (2006) work served as an excellent vehicle to demonstrate how research can show best practices. Van de Walle stressed the value of manipulatives to students who can use them to help explain how they solve a problem and permit them to see other strategies used by their classmates.

Van de Walle (2006) suggested,

Students should solve problems not to apply mathematics but to learn mathematics. A math problem for problem solving should start where the children

are mathematically, what do they currently understand, and how can they be challenged to learn more doing the problem solving? (p. 10)

While solving the problem the students should be actively involved in making sense of the math itself and applying what they already know. Finally the students should be able justify their answers and how they got them. (p. 11).

The group found this interesting. Annie shared that she had never thought of manipulatives in Van de Walle's terms. Fran agreed that she had not seen manipulatives used by students to explain answers and solve problems. Several team members commented that they used manipulative in their mathematics lessons; however, upon further discussion it was noted that they were not necessarily used in the manner in which Van de Walle suggested. Beth and Fran felt that "letting" the child keep the manipulative would provide a crutch and be harmful in later mathematics experiences. None of the participants had taught their students to use the manipulative as a tool in thinking through a mathematical process. All of the teachers indicated some discomfort with this strategy because they, themselves, had not learned mathematics in this way.

This was an interesting discussion because the team actually seemed to come to the realization that their comfort level with mathematics activities and strategies was directly related and limited to the ways in which they had been taught (and learned). It was difficult for them to admit that they perhaps needed to shift their thought processes when teaching mathematics because their lack of experience may have been contributing to their students' lack of success. Before the meeting concluded, Annie, Beth, and Fran indicated that they were going to implement a couple of different strategies during the

coming week and see if they could observe any differences for their students. They agreed to report back to the group regarding their changes in practice.

New Understandings

During this session, Fran shared her use of the number line with the use of “jumps” to show computation. Another strategy that had interested the group was invented strategies, and Van de Walle’s (2006) text also contained a section on the use of invented strategies with students. Teachers had not used activities such as adding tens, then ones, and combining or moving some to make tens. The group had begun to see that these were valid strategies that could help many of their students.

The researcher shared some of the other ideas put forth by Van de Walle (2006) including: (a) that many errors occur with the use of manipulatives, (b) that teachers model exactly how those manipulatives should be used without actually understanding what concept is being modeled, and (c) manipulatives should encourage thinking rather than helping students to achieve the correct answer. The group also revealed that not only did they see evidence that their students were experiencing success but that they, as teachers, were also experiencing success in their teaching of mathematics, some for the first time in their careers. Annie noted that her students who traditionally had difficulty solving problems were being successful and that she had observed some of her weakest students teaching a classmate a strategy that had been successful for them.

Changes in Group Efficacy

Fran, one of the veteran teachers in the group, changed her focus at this meeting, and it had a positive effect on the group. She stated that she felt validated by the group because she knew after the discussions that all group members were dealing with similar situations in their classrooms. She indicated that it helped to know that all of the group struggled with certain concepts in mathematics. She commented on the demands on teachers to continually learn and adjust to curricular changes and the importance of providing in-depth professional development to support this growth, something she did not believe she had experienced at any time during her career. Fran had a definite influence on her team, and the fact that she felt the group was an effective tool for her to learn new things was huge.

Reasons for Changes in Group Efficacy and Why or Why Not?

After working together for several weeks, the group was able to discuss issues and learning within the constructs of mathematics and their focus for the PLC. A typical discussion later in the group involved what strategies members were using and the success students were or were not experiencing. The introduction of the work of Van de Walle (2006) was also helpful in developing more understanding in terms of how strategies should be implemented. The conversations also focused on new strategies that students discovered within the constructs of the mathematics lesson and how that occasionally helped other students get a clearer view of what was expected. The other reason for changes in the group efficacy was the supportive attitude of Fran. As a leader

in the group, her acknowledgment of the value of the PLC was of great importance in setting the stage for future meetings and sharing.

Analysis of PLC Meeting 6 (October 12, 2010)

Changes in Practice

The major focus of this meeting was a discussion of participants' experiences with the use of manipulatives in mathematics lessons during the prior week. Emily and Fran stated that they had already implemented some other strategies that had been discussed and were overwhelmed with the idea of completely changing their thought processes to accommodate the use of manipulatives as tools for learning. They stated that they knew it was something they needed to do but that they were not sure as to how to proceed.

Annie commented on the difference in reading about manipulative use and using manipulatives in working with students. Beth stated that she had tried using the manipulatives differently, using bear counters. She taught the children how to use the bear counters as tools to help with their understanding of the distributive property. She then made available other tools such as counters for the children to use and let them determine what was appropriate use depending on their comfort levels. She shared that the result was, in her opinion, somewhat chaotic and required a great deal of patience on her part. She further stated that most of her students elected to use the bear counters as

she had modeled them, but a few had chosen to use the manipulative and had some success at understanding the problems using trial and error tactics.

New Understandings

With each week of PLC meetings, a shift in teachers' mathematical understanding occurred. Unlike the sense of success they had experienced in regard to literacy due to plentiful professional development in the area of reading, teachers were less secure and had not experienced similar success in mathematics. They had come to the PLC with feelings of inadequacy in regard to their teaching practices and mathematical content knowledge. This topic was a constant theme within the group. It was most apparent when they learned something new and wished that they had been exposed to mathematics in this way before. The researcher noticed an increasingly receptive attitude towards the PLC activities by some group members.

Changes in Group Efficacy

Generally, the group had become a self-motivating force. Each week, members were becoming more adept at sharing experiences. They displayed increasing comfort with their own mathematics ability within the context of the group. The changes were not as dramatic as they had been in the first few weeks, but participants were regularly sharing their experiences. Several members of the group also called or dropped by the researcher's classroom when they had difficulty with a lesson in the mathematics curriculum. The trust level within the group had definitely increased. Annie, Beth, Emily,

and Fran stated that they now felt comfortable talking about mathematics within the group and were hoping that with time this level of comfort would be present in their classroom with their students.

Reasons for Changes in Group Efficacy and Why or Why Not?

The most likely reason for changes in the group efficacy was the fact that group members were now communicating at a more intimate and in-depth level. This encouraged members to be candid regarding their level of knowledge and areas where they needed assistance in improving understanding at each meeting. Cathy and Dena and their absence did not appear to affect the dynamics of the group. Rather, the time was welcomed in that all present had more time to share and discuss.

Analysis of PLC Meeting 7 (October 19, 2010)

Changes in Practice

The researcher's aim in having the group read excerpts from Ma's text was to help them understand the value of being exposed to the diverse thinking of researchers in terms of broadening their own perspectives. In sharing their reactions to Ma's (1999) *Knowing and Teaching Elementary Mathematics*, various members indicated that the readings had proven to be thought provoking. As teachers of elementary students for a range of 6 to 17 years, the group had seen many different approaches to math come and go. The constant, in their opinion and throughout the changes, was that the nation had

seemed to focus less on teaching students to understand and problem solve. Fran reflected on Ma's treatment of subtraction in the book, commenting that she.

had never really thought of the word "borrowing" as being a problem before. I know that I have thought how we can we say "borrow" when we do not pay it back? The word decompose makes much more sense and it would probably make more sense to a child learning the concept of subtraction. (TR 19, p. 1)

Fran stated that today's focus in Florida seemed to be on "whether or not the students we teach are capable and able to compete with the nation when it comes to high school graduation, SAT scores, and AP courses." (TR 19, p.1) She elaborated, describing the focus as being "more on whether or not students can pass the state mandated test versus problem solve and thus be better math students because they can actually apply what they learn." (TR 19, p. 1)

The researcher reminded the group that their home state had new standards guiding "Big Ideas" and that the expectation was that problem solving activities/experiences would begin in kindergarten and continue throughout the elementary grades so that students would be better prepared when mathematical problem solving was required. Beth commented that though she realized that testing and accountability were necessary, she believed that the state mandated testing and all it required was out of control and that the educational process was more than a test. She explained that "testing should be a means to look at data to determine where a child needs help and where we as teachers need to focus."(TR 19, p. 2)

In examining the differences Ma (1999) saw and studied between Chinese and American teachers, Emily stated that she found herself asking many questions, including the following:

How do we as a country change this? How do we teach our teachers to understand the many ways mathematics is related and that there is more than one way to do mathematics problems? How do we give these teachers the confidence and the background they need and deserve to be better at their job and thus produce children who are better able to compete in the world? (TR 19, p. 4)

Fran then brought up the fact that Ma (1999) talked about multi-digit multiplication and the fact that children in America do not understand the process of multiplication and have no idea of how solve problems without the traditional algorithm. Fran also expressed her disbelief that the teachers Ma interviewed could not even describe a different way of computation. She recalled a personal experience,

I remember attending an AIMS workshop that taught multiplication this way and when I got back to school I started out teaching the way I had learned. I ran into road blocks and now I understand it was because I, myself, was not comfortable with the subjects nor could I approach it in different ways as I had never been taught to think that way. (TR 19, p. 4)

New Understandings

The discussion at this meeting, though somewhat philosophical, concerned issues related specifically to instruction or particular problems for students. The group observed that, they, unlike their Chinese counterparts, did not have an understanding of decomposition of numbers. Using Ma's (1999) thinking, they were at somewhat of a disadvantage in teaching mathematics. What did spark their interest, and became the major focus for the group, was that students needed to learn strategies for use in learning

mathematics and that there were many ways to solve a mathematics problem. Initially, the group discussions at weekly meetings had focused on what was going on in their classrooms in a general way.

Ma's (1999) comparisons led Annie to state, and Beth, Cathy, Emily, and Fran concurred with her, that part of the problem with public schools in the United States has been a tendency to "jump on all of these curricular band wagons and then only give our teachers minimal training. Then they do not follow through as they do not have the backup in-service to help them." (TR 19, p. 6) In addition, she indicated that she believed that

As a school system in America we are producing too many children that cannot problem solve. That this may be a detriment in the future of our country, and how we rank with other countries when it comes to inventions, global problems such as pollution and energy sources, and the economic market.(TR 19, p. 6)

Changes in Group Efficacy

The group stated many times during the course of the 10 weeks that mathematics was not viewed as being as important as literacy in their school district setting, and they repeated this concern in this meeting. They also believed that this perceived lesser importance contributed to the lack of comfort teachers had with sharing and with questioning by students in mathematics. Annie, Beth, and Fran stated that asking their students more "how" and "why" questions had opened up entire conversations within their classrooms. (TR 19, p. 7) They also agreed that it was sometimes difficult for them to try new things and that sometimes it was simply work to stay within one's comfort zone than venture out in making a change.

Participants, in their discussion, agreed that procedural and rote mathematics were the norm in mathematics classrooms, and that conceptual understanding and questioning in mathematics meant that they, as teachers, had to be comfortable in their knowledge of the actual mathematics being taught. They all felt that this was sometimes difficult--that it was easy to know how to arrive at a correct answer but much more difficult to explain and teach someone else.

Reasons for Changes in Group Efficacy and Why or Why Not?

Group efficacy did not change a great deal since the last meeting. The group worked well together in this seventh meeting and shared thoughts regarding meaningful mathematical issues. As already noted, Cathy and Dena had missed two meetings in a row. Though they seemed to buy into the ideas that were shared by the rest of the group, they were more observers than participants at this meeting. It was most likely that they needed to “catch up” with the group and determine what had been discussed in their absence. They did share their views when queried by another member for their opinions. The importance of group members’ presence was recognized, as was the distance that can occur between members when all have not shared the same content and experiences.

Analysis of PLC Meeting 8 (October 26, 2010)

Changes in Practice

The participants were skeptical about the change to teaching division in third grade. Teacher A mentioned that, since she had only taught third grade that she had no experience teaching division and really did not know much about the process involved.

The discussion began with an explanation of how division and multiplication have the same inverse relationship as addition and subtraction. The discussion shifted to the changes in presenting certain assists or “tricks” related to fractions that had previously been presented as part of division in the fifth grade. The researcher shared some of the basic “rules” related to division, e.g., if a number is divisible by 3 and 6, it is divisible by 9; if the last two digits are divisible by 4, the number is divisible by 4; a number ending in 5 is divisible by 5; and if a number ends in 0, it is divisible by 5 and 10.

Beth responded that she did not recall learning these rules, and she could see how they would help a child to factor fractions and divide. She also shared that she had not taught much division or fractions (two “Big Ideas” in the NGSSS), and she expressed concern that she would not be able to teach these topics effectively due to her inexperience. Annie, Cathy, Dena, and Emily all agreed that they, too, had very little experience with this subject matter, as they had basically only taught third grade students until this year. Fran, who had taught at many grade levels, said that teaching multiplication and division together seemed appropriate, and that fractions would make

more sense to students if they saw how the mathematics (multiplication and division) were related.

This discussion further reinforced for the group that, though they had not been previously exposed to this teaching method, there was more than one way to present mathematics concepts to students. Fran stated that she believed that a majority of her friends who were teachers had many misconceptions about the teaching of mathematics, especially at the elementary level, and that this should be a concern for the administration and county level curriculum representatives. Given the emphasis on reading and literacy throughout the state, this was a problem compounded by limited funding for in-service. She noted the decline in resources at the school level devoted to mathematics in that a mathematics coach had been eliminated in the prior year.

The group requested that the researcher look for some materials to aid students in their understanding of fractions. Fractions would be emerging as lesson topics within the next two months, and teachers wanted to build their capacity to teach in this area where they had not had much prior experience. The researcher agreed to bring some resources that might be helpful to Meeting 9.

New Understandings

The discussion this week focused somewhat on the realities of the curriculum choices that had been made at both the state and district level and how those decisions impacted them in their day-to-day teaching. The group also recognized that regardless of any beliefs they might hold, there was very little that they could do to change the

situation. They agreed that they needed to focus on their own classrooms and provide the best education they possibly could for their students. They also realized that, in teaching multiplication, division, and fractions, they needed to make a connection for their students so that their understanding would be a more valid one.

Changes in Group Efficacy

Changes in group efficacy at this meeting were minimal. The group seemed to recognize and understand the various positions that were shared as well as the concerns for levels of understanding of the various teachers.

Reasons for Changes in Group Efficacy and Why or Why Not?

At this point, the group appeared to the researcher to be a fully functioning professional learning community. Participants recognized group members' accomplishments, shared successes and challenges, and were prepared to learn from one another.

Analysis of PLC Meeting 9 (November 2, 2010)

Changes in Practice

Annie stated that she could recall many times during her past mathematics instruction situations in which certain students arrived at a correct answer and she unthinkingly ignored the fact that the rest of the class did not understand the lesson and

that they needed further instruction or an alternate way to approach the problem. She even recalled telling co-workers that she believed there was no fault with her methodology and that the students, themselves, were responsible for their failure to understand. She had come to the realization, using different strategies, that though some students still did not understand, they were listening to each other and that the more they observed, shared, and questioned their peers the better understanding they would have. The rest of the group agreed that their classrooms were much more dynamic with the increased discussion of mathematics, and they believed this was a tremendous improvement in the learning environment.

New Understandings

New understandings this week stemmed from the fact that the group was continuing to realize that there are many ways to teach mathematics. Annie described it well. “The students need to work with each and share what they have done. Through this process of trial and error and sharing each other’s work, the most learning and problem solving occurs.” (TR 21, p.2) She further stated that she had several examples over the course of this professional development experience that stood out as moments where student driven instruction changed the thinking in her classroom. One such occasion was when she introduced the concept of prime numbers. She stated that when she introduced the concept, she simply stated, “I have listed some numbers on the board. I want you to figure out in your group what it is they have in common.” (TR 21, p. 2) She did not use the vocabulary and provided minimal assistance. The numbers she wrote on the white

board were 1, 3, 5, 7, and 11. In describing the experience, she commented that since she had not previously taught in third grade, she had forgotten some of the related computational skills. She referred to the prior discussion of prime numbers and divisibility rules in a previous PLC meeting as being helpful to her in being able to anticipate what students might do.

She further stated that, after about 30 minutes of brainstorming, the students came up with the following rule for the numbers: none of these numbers can be divided by anything but 1 or the number. She was delighted with the process in that students discovered and learned a mathematical concept without being taught the “rule.” (TR 21.p.3)

Beth stated that this week she had allowed more student directed problem solving and that her class in general seemed more engaged than usual and not just for a short period of time, but for the entire lesson. She noted that even her most difficult children were participating and learning with her new approach. The group agreed that this was perhaps the greatest lesson they would take from this process--that students need to be fully engaged, involved in the process, and problem solving together.

As promised, the researcher brought resource materials to aid the team in their teaching of fraction concepts and provided them with sample several activities that could be used. The examples were taken from Hillen’s (2000) *Fabulous Fractions*, and had been used by the researcher in various grade-level teaching assignments. The group completed one of the activities (Fraction Fringe on the Cutting Edge) designed to give children a hands-on approach to seeing the relationship between various sets of

equivalent fractions. The other activities were similar and showed such relationships as equivalency, ratios, percents and decimals to fractions.

Changes in Group Efficacy

This week the group indicated that they were going to miss the additional support that the PLC meetings had brought them. Fran expressed her belief that the support did not have to end just because the researcher's study had concluded, and the researcher concurred that participants could continue to provide effective support for each other throughout the first year of the new mathematics adoption and beyond.

Reasons for Changes in Group Efficacy and Why or Why Not?

Each week was somewhat amazing in terms of what the group brought forth to discuss and what they believed they could or should address because of events that had occurred in their classrooms or materials they had read. It should be noted that the reading was completed on participants' time, not school time, which was an indication of their commitment to the PLC process. PLC activities had required these teachers to deal with their own comfort levels in regard to their mathematics knowledge and to, upon occasion, step out of what they considered to be the 'norm' in their teaching styles. The experience was, at times, uncomfortable and frustrating. The group, by their own admission, had discovered on this short journey, that accepting new challenges can expand one's comfort zone.

Analysis of PLC Meeting 10 (November 9, 2010)

Changes in Practice

Once the post-test of content knowledge was administered, discussions focused on the new knowledge and skills that participants had acquired during the 10 weeks of the PLC. The general tone of the discussions and comments was that teachers believed that their time had been well spent.

New Understandings

New understandings for this week came in the form of final sharing and discussing possible future meetings of the group. All members agreed that they would like to continue meeting, not weekly, but at least monthly. They also discussed the possibility of sharing their experience with the PLC, e.g., some of the activities of the group, with their faculty colleagues, so as to encourage other grade-level teams to form PLCs to learn more about the teaching of any subject, especially mathematics.

Group members reiterated the importance of information they had received and how their levels of skill and knowledge had expanded in ways that might not have occurred without the PLC. In particular, some members had developed skills that permitted them to increase the use of manipulatives and the incidences of students working together on a regular basis within their classrooms. It was helpful in this regard that three members of the group, Annie, Emily, and Fran, had higher comfort levels, and so the assignments in the new math series were not as daunting to them.

Changes in Group Efficacy

The participants of this study decided to join this PLC because they saw a need in both themselves as learners and teachers of mathematics and in their student's ability to learn mathematics. As the PLC progressed, they began to apply their new knowledge through strategies and practice that they had learned in the PLC. Throughout this process, they learned and implemented activities and used strategies that both brought success and frustration because they were not effective. Each member expressed the importance of being able to share their successes and failures with the PLC members. The PLC environment made it easier to experiment with new ideas and teaching strategies.

Reasons for Changes in Group Efficacy and Why or Why Not?

The group dynamics changed considerably over the 10-week period. All members agreed that their participation had been beneficial and was well worth the time and effort expended. Beth and Emily, however, expressed their concern for continued support and the need to have a place to de-stress each week after teaching mathematics in different ways. The concern was related to how independent they would be willing to be without the support of the weekly group meetings. Annie and Fran stated that they were sure they could continue to experiment to some degree. Cathy and Dena felt that they had learned a great deal but also expressed that they would, in implementing materials, do so only within their comfort level.

Summary: Analysis of PLC Meetings

As the teachers came to the PLC each week, a shift in their understanding of teaching and learning mathematics occurred. The group, having had substantial professional development in the area of reading, had confidence in their literacy instruction. They did not, however, have that same confidence regarding mathematics instruction. Rather, they had feelings of inadequacy and were not experiencing the kind of success in their teaching practices and their content knowledge of the subject area that they wished for themselves and their students. Additionally, they were experiencing a change in the mathematics curriculum as a result of the adoption of a new Mathematics series which was causing all some level of frustration.

Changes in Practice

It took several meetings for a significant shift to be observed in regard to changes in practice of the group. The fourth meeting of the group provided a turning point for a majority of the group. At this meeting, successes and failures were shared. Several participants indicated that they had observed an increase in participation by students in their classes. They thought this heightened interest was related to their increased enthusiasm and better preparation. Researchers have concurred that being vested in the group improves the chances for effectiveness (Darling-Hammond, 1998; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001).

Group members also changed the way in which they approached their students and the use of manipulatives with their students because of discussions centered around

the de Walle (2006) text and his belief that students should use manipulatives to explain their answers rather than to find their answers. All members of the group expressed that they had, for the most part, been using manipulatives incorrectly with their students for their entire teaching careers.

After the experience with the Liping Ma text (1999), the group also changed their practices when it came to strategies and the thinking process they allowed their students to engage in within their classrooms. The participants noted that they worked to have their students think aloud and talk mathematics with each other when they were solving mathematical problems. This aided students in improving their problem-solving abilities. All participants shared that they believed the mathematical discussions that were taking place in their classrooms improved the learning environment for their students.

New Understandings

A majority of the group had not used mathematics games, number lines, 10-frames and 100 charts as the basis of their teaching before. The teachers were particularly intrigued by the use of thinking strategies that were emphasized in the new mathematics series. These strategies were within the constructs of the *Go Math* series, as well as topics discussed in the mathematics resources the researcher had shared with the group.

The group were also began to understand that manipulatives and their use in the classroom were crucial to the students' learning. The new realization for the group was that manipulatives could serve as tools to help students learn by aiding them in explaining their answers.

Another new understanding that occurred within the group was related to the increased sharing in the group and the benefits teachers saw in learning from one another about strategies colleagues were using. This knowledge gave each member the ability to use strategies that their peers had tried. Teachers indicated that the PLC had expanded their opportunities to learn from one another.

Finally, a shift in the participants' confidence in their own abilities occurred in regard to their ability to teach mathematics. Members demonstrated each week that they wanted to be in attendance, that they wanted to learn new strategies for teaching mathematics in the same way that they had already learned about literacy. The group's comfort level with mathematics did not approach that of literacy because of the concentrated professional development that had been provided in the district related to literacy. It was encouraging, however, that all of the group members expressed in various ways throughout the process that they had learned a tremendous amount. It was their belief that this could only improve the way that they taught mathematics and in turn improve their students' success in mathematics.

Changes in Group Efficacy

What made this PLC most difficult for each of its members were their own comfort levels in mathematics and the teaching of it. When the participants as individual professionals had to step out of what they considered the 'norm' for teaching a certain subject, they found it uncomfortable, difficult, and frustrating at times. What the group discovered on this journey was the importance of expanding their comfort zones by

learning and testing new strategies (Cobb& Bauersfeld, 1995, 2001; Katz, 2007; Simon, 1993; Tzur & Simon, 2004; Tzur et al., 2008)

Changes in group efficacy was the area in which participants showed the most growth throughout the study. The focus of the group, for many of the meetings, was on lessons that all participants felt that neither they nor their students understood. One specific example, which had students and teachers concerned, was related to teaching a lesson on the distributive property. It was during the fourth meeting that the frustrations teachers were having emerged, and a lengthy conversation ensued relative to the topic (the distributive property). What came from this conversation was an improved understanding of the need to refocus student attention on the numbers (breaking them apart) rather than being intimidated by the vocabulary. Teachers were encouraged to deal with the vocabulary of the distributive property later as students became more adept at the concept.

It was after this meeting that the group seemed to improve their group skills by “listening” to one another rather than just “talking,” and they began to experience the benefits of learning from one another about conveying mathematics content in more student friendly ways. This was an example that established a model for the group, showing them that by discussion and sharing with each other, new ways of teaching could be discovered that each, alone, may not necessarily have understood. Researchers have agreed that effective groups have to be able to listen to all members and should have formed a trust level that allows them to share both their successes and failures (Cobb&

Bauersfeld, 1995, 2001; Katz, 2007; Simon, 1993; Tzur & Simon, 2004; Tzur et al., 2008; Welsh, 2008)

Reasons for Changes in Group Efficacy

After the group met several times and they built the “trust” necessary for a successful PLC, they really became a solid group that could discuss and analyze the lessons and the mathematical content that they were struggling to teach their students and understand themselves. Once the group formed this bond, participants could relax and share all the “issues” that were troubling them in their mathematics teaching without fear of judgment or failure. This improved climate gave the participants the ability to see teaching through the eyes of their colleagues and learn of new perspectives. Had they not been in the group, this might not have occurred (Darling-Hammond, 1998, 2007, 2008; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001).

The reason for the change in group efficacy, from the researcher’s perspective, was the recognition/admission by the members of the group that they did not understand something (a mathematics concept) and that by bringing it to the group and trusting their peers they could arrive at a solution together. The concept of the distributive property, used as an example here, was not particularly difficult. These members learned what many authors and researchers have advocated--that they needed to really understand a concept in order to be able to teach it to their students (Darling-Hammond, 1998, 2007, 2008; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001)

Post-Test of Mathematics Content Knowledge

Annie, Beth, and Emily all showed growth in all areas of the post-test of content knowledge. It was the conclusion of this researcher that these participants all indicated throughout the study through their words and dedication to the group that their intention for this study was that they wanted to grow and show an ability to understand differing thought processes for the learning of mathematics for both themselves and their students.

Cathy, Dena, and Fran showed growth for all items except items 1 and 3 which they answered correctly but without explanation. Items 1 and 3 dealt with multiplication and division and a student's ability to show understanding using various methods such as arrays, partitioning, and repeated addition. Fran also answered survey item 4 correctly but did not provide an explanation of the thinking process. This item dealt with a student's ability to solve addition and division using varying strategies.. These participants did not show the consistent level of commitment to the learning process in the PLC as did the other three group members. Although they did show a desire to learn and improve their teaching practices by attending most of the sessions, two of the participants were absent for two meetings. Their lack of explanation related to these items could be due to the fact that they were not present on the dates of the discussions of the mathematical concepts and strategies related to the test items.

Overall, growth was experienced by all participants in the study. However, due to the small number of participants and the short duration of the study, gains were smaller than might have been expected with a larger group and more PLC exposure. What the post-test of content knowledge did show was that by participating in the PLC, group

members did increase their mathematics content knowledge about multiplication and division. This finding related to the benefits of specific professional development was supported by Ball's research (2009) as well as many others in the areas of teacher content knowledge in mathematics and professional development (Ball, 2000; Ball et al., 2005; Burton et al., 2005, 2008; Cobb & Bauersfeld, 1995, 2001; Cwikla, 2004; Darling-Hammond, 1998, 2007, 2008; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001; Katz, 2007; Simon, 1993; Tzur et al., 2008; Tzur & Simon, 2004; Wei et al., 2009)

Post-Study Interviews with Participants

Post-study interviews were conducted with each of the six teacher participants in the study. The independent observer met individually with each of the participants between November 15 and November 19, 2010 at the conclusion of the study. Because the purpose of this study was to investigate the growth of teachers' content knowledge in mathematics, specifically in the areas of multiplication and division, and the effects of their professional learning within their classrooms, the four questions which guided the interviews centered on teachers' perceptions of (a) changes in their practice; (b) new understandings; (c) changes in group efficacy; and (d) reasons for changes in group efficacy.

Changes in Practice

With regard to changes in practice, all participants stated that they had made some changes in their classroom practices in the teaching of mathematics as a result of their

participation in the study. All participants stated that they were using a more “hands-on approach” to teaching mathematics and that they were allowing more “mathematical talk” in their classrooms, and that this was making a difference in their students’ performance in mathematics. Annie and Cathy stated that they were teaching their students more strategies for solving problems and that they believed that because they had been able to share these strategies in the PLC they were better equipped to help their students use differing techniques (Darling-Hammond, 1998, 2007, 2008; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001).

New Understandings

In the area of new understandings, the participants expressed that they had developed new mathematical understandings within the PLC group and that this understanding was being transferred into their mathematical instruction with their students. Beth, Dena, Emily, and Fran stated that they were now more comfortable with their students solving problems in more than one way and sharing their understandings with their fellow classmates. This is a practice advocated by teacher educators and researchers that provides support for diverse learning styles of students. Researchers have agreed that when teachers are taught and exposed to best practices and effective problem solving strategies in mathematics that their students will benefit from their knowledge. The comfort level, and thus the confidence, of classroom teachers has been instrumental in developing high performing students. Confident, capable teachers lead to competent,

capable students (Ball, 2000; Ball et al., 2005; Cwikla, 2004; Darling-Hammond, 2001, 2008; Wei et al., 2009).

Group Efficacy

In the area of group efficacy the participants all stated that they felt more comfortable having a group of peers with whom to share and discuss mathematics. They also stated that the meetings each week were something that they believed were having an effect on their ability to teach mathematics and in turn better understanding for their students learning. (Darling-Hammond, 1998, 2007, 2008; Doolittle et al., 2008; DuFour et al., 2004; Garet et al., 2001)

An interesting aspect of this study was that the participants had already worked together as a team for several years. They also stated several times throughout the process that they believed they already worked well together and “shared” with each other. However, a shift in group dynamics, for the better, occurred during the course of the 10 weeks of PLC meetings. Though the group had shared and worked as colleagues, they had not really engaged in professional discussion related to mathematics and their attitudes toward the teaching of related concepts. The PLC organization brought the group together as professionals who realized they all could benefit from new knowledge and could learn from one another. Darling-Hammond (1998, 2007, 2008) has stressed the importance of colleagues in schools nurturing their relationships, indicating that just because a team of people work together does not mean that they develop a sharing and mutually beneficial relationship.

Changes in Group Efficacy

The participants all stated that they believed the group's efficacy changed because of trust and mutual discussion regarding their individual challenges in delivering mathematics instruction. Each week when the group shared and discussed strategies and the new math series for multiplication and division as well as other areas of mathematics, members saw that they were not alone in their struggles to learn mathematics and teach effectively. This gave validation to them as individuals and as a group, and this helped them grow in readiness to expand their knowledge base. Researchers have addressed the problem of isolation for teachers and the fact that sharing generally only occurs when forced through some sort of professional development. Advocates of PLCs have addressed the potential of this form of professional development as an effective tool that over time, with work and trust, can enhance the professional growth of groups of teachers beneficial to individual teachers, teams of teachers, and ultimately the students in their classrooms (Ball, 2000; Ball et.al. 2005; Cwikla, 2004; Darling-Hammond, 2001,2008; Wei et al., 2009).

Themes Emerging From the Research

Throughout this research, several themes emerged in each area of the study. The themes that emerged in pre-study interviews were relevant in that they provided insight into the participants' background knowledge in mathematics as both teachers and learners

of mathematics. The post-study interviews enabled the researcher to elicit the participants' perceptions of what they had learned throughout their participation in the study that had relevance to themselves as both teachers and learners. The pre- and post-tests of content knowledge showed the participants' basic understandings of skills and strategies both before and after their participation in the study. The professional learning community (PLC) showed the groups' progressive growth as a cohesive unit of learners and classroom practitioners in the area of mathematics.

There were several themes that emerged from this research that are quite relevant to the teaching profession in general. The first and most prominent theme was a lack of mathematical understanding on the part of the participants. This lack of mathematical understanding was evident in the responses participants provided in pre- and post-study interviews and pre- and post-tests of content knowledge. Participants were required to provide specific information to questions so as to determine their understanding of mathematical concepts as well as their understanding of instructional strategies related to these concepts. Mathematical understanding is crucial to effective teaching of mathematics, and much research has been conducted by Ball (2009) and Ball et al. (2005) on this topic. It is this deficit on the part of teachers that has contributed to the problems of students who do not understand mathematics and cannot problem solve or "explain" their mathematical answers. A singular solution to this problem has not been found, but researchers have indicated that better teacher education is one key to resolving the problem.

Another theme that was apparent in this study was the lack of professional development specifically related to mathematics that had been available to these teachers. Researchers have shown that effective professional development must take place in order for teachers to remain “fresh” and current. A substantial amount of professional development has been delivered in the area of literacy in the state of Florida, but that same attention has not been devoted to assisting teachers in strengthening them as teachers of mathematics.

A third theme that emerged in this study was the value of structures, such as the professional learning community, that create opportunities for teachers to collaborate, share, and learn from one another. In this research, a professional learning community met that need for teachers. Darling-Hammond (2001; 2008), has highlighted, in her work with other countries, the fact that American schools lack dedicated time for professional collaboration. The participants in this study shared and grew as result of their collaboration for this research. Participants expressed that they did not feel as isolated once they began working together and that the resolutions regarding various mathematical issues could only be beneficial to their students as well as themselves.

The need to encourage growth in teachers by sharing current research and best practices was also a theme that emerged from this study. These participants were exposed to materials that were already available to them at their school site, but none realized what was available and how those materials could help them use more effective teaching strategies within their classrooms. The facilitator was able to support teachers in this study in the same way dedicated personnel, i.e., mathematics coaches or curriculum

resource teachers, would. It is doubtful that most teachers would independently find the time in their busy work days in classrooms to read, reflect on, and try new strategies.

A final theme became increasingly apparent over the 10-week period during which teachers met in the professional learning community. The participants had initially demonstrated a willingness to participate in a “research project,” but as time went on, they displayed a collegial interest in sharing their successes and their occasional failures as they tried new strategies. They became a small community of learners who together made decisions that would help them advance their skills in their mathematics teaching, particularly related to multiplication and division.

Summary

This research was conducted to explore the following research question:

To what extent does participation in a professional learning community comprised of elementary grade level teachers in one central Florida elementary school influence teachers’ mathematical understanding of basic multiplication and division strategies?

The PLC in this study proved to be an effective tool to improve teachers’ content knowledge in mathematics and, therefore, to improve their ability to teach mathematics to their students. Teachers participating in the PLC benefited from sharing their experience with one another as well as exposure to the resources available at their school site. During this study, the participants were able to read and share examples of research-based best practices in mathematics, and participants then used this new information and additional mathematical content knowledge in their classrooms in teaching their students.

This PLC influenced this group of teachers on many levels both as a group and as individuals. The group learned that despite the fact that they had worked together and already felt that they were a cohesive group the process associated with the PLC enhanced their working relationships. As a team, they were able to grow and work together at a new level, one that required trust and commitment and enabled participants to share their successes and failures with one another. The group learned that by working together they could better understand concepts and arrive at effective ways to teach mathematics strategies that differed from their previous mathematics experiences. They also learned to use strategies and mathematics resources to gain insight into and knowledge about better instructional methods. They could refine their plans for teaching selected material within the group before they actually taught it to their own students. The greatest achievement of the group, as expressed by one of the team members, was, “We put ourselves out there to each other, and despite the fact that we might have felt inadequate, we still dove in and learned from it.”

Recommendations for Practice

This dissertation looked at one specific example of a PLC that consisted of six third grade teachers from the same school site. Despite its narrow base, the findings and implications of this research extend beyond the participants of this study. The study has added to the research in the area of professional development, specifically professional learning communities and their potential for impacting teachers’ mathematical content

knowledge. This research has added to the data on teachers' improved content knowledge in mathematics.

The first recommendation emerging from this study is that consideration should be given to targeted professional development to support teachers in mathematical instruction. Participants in this study lacked the background and guidance needed to be able to further their understanding in mathematics without support. The findings in this study were in agreement with those of Ball (2000) who found that effective mathematical instruction cannot be achieved without effective teacher understanding of the mathematical content to be taught (Ball, 2000; Ball et al. 2005). In this research, all participants expressed, to varying degrees, a lack of understanding of basic content knowledge in mathematics, specifically in multiplication and division.

The second recommendation, upon completion of this study, is that school districts should consider the value of specific group structures designed to assist teachers in expanding their content knowledge and exposing them to best practices. This study revealed a lack of natural peer collaboration among elementary school teachers and reinforced the well known isolation of many elementary classrooms. The structure of the PLC provided an atmosphere in which participants could work together, support one another, and be exposed to varied instruction and best practices. The PLC structure created an environment in which participants could develop professional relationships that would benefit each of them. Darling-Hammond (2008) has emphasized the success of countries that allot time for teachers to work together in terms of effective results with student achievement in the area of mathematics (Darling-Hammond, 2001, 2008;

Darling-Hammond). Other structures such as study groups could be used to benefit teachers by supporting targeted professional development.

A third recommendation, based on the findings of this study, is in reference to the benefits of exposing teachers to the results of current research that supports the implementation of new strategies and teaching techniques in their classrooms. The resource books chosen for this study were selected because they represented resources that were readily available in the school's mathematics resource room. Though Liping Ma's *Knowing and Teaching Mathematics* (1999) and Van de Walle's book *Teaching Student Centered Mathematics* (2006) had been available to these participants, they had not been accessed. The researcher, by sharing with the group what was available to them for their daily use, and suggesting specific relevant reading selections, provided the necessary motivation for teachers to access the materials and use them. Once exposed to the strategies, participants were quite willing to discuss and model for each other how they would use strategies. Given a common expanded research base, they freely discussed the potential for success, their concerns as to failure, and the constraints they anticipated in their own classrooms.

A universal concern in regard to staff development relates to time. In this research, the need for time was clear. In order to have a professional learning community, time must be allocated to support teachers in meeting, planning, learning, and reflecting. Time was definitely an element that all members of the group acknowledged as lacking when it came to studying or improving their teaching background knowledge.

Similarly, in encouraging reviews of research by teachers, another recommendation is that a supportive structure including professional staff should be provided which encourages focused distribution of materials and time to read and reflect on selected materials in order that teachers can learn and share new knowledge. In the case of this study, the participants viewed their exposure to additional mathematics resources as a part of the commitment that they made to the professional learning community research. Researchers have indicated that when teachers are exposed to literature and resources that show examples of effective mathematical teaching they are more likely to experiment and implement some of their newly acquired knowledge in their classrooms (Darling-Hammond, 1998, 2007, 2008).

Based on the experiences in the professional learning community, it is recommended that when new curriculum is adopted in a school district, extensive support and training should be provided throughout the adoption period. This group of teachers had not received any formal training in the use of the mathematics curriculum materials prior to their PLC experience. Numerous authors and researchers have cited this as being typical in that teachers implementing the materials adopted by their respective states have not had a chance to look and “play” with the information, assessment, planning tools, intervention materials, and manipulatives (Ball, 2000; Ball et.al. 2005; Darling-Hammond, 1998, 2007, 2008). Teachers in this PLC were able to work with the on-line resources (to which they had not been previously exposed) that were available to support their newly adopted mathematics curriculum. Though it is realized that 21st century budget challenges place tremendous constraints on what districts can and cannot provide,

it is recommended that all possible steps are taken to ensure sufficient technology support for new curriculum implementation. As has been indicated by mathematics and science researchers, America's students need to be exposed to the technical advancements in math and science to be competitive with the rest of the world (Ball, 2000; Ball et.al. 2005; Darling-Hammond, 1998, 2007, 2008).

It is further recommended that schools and school districts examine carefully their use of personnel to provide ongoing support for teachers. In times of tight budgets, curriculum resource personnel, supervisors, mentors and other professionals beyond administrators who provide instructional leadership are growing less in number. Darling-Hammond has written that teachers are typically left to their own devices with little guidance from anyone, unless they are under-performers or informally mentored by a fellow teacher (Darling-Hammond, 1998, 2007, 2008).

This study provided a good example of the kind of assistance facilitators and mentors can provide. The researcher/facilitator was able to explore misconceptions about mathematics in the areas of division and multiplication in the context of the NGSSS for third grade, and convey helpful strategies as to how the standards can be effectively taught to students using the new state mandated mathematics curriculum. The setting of the professional learning community, supported by a facilitator, gave participants an opportunity to experience and discuss the new curriculum and to have various aspects modeled appropriately. It also enabled the participants to experience the use of the strategies they were learning within the group as well as in their classroom.

A final recommendation that stems from this research would be that colleges and universities should consider requiring more mathematics content in the programs of study of elementary education teacher candidates. Currently, unless the student is a mathematics major the average number of classes taken by an elementary education major in college is two or a total of six credit hours. These two classes are usually methods classes with little content. Ball (2000) and Ball et al. (2005) have shown that teachers who are better prepared in the fundamental knowledge of a subject area are better able to understand what they are teaching and in turn teach their students using variety of methods and strategies

Recommendations for Future Research

1. This study was conducted with a very small group of teachers. The study could be repeated with a larger voluntary group that might include various grade levels.
2. Professional Learning Communities take many forms. Future research might be conducted to explore different formats and their professional development benefits to teachers.
3. Student achievement was not considered in this study. A follow-up study could be conducted to investigate student's achievement as it relates to PLC participation.
4. A study could be conducted to investigate student achievement in schools structured to include support staff to mentor and facilitate professional

development for teachers as opposed to those districts where this support is not present or has been discontinued.

5. A study could be conducted to investigate a group of teachers who are either all male or mixed gender. The focus of this research could be concentrated on gender differences, if any, in success in teaching mathematics.

Conclusion

In conclusion, the findings of this research study showed a clear and defined link between teacher content knowledge, professional development delivered through a professional learning community, and teachers' ability to teach their students using a variety of research-based strategies and methods. Teacher participants in this study showed growth in both their understanding of mathematics content knowledge and their perceptions of their ability to deliver mathematics instruction to their students.

APPENDIX A
PRE-STUDY INTERVIEW QUESTIONS AND GUIDE

Letter Representation of interviewee _____

Section #1: You as the Learner of mathematics

1. What sort of mathematics classes did you take in high school and college?
2. When you think back on your own mathematics education what experiences stick out most to you?
3. What did you learn in mathematics classes?
4. What were your teachers like in math class?
5. Did you like or dislike your math classes? Why?
6. Are there any other experiences that stick out for you in mathematics classes?
7. I have a list of typical high school mathematics classes here; do you recall which ones you took? If so, can you tell me what the content of the class was?
8. Did you receive any help with your mathematics from a sibling, your parent s, another relative, or a tutor? If so who? Did they help you?
9. What courses did you take at the college level?
10. Can you tell me what any of these courses were about? What do you remember about the course? The professor? Your experience in general?
11. Did your experiences in mathematics class's change from high school to college? Were they for the good or not so good?
12. Do you feel that your background in high school and college has helped you with the teaching of mathematics? Why or why not?

Section #2: You as the teacher of mathematics

1. Why did you become a teacher?
2. When did you first start thinking about being a teacher?
3. In order to teach mathematics in elementary school what level mathematics do you feel that you need or needed to understand?
4. Why did you answer the previous question the way you did?
5. Do you like a particular area of mathematics?
6. Why did you answer the previous question the way you did?
7. Do you particularly dislike an area in mathematics? *What area of mathematics do you dislike?*
8. Why did you answer the previous question the way you did?
9. When you teach mathematics to your students are there some things you do not understand as well as others? If so, what are they? Why do you feel this way?
10. Now, are there some topics in mathematics that you enjoy teaching? If so, what are they? Why?

11. Can you tell me of a particular **student's success** in your mathematics class?
Why do you feel **they were** successful? Were you responsible for that success?
If so how? If not who was?
12. Can you tell of a particular student's failure in your mathematics class? Why do you feel that student failed? Did you feel responsible? If not who was?

Section #3: You and your perceptions of mathematics learning and teaching

1. Do you know anyone of whom you think is an excellent mathematics student?
Why? What do they do for a living?
2. **?In # 14, you had to tell me someone who in your opinion is excellent in math, now tell me why you think they are excellent in mathematics.**
3. Do you know anyone that is not particularly great **in** mathematics? Who?
4. In question #16 you had to tell me someone who is not great **in** mathematics, what do they do for a living? In your opinion, why are they not excellent **mathematic** students?
5. If you could improve in any area of mathematics instruction, what would it be?
Why?
6. Would you ask for help from a co-worker when you didn't understand a mathematics lesson that you had to teach? Why or why not?
7. If you could not ask, a co-worker for the previous question is there anyone you could ask? Who? Why would you feel comfortable with them verses a co-worker?
8. Have you ever been asked to help a co-worker with their mathematics instruction?
When? How did it go?
9. Would you attend a professional development on mathematics?
10. Have you attended professional **development regarding** mathematics? If so, what was the subject matter? If not, why not?
11. Did you feel a benefit from the professional development courses you took specifically for mathematics instruction? Is so why? If not, why not?
12. Did you feel that there was enough support for any professional development you have taken in the area of mathematics? If so, what sort of support was there?

APPENDIX B
PRE- AND POST-TEST OF MATHEMATICS CONTENT KNOWLEDGE

Identifying Teacher Letter A-G _____

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.

Explain what each statement below tells you about the student's number sense.

- a. 0 is an even number.
- b. 0 is not really a number.
- c. It is a placeholder in writing big numbers.
- d. The number 8 can be written as 008.

2. 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 strategy demonstrates that the student understands the concept of prime numbers? Explain your 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.

3. 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:

How does each student's method reflect his or her understanding of the two digit multiplication process?

Student A	Student B	Student C
35	35	35
X 25	X 25	X 25
<u>125</u>	<u>175</u>	<u>25</u>
+75	+700	150

4. 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.

Explain why you selected your specific answer.

5. 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:

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

What does his method say about Todd's understanding of place value?

6. Ms. James' class was investigating patterns in whole-number addition. Her students noticed that whenever they added an even number and an odd number the sum was an odd number. Ms. James asked her students to explain why this claim is true for all whole numbers. After giving the class time to work, she asked Susan to present her explanation: I can split the even number into two equal groups, and I can split the odd number into two equal groups with one left over. When I add them together I get an odd number, which means I can split the sum into two equal groups with one left over. **Why?**

7. Mr. Garrett's students were working on strategies for finding the answers to multiplication problems. Which of the following strategies would you expect to see some elementary school students using to find the answer to 8×8 ?

- a) They might multiply $8 \times 4 = 32$ and then double that by doing $32 \times 2 = 64$.
- b) They might multiply $10 \times 10 = 100$ and then subtract 36 to get 64.
- c) They might multiply $8 \times 10 = 80$ and then subtract 8×2 from 80: $80 - 16 = 64$.
- d) They might multiply $8 \times 5 = 40$ and then count up by 8's: 48, 56, 64.

Why would some of Mr. Garrett's students select strategy B?

8. Students in Mr. Hayes' class have been working on putting decimals in order. Three students -- Andy, Clara, and Keisha -- presented 1.1, 12, 48, 102, 31.3, .676 as decimals ordered from least to greatest.

What error are these students making? (Mark ONE answer.)

- a) They are ignoring place value.
- b) They are ignoring the decimal point.
- c) They are guessing.
- d) They have forgotten their numbers between 0 and 1.
- e) They are making all of the above errors.

Tell why these students are making this error.

9. You are working individually with Bonny, and you ask her to count out 23 checkers, which she does successfully. You then ask her to show you how many checkers are represented by the 3 in 23, and she counts out 3 checkers. Then you ask her to show you how many checkers are represented by the 2 in 23, and she counts out 2 checkers.

What problem is Bonny having here? (Mark ONE answer.)

- a) Bonny doesn't know how large 23 is.
- b) Bonny thinks that 2 and 20 are the same.
- c) Bonny doesn't understand the meaning of the places in the numeral 23.
- d) All of the above.

Explain why she is having this problem?

10. To introduce the idea of grouping by tens and ones with young learners, which of the following materials or tools would be most appropriate. (Circle ONE answer.)

a) A number line

b) Plastic counting chips

c) Pennies and dimes

d) Straws and rubber bands

e) Any of these would be equally appropriate for introducing the idea of grouping by tens and ones.

How would using pennies and dimes help students increase their understanding of grouping tens and ones?

APPENDIX C
PERMISSION FOR USE OF CONTINUUM
AND LEARNING MATHEMATICS FOR TEACHING RELEASE ITEMS

From: Rick DuFour <rdufour923@gmail.com>
Date: September 16, 2009 9:03:48 PM EDT
To: Beverley <queenmum@cfl.rr.com>
Subject: Re: Professional Learning Communities

You may use the continuum for your research project.

Rick DuFour
On Sep 13, 2009, at 11:32 AM, Beverley wrote:

image001.jpg@01CA3465.CB535DA0

Hello Dr. DuFour

Please allow me to introduce myself, I am Beverley Christmas Price and I am a doctoral student at the University of Central Florida. I am writing a proposal for my dissertation on Professional Learning communities. I would like your permission to use "The Professional Learning Community Teachers Collaborative Continuum" for data collection instrument in my dissertation.

Thanks,

Beverley C. Price

Re: e-mail

Phelps Geoffrey <gphelps@umich.edu>

Re: e-mail

Beverley Price <beverley_price@scps.k12.fl.us>

Hi Beverley,

Sorry I have been hard to reach and slow to respond. You have permission to use the LMT released items as indicated in your email. Good luck with your work.

Best,

Geoffrey

Geoffrey Phelps, PhD

University of Michigan

610 E. University, 1600 SEB

Ann Arbor, MI 48109-1259

Phone: 734-615-6076

Fax: 734-615-7441

Email: gphelps@umich.edu

LMT: <http://sitemaker.umich.edu/lmt>

> [Florida has a very broad Public Records Law. Virtually all written communications to or from School District Personnel are public records available to the public and media upon request. E-mail sent or received on the School District system will be considered public and will only be withheld from disclosure if deemed confidential pursuant to

APPENDIX D
POST-STUDY INTERVIEW QUESTIONS

POST-STUDY INTERVIEW QUESTIONS

1. What if any changes did you make in your practice in the classroom because of the PLC.
2. What new understandings of mathematics did you find because of your participation in the PLC?
3. What changes occurred in the group efficacy while you participated in the professional learning community?
4. What were those changes if they occurred? If changes did not occur, why might that be?

APPENDIX E
INSTITUTIONAL REVIEW BOARD APPROVAL



University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Beverley C. Price**

Date: **July 08, 2010**

Dear Researcher:

On 7/8/2010, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review: Exempt Determination
Project Title: Professional Learning Communities Effect Upon Teachers
Content Knowledge for Mathematics
Investigator: Beverley C. Price
IRB Number: SBE-10-07012
Funding Agency:
Grant Title:
Research ID: SBE-10-07012

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in IRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Joseph Bielitzki, DVM, UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 07/08/2010 04:50:38 PM EDT

IRB Coordinator

APPENDIX F
SCHOOL DISTRICT PERMISSION



SEMINOLE COUNTY
PUBLIC SCHOOLS

BILL VOGEL, Ed.D.
Superintendent

Educational Support Center
400 E. Lake Mary Boulevard
Sanford, Florida 32773-7127

RONALD L. PINNELL, Ed.D.
*Executive Director of
Secondary Education*

WALT GRIFFIN
*Executive Director of
Secondary Education*

Telephone: (407) 320-0039

Facsimile: (407) 320-0293

Suncom: 351-0038

Visit Our Web Site
www.scps.k12.fl.us

July 13, 2010

Ms. Beverley Christmas Price
1305 MacTavandash Drive
Oviedo, FL 32765

Dear Ms. Price,

I am in receipt of the proposal and supplemental information that you submitted for permission to conduct research in the Seminole County Public Schools. After review of these documents, it has been determined that you are granted permission to conduct the study described in these documents under the conditions described herein.

Your school principal and teachers have the authority to decide if he/she wishes to participate in your study. Since you already have the 3rd grade teachers approval, please contact Dr. Phillips and explain your project and seek permission to conduct the research. You are expected to make appointments in advance to accommodate the administration and/or staff for research time. Please do not use SCPS email or courier mail to disseminate your research information.

Please forward a summary of your project to my office upon completion.
Good Luck!

Sincerely,

Ronald L. Pinnell, Ed.D.
Executive Director
Secondary Education

RLP/jr
Dr. Kathy Phillips

APPENDIX G
PARTICIPANTS' INFORMED CONSENT

Professional Learning Communities

Background Information:

The purpose of this research study is to determine teacher's attitudes while working in professional learning communities in addressing strategies and instructional approaches teachers need to teach students in the area of mathematics. This study will give teachers a model of what professional development and research based strategies they need to ensure success for teachers and students. The focus of this study is on teachers collaborating, sharing strategies, rather than working in isolation.

Procedures:

If you consent to be in this study, you will be asked to meet as a team once every other week for 60 minutes, participate in an interview with the researcher, take a survey to determine attitudes about professional development, and participate in a focus group that focus on mathematics instructional strategies and methods. These meetings will be recorded so that the researcher can transcribe them later and study the information. You will then participate in a focus group conducted by the school Assistant Principal.

Voluntary:

Your participation in this study will be voluntary. Your decision whether or not to participate will not affect your current position as a teacher in any way at all. If you initially decide to participate, you are still free to withdraw at any time without penalty or repercussions.

Risks and Benefits of Being in Study:

There are no risks associated with being in this study and the benefits would be to provide teachers with professional development, work in a collaborative structure to share strategies to support mathematics education. You may refuse to answer any questions you consider invasive or stressful. You may withdraw from the study at any time.

Compensation:

There will be no compensation for participating in this study.

Confidentiality:

The records of this study will be kept private. In any report of this study that might be published, the researcher will not include any information that will make it possible to identify you. Research tools will be kept in a locked file, and only the researcher will have access to the records. All tape recording will be locked away and will be destroyed after six months time.

Contacts and Questions:

The researcher conducting this study is **Beverley Christmas Price**. The researcher's faculty advisor is **Dr. Jeffrey Kaplan** and his email address is jkaplan@ucf.mail.edu.

You may ask any questions you have now. If you have questions later, you may contact Beverley Price at queenmum@cfl.rr.com. You will receive a copy of this form from your researcher.

Statement of Consent:

I have read the above information. I have asked questions and received answers. I have consent to participate in the study.

Printed Name of Participant _____

Participant Signature _____

Signature of Investigator _____

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