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Professional development in elementary school mathematics

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This is to certify that the doctoral study by

Carrie Scoggins

has been found to be complete and satisfactory in all respects,
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Walden University
2010

Abstract

Professional Development in Elementary School Mathematics

by

C. Scoggins

M.A., Piedmont College, 2005

B.S., University of West Georgia, 2001

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Teacher Leadership

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Abstract

This study was an investigation of mathematics instruction and professional development at a rural elementary school. The Department of Education in a southern U.S. state implemented a new curriculum in 2007 that required major changes in mathematics instruction. The problems were that teachers engaged in different levels of training and many students experienced a decline in mathematics scores on the Criterion-Referenced Competency Test (CRCT). The historical learning theories of Piaget and Vygotsky framed the study. The guiding questions focused on how to improve mathematics instruction through professional development for teachers. Nine elementary school educators served as purposefully selected participants. The research design was a case study that included triangulation of data from teacher interviews, a research journal, and documents such as lesson plans. Open coding and selective analysis generated 9 themes and 9 subthemes to answer the guiding questions. Findings showed that participants believed content and pedagogy should be addressed through professional development led by teachers themselves. Additional findings were that teachers valued collaboration, literature and research, observation, vertical alignment, engagement, relevance, and support. Results were used to guide the design of a mathematics professional development program (MPDP), a collection of relevant tasks, literature, and online resources geared toward improving teachers' content and pedagogical knowledge. The MPDP is immediately applicable in an elementary school setting. The implications for positive social change include better mathematics instruction that will prepare U.S. students to compete in the modern economy and world of mathematical and scientific advances.

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Dedication

I lovingly dedicate this doctoral study to my precious niece and nephew, Alena (age 8) and Calvin Carter (age 6). You are my inspiration! I love you with all my heart. I hope that one day you will pursue your dreams and work hard to accomplish your goals.

I know you thought Aunt Carrie would *never* be finished with her homework, but I am! What would you like to do now? I'm ready!

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"For I can do everything through Christ who gives me strength." Phillipians 4:13. Without the ever-flowing spirit of my Lord and Savior, I never could have persevered.

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Next, I would like to acknowledge my friends and family who supported me unconditionally. First on that list is Daniel, my precious husband. He has earned an honorary doctorate degree in marriage! He did so much more than make frantic trips to the store for ink cartridges and printer paper. He also provided tissues and hugs during Sob Fest 2008, Bawl of Tears 2009, and Blubber Mania 2010. He comforted me, prayed with me, and loved me through all my craziness. I am the luckiest girl in the world.

My mom Sandy Dixon, who would only half-heartedly allow me to entertain the thought of giving up, definitely warrants praise. She never missed a chance to tell others how proud she was of her daughter who was working on her doctorate. Now she can brag a little bit more. She always told me how important education was, and I never forgot it.

Thank you to my sister Casi Stephenson for telling me not to give up, for listening to me cry, and for being on my side always. I think she, more than anyone else, truly shares in the joy of this accomplishment.

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To Michelle, Kim, Ralph, Angie, Melissa, Viki, Ted, Joy, Gwen, Chuck, Emily, Paula, Kathy, Bob, Christy and any other souls who made the unfortunate mistake of asking me how school was going. I'm sorry for being so . . . detailed . . . in my responses. Thank you for listening. Thank you for your prayers.

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Miller, with all my heart, I wish you were still here harassing me while I worked. I would have endured a thousand more of your shenanigans rather than lose you the way we did. You were loved, and you are missed.

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Section 1: The Problem

Introduction

Mathematics achievement of students in the United States requires serious attention (National Council of Teachers of Mathematics [NCTM], 2000; 2009; National Mathematics Advisory Panel [NMAP], 2008; Ysseldyke et al., 2003, p. 248). The lack of student success in mathematics could be attributed to procedure oriented teaching practices that have been observed in classrooms (Hiebert et al., 2005; Mann, 2006; NCTM; NMAP; Stigler & Hiebert, 1999; Wallis & Steptoe, 2006). For many years, mathematics instruction in typical U.S. classrooms has relied upon textbooks and memorization (Caron, 2007; Farr, Tulley, & Powell, 1987, p. 59; Mann, 2006, p. 248; Mtetwa & Garofalo, 1989; National Research Council, 1989; Patton, Fry, & Klages, 2008, p. 494; Stigler & Hiebert, 1999). Arithmetic has been a focus, and teachers have insisted that students become proficient at computational procedures (Bottge, 2001; Bransford, Brown, & Cocking, 1999; Desimone, Smith, Baker, & Ueno, 2005; Goldsmith & Mark, 1999; Hiebert et al., 2005; Mann, 2006; Mortiboys, 1984; Mtetwa & Garofalo, 1989; Stigler & Hiebert, 1999; Timmerman, 2004). These practices have come to be accepted throughout the United States, with many teachers and students developing a view of mathematics in which rote memorization is the expected outcome (Caron, 2007; Goldsmith & Mark, 1999; Mann, 2006, p. 249; Montague, 2003, p. 166; Mtetwa & Garofalo, 1989).

Educational researchers in the United States have examined the teaching beliefs and practices of mathematics educators in Japan (Desimone et al., 2005; Hiebert et al., 2005; House, 2006; Stigler & Hiebert, 1999), because Japanese students typically perform better than U.S. students on standardized mathematics tests (National Center for Education Statistics, 2000, 2004, 2008). Experts have noted critical differences between instructional philosophies and methods of mathematics teachers in the United States and in Japan. In 2006, Georgia's State Department of Education adopted a new mathematics curriculum modeled after mathematics standards in Japan (Georgia Department of Education, 2005b). Mathematics education reform efforts called for teachers to implement a balanced approach for teaching mathematics, including a focus that includes procedural fluency, conceptual understanding, and practical application (Greenberg & Walsh, 2008; NCTM, 2000; NMAP, 2008).

Traditional pedagogical methods employed in U.S. classrooms send a message to students that "mathematics does not make sense" (Timmerman, 2004, para. 4). Instead, students may view mathematics as material that must be memorized. The focus on procedures "discourage[s] understanding" (Bottge, 2001, para. 16). Instead of fostering the notion that all students are capable of learning mathematical concepts (Schwartz, 2006, p. 50), procedure based teaching fosters the idea that only people with the ability to memorize complex procedures can perform proficiently in mathematics (Dogan-Dunlap, 2007; Kamii & Lewis, 1993; Mtetwa & Garofalo, 1989; NCTM, 2000; Reinhart & Timmerman, 2004; Timmerman, 2004).

Factors that may contribute to misunderstandings about mathematics are teacher beliefs, attitudes, or perspectives about what mathematics is and how to best teach it. Patton et al. (2008) and Schubring (2006, p. 675) found that teachers' personal beliefs about mathematics can directly affect their teaching practices, while Desimone et al.

(2005, p. 525) speculated that teacher education programs may not adequately prepare prospective teachers to teach mathematics conceptually. Patton et al. found that a significant number of U.S. preservice teachers believed that mathematics instruction involves primarily delivering facts and procedures (p. 494), possibly because of their own experiences as mathematics students. Timmerman (2004) examined the perspectives of student teachers and discovered that many of them saw mastery of information as the goal. A negative consequence associated with this idea is that teachers, after having developed their own conceptual understandings of mathematical ideas, require students to simply master skills (p. 486). Reinhart (2000) claimed that when teachers show students the "shortcuts" (p. 57) in mathematics, they undermine the logic and reasoning that encompasses the subject. In doing this, teachers can lead students to learn skills in isolation without realizing that mathematics is logical (Bransford et al., 1999; Montague, 2003, p. 167; Reinhart, 2000; Timmerman, 2004, para. 4). Therefore, teachers' perceptions of mathematics are important when examining student achievement.

Teachers' emphasis on computation without context (Desimone et al., 2005; Goldsmith & Mark, 1999; Hiebert et al., 2005; Mann, 2006, p. 249; Mortiboys, 1984; Mtetwa & Garofalo, 1989; Stigler & Hiebert, 1999; Timmerman, 2004) has likely contributed to the finding that many students lack the ability to apply procedures to solve authentic problems (Chard et al., 2008, p. 17; Graeber, 2005, p. 356, Mann, 2006; Mastriopieri, Scruggs, & Shiah, 1991). Bottge (2001) stated that in some cases, students' natural thoughts about mathematics may be overpowered by the tendencies of teachers to focus on heuristics. These methods are not enabling students to meet expectations on standardized tests in mathematics (American Institutes for Research, 2005; Georgia

Department of Education, 2006, 2007a, 2008; National Center for Education Statistics, 2000, 2004, 2008; NMAP, 2008), which suggests a need for reform in the area of mathematics education.

Definition of the Problem

Student achievement in mathematics at ABC Elementary School (a pseudonym) decreased in 2007 and 2008 after Georgia's state curriculum changed (Georgia Department of Education, 2007a, 2008). ABC Elementary School is a rural school of approximately 400 students in northwest Georgia. The student achievement problem was exacerbated by teachers' and administrators' concerns about how to meet instructional expectations with little or no prior training in teaching mathematics conceptually (A. Ingram, personal communication, September 8, 2006; K. Gilstrap, personal communication, September 10, 2006).

While the previous curriculum required students to learn a broad number of topics at a somewhat shallow level, the new curriculum pushed students to learn fewer topics with great depth and rigor (Georgia Department of Education, 2005b). In relation to Bloom's (1956) taxonomy of cognitive objectives, students needed to experience mathematics at all six cognitive levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. For teachers, this meant that traditional methods of instruction were no longer sufficient, as students must be able to demonstrate conceptual understanding of mathematics topics instead of surface knowledge. They must be able to apply mathematical ideas to solve authentic problems, rather than just use procedures to demonstrate basic computational skills. Most importantly, teachers must understand how to facilitate this type of learning within the classroom (Borko & Whitcomb, 2008; NCTM, 2009; NMAP, 2008).

Additional facets of the problem included increased measures for accountability (No Child Left Behind, 2001) and statewide concerns for appropriate teacher training (Georgia Department of Education, 2007b). There was mounting pressure to achieve success on standardized tests. The problem of low student achievement in mathematics arose from a local context but is a problem that was observed at state, national, and international levels (American Institutes for Research, 2005; Georgia Department of Education, 2006, 2007a, 2008; National Center for Education Statistics, 2000, 2004, 2008; NMAP, 2008).

Rationale

According to the NMAP (2008, p. 2), teachers must possess their own knowledge of concepts if they are expected to help students develop deep understanding. If teachers do not know material, they cannot effectively teach it (Borko & Whitcomb, 2008; NCTM, 2000). The ultimate goal of reform based mathematics instruction is an increase in student achievement through better instruction. Before the increase can be expected, however, teachers must become familiar with philosophies, research, and literature about what constitutes effective mathematics instruction (Greenberg & Walsh, 2008; NCTM, 2000, 2009).

Georgia's implementation of the Georgia Performance Standards (GPS) in 2006 and 2007 required major changes in the area of mathematics instruction. To effect these changes, educators needed extensive support and professional development (Georgia Department of Education, 2005b). The rationale for selecting this project study was that teachers need appropriate professional development to meet new instructional requirements in mathematics (Georgia Department of Education, 2005b; Greenberg & Walsh, 2008). In this study, I responded to a problem in the state of Georgia, and more locally in ABC Elementary School where I serve as a mathematics interventionist.

Teachers at ABC Elementary School engaged in differing levels of training in 2006, 2007, and 2008 related to the changes in mathematics (A. Ingram, personal communication, September 8, 2006). Prior to the curriculum change, many teachers relied heavily on their mathematics textbooks and led students through them, page by page. For the most part, teachers taught mathematics skills in isolation, and required students to work independently to solve equations. This was evidenced by archived lesson plans and confirmed through personal communication with the school principal. Teachers were continuing the pattern of teaching mathematics the way they learned mathematics, a common pattern of mathematics instruction in the United States (Mann, 2006).

After the curriculum change, in 2006, school and district leaders insisted that teachers modify their instruction (C. Cobb, personal communication, September 1, 2006). Administrators mandated that teachers adopt an entirely student centered approach for teaching mathematics. Teachers were not allowed to use textbooks for instruction, as administrators felt they needed to move away from a textbook approach in order to teach mathematics conceptually (A. Ingram, personal communication, August 1, 2006; K. Gilstrap, personal communication, August 1, 2006). During the course of the 2006-07 school year, teachers implemented a completely new style of mathematics instruction. These actions contrasted with findings by Marsigit (2007, p. 143) that suggested educators must be given adequate time to learn new models of teaching. Some teachers completed a book study focused on conceptual mathematics, and others attended professional development workshops to increase their understanding. However, there were still many concerns about the changes in instructional expectations.

Data from student test scores demonstrated that the strict student centered approach imposed by ABC Elementary School District was not effective for all students (Georgia Department of Education, 2008). Findings from the NMAP (2008) claimed that research does not support a call for instruction to be completely “student-centered” (p. xxii) or “teacher-directed” (p. xxii), but that it should include a balance of pedagogical methods. School administrators acknowledged that teachers needed additional training to implement instructional practices that coincided with the state’s change in curriculum (A. Ingram, personal communication, May 4, 2007).

Research is needed in the areas of mathematics instruction and professional development so that it can be used to address the problem of low student achievement in mathematics (Greenberg & Walsh, 2008; NCTM, 2009; NMAP, 2008). The increasing call for teacher accountability and more pressure to improve student learning (No Child Left Behind, 2001) made change even more imperative. The following subsections support the rationale for this study with evidence of the problem at the local level, as well as through professional literature.

Evidence of the Problem at the Local Level

Evidence of the problem was measured by the Criterion-Referenced Competency Test (CRCT) and the Standards Assessment Inventory (SAI). The CRCT results provided student achievement data in school, district, and state contexts. The SAI conveyed data that involved teacher concerns for better professional development. Each instrument is subsequently described and related to the problem of this study.

The CRCT is an instrument used in Georgia to assess students' understandings of reading, language arts, mathematics, science, and social studies. The Georgia Department of Education established validity and reliability for the CRCT (Georgia Department of Education, 2001). For the purposes of this project study, only data from the mathematics portion were reported. These data are classified as public data and were compiled from several documents within the Georgia Department of Education Web site (Georgia Department of Education, 2004, 2005a, 2006, 2007a, 2008). The first table provides an overview of data for comparison, and the three subsequent tables provide a narrower view of student achievement progressing from state to district to school success rates.

Table 1 provides an overview of the percentage of students who met the minimum requirements on the mathematics portion of the CRCT during the past 5 years within ABC Elementary School, ABC Elementary School District, and across the state of Georgia. School and district data were not available for 2004 and 2005. The numbers of students who passed the test declined sharply in 2007 in Grades 1 and 2 compared to the previous 3 years, as this was the first year that students were tested based on the GPS. Students did make gains after the second year of a new curriculum, but scores still fell below the percentage of students who passed during the years before the curriculum changed. The same decline occurred for students in Grades 3, 4, and 5 in 2008 when they were tested according to Georgia's new curriculum. Significant declines in student achievement suggested a need for improvement in this area.

Table 1

Percentage of Students Who Passed CRCT Mathematics 2004-2008 in the State of Georgia, ABC Elementary School District, and ABC Elementary School

	2004	2005	2006			2007			2008		
	ST	ST	ST	DI	SC	ST	DI	SC	ST	DI	SC
Grade 1	90	89	90	93	94	82	84	70	86	88	84
Grade 2	87	88	87	93	90	81	88	81	85	88	87
Grade 3	90	89	91	93	93	90	94	98	71	72	73
Grade 4	76	75	79	87	88	79	79	74	70	74	63
Grade 5	74	87	89	89	92	88	90	95	72	72	67

Note. ST=State, DI=District, and SC=School. District and School data were unavailable for the years 2004 and 2005.

Table 2 shows how student test scores across the entire state of Georgia declined at every grade level in the year immediately following the curriculum change, 2007 for Grades 1 and 2 and 2008 for Grades 3, 4, and 5. Numbers in Table 2 indicate percentage of students who met minimum requirements on the mathematics portion of the CRCT. Data suggested a need for improvement throughout the state of Georgia, although scores most likely reflect the newness of the standards and the test based on those standards. One can assume that teachers need more support so that they can meet expectations set by new curriculum and requirements mandated by NCLB (2001) legislation.

Table 2

State of Georgia CRCT Mathematics Student Achievement

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Before Curriculum Change	90%	87%	90%	79%	88%
After Curriculum Change	82%	81%	71%	70%	72%
Decline in Student Achievement	-8%	-6%	-19%	-9%	-16%

Table 3 shows how student test scores within ABC Elementary School District declined at every grade level in the year immediately following the curriculum change, 2007 for Grades 1 and 2 and 2008 for Grades 3, 4, and 5. This could be explained by acknowledging that both teachers and students usually need time to adjust to a new curriculum, along with a new test. Ideally, however, students would achieve the same or better successes with the new curriculum than they achieved before the curriculum and CRCT changed.

Table 3

ABC Elementary School District CRCT Mathematics Student Achievement

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Before Curriculum Change	93%	93%	94%	79%	90%
After Curriculum Change	84%	88%	72%	74%	72%
Decline in Student Achievement	-9%	-5%	-22%	-5%	-18%

Table 4 shows how student test scores within ABC Elementary School declined at every grade level in the year immediately following the curriculum change, 2007 for Grades 1 and 2 and 2008 for Grades 3, 4, and 5. There is a disparity between the decline in Grades 3 and 5 and the decline in Grades 1, 2, and 4 at state, district, and school levels. This could be attributed to the quality of instruction at those grade levels; but, the fact that the phenomenon occurred consistently throughout the school, district, and across the state of Georgia indicates that another explanation is more likely. Although there are no concrete data to confirm this speculation, the discrepancies in test scores could indicate that the test did not accurately reflect the curriculum at Grades 3 and 5. Standards and test items at all grade levels have been revised annually since testing began in 2007 and 2008.

Table 4

ABC Elementary School CRCT Mathematics Student Achievement

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Before Curriculum Change	94%	90%	98%	74%	95%
After Curriculum Change	70%	81%	73%	63%	67%
Decline in Student Achievement	-24%	-9%	-25%	-11%	-28%

Data demonstrated the need for improvement in the area of mathematics within the local context and indicated the more widespread problem of low mathematics achievement throughout the state of Georgia. At ABC Elementary School, the problem is supported by teacher concern for appropriate training in conceptual mathematics instruction. The facet of the problem that involves teachers' concerns was derived primarily through personal communication, but was also confirmed through a professional development survey completed by teachers after the curriculum changed.

Evidence of teacher concern for professional development was measured by the Standards Assessment Inventory (SAI). The SAI is an instrument developed by the Southwest Educational Development Laboratory, which worked in conjunction with members of the National Staff Development Council (NSDC). It is a 60-item questionnaire designed to help educational leaders assess the degrees of alignment between schools' professional development plans and the NSDC Standards for

Professional Development. Items included on the SAI cover 12 areas of professional development: learning communities, leadership, resources, data driven decisions, evaluation, research based practices, design, learning, collaboration, equity, quality teaching, and family involvement. Reliability and validity were established for the SAI (NSDC, 2009). Educational leaders use results of the SAI both to evaluate past professional learning programs and to plan for future opportunities.

At ABC Elementary School, teachers and administrators completed the questionnaire in 2007 after the curriculum changed, and results indicated a strong desire for professional collaboration. Since the entire intended population (all teachers who taught mathematics during the 2006-2007 school year) took the survey, results did not have to be generalized from a small sample. Teachers also voiced concerns informally at faculty meetings and various committee meetings (A. Ingram, personal communication, September 8, 2006; K. Gilstrap, personal communication, September 10, 2006). Before the curriculum change in 2006 and 2007, there had been no schoolwide professional development for ABC Elementary School teachers in the area of mathematics for at least ten years (A. Ingram, personal communication, October 1, 2006). According to the school principal, the differences in classroom lesson delivery were as great within grade levels as across them. Essentially, each teacher determined his or her own method of teaching mathematics, and most relied upon textbooks for daily instruction. These factors led to teacher concerns when instructional expectations changed.

Evidence of the Problem From the Professional Literature

This section focuses on evidence of the mathematics student achievement problem from educational research literature. Students at ABC Elementary School performed lower than students from some other schools within the district (Georgia Department of Education, 2004, 2005a, 2006, 2007a, 2008). Students within the state of Georgia performed lower than students in several other states in the United States (American Institutes for Research, 2005; National Center for Education Statistics, 2007; NMAP, 2008), and students within the United States performed lower than students from several other countries throughout the world (National Center for Education Statistics, 2000, 2004, 2008). However, substandard mathematics achievement was not unique to ABC Elementary School District or to the state of Georgia. A majority of low income students in the United States have not met academic standards in mathematics (Ysseldyke et al., 2003, p. 247).

Past national and international standardized test results suggest that mathematics achievement has been a long standing problem for students in the United States, although some experts question the accuracy of these findings (Berliner & Biddle, 1995; Bracey, 2000, 2003, 2009; Holliday & Holliday, 2003). In 1992, the National Assessment of Educational Progress (NAEP) results indicated that 41% of high school seniors could not solve multistep word problems (Office of Educational Research and Improvement, 1992). Problems that involved tasks more complex than whole number operations stumped U.S. 12th-graders. In 1995, the Third International Mathematics and Science Study (TIMSS) demonstrated that students from 16 foreign countries scored higher in mathematics than U.S. eighth-graders (National Center for Education Statistics, 2004). When researchers administered the TIMSS in 1999 and 2003, students in fourth grade showed similar results. While fourth-graders showed no improvement between 1995 and 2003, eighth-graders increased their average score significantly (p. 6). On the 2003 TIMSS, fourth-graders in the U.S. scored lower than did students in 11 foreign countries and eighth-graders scored lower than did students in 14 countries (National Center for Education Statistics, 2004, p. 4). However, there was an overall improvement in achievement from the 1995 administration. In the state of Georgia specifically, the National Center for Education Statistics (2008) showed that fourth and eighth grade students scored below the national average on the mathematics portion of the NAEP all six times it was administered, in 1992, 1996, 2000, 2003, 2005, and 2007.

The NMAP conducted the most recent analysis of research on this topic. President George W. Bush created the NMAP in 2006 to address the concerns about mathematics achievement in the United States (NMAP, 2008, p. 1). The panel was made up of 19 expert panelists and five ex officio members, and its mission was to compile and analyze scientific findings about mathematics teaching and learning. The panel considered several sources to extract information and data, reviewing studies that yielded statistically significant results. The NMAP also examined research publications, teacher survey results, anecdotal evidence, and verbal testimonies (p. xvi) to extract valid information. As with previous assessments, however, the findings were debated by experts (Boaler, 2008; Borko & Whitcomb, 2008; Thompson, 2008).

The panel's findings, published in 2008, included information from the United States National Report Card. On the latest test for mathematics achievement, 32% of U.S. eighth graders performed at the proficient level, but only 23% of all students remained proficient at Grade 12 (p. xii). The need for improved performance by students in the United States is supported by the increasing call for remedial mathematics classes among college freshmen throughout the country (p. xii). The NMAP called for nationwide mathematics reform, but some researchers questioned the quality of the data. When viewed in light of NCLB legislation, which requires that 100% of students meet minimum requirements in mathematics by the year 2014, concerns for achievement of U.S. students in this subject are paramount. In this study, I sought to address the local problems of student achievement in mathematics and teacher concerns for professional development.

Definitions

Conceptual knowledge: Conceptual knowledge in mathematics refers to understanding of the number system and underlying patterns and relationships of mathematical certainties (Van de Walle & Lovin, 2006).

Manipulatives: A term widely used in the educational realm, manipulatives refer to hands on tools that students and teachers use to illustrate mathematical concepts (Van de Walle & Lovin, 2006). Drickey (2006) introduced virtual manipulatives, or computer based models.

Model: As described by Van de Walle and Lovin (2006, p. 7), models include any visual representations of concepts or mathematical relationships.

Procedural knowledge: Van de Walle and Lovin (2006) listed rules, procedures, and symbolism as the anchors of mathematics procedural knowledge. In mathematics, procedural knowledge refers to being able to perform sequential steps that lead to a correct solution.

Professional development: Ongoing learning by teachers to fulfill the purposes of improving instruction and enhancing learning for students (Mundry, 2005).

Word problem: A written mathematical story that requires students to comprehend meaning and reach a logical solution through calculation (Fuchs et al., 2009).

Significance

This study, based on a decline in student achievement in mathematics, is worthy of scholarly attention for several reasons. The NMAP (2008) stated that students must be competent in mathematics in order to function in the modern economy. Mann (2006, p. 244) addressed the importance of the problem by stating that mathematical reasoning leads to human advancement by helping mankind better understand the world. In addition to local, state, and national significance, this mathematics specific project holds importance in the broad realm of 21st century life.

> Leading societies have commanded mathematical skills that have brought them advantages in medicine and health, in technology and commerce, in navigation and exploration, in defense and finance, and in the ability to understand past failures and to forecast future developments. (NMAP 2008, p. xii)

Mathematics education supports American independence and leadership.

Increasing student achievement in mathematics has strong implications for the community in which the research took place. ABC Elementary School District compares unfavorably to the state of Georgia in its high school graduation rate. While the state maintains a 78.9% graduation rate, ABC Elementary School District’s graduation rate is 66.1% (Governor’s Office of Student Achievement, 2010). In mathematics specifically, students in ABC Elementary School District lag behind the state and national averages as measured by the American College Test (ACT). Because this project aims to increase student achievement in mathematics at the elementary level, it holds potential significance as a catalyst for increased success for students throughout middle and high school as well.

Guiding Questions

The guiding questions framed the collection and analysis of data, as well as informed the design of the final project.

1. In order to improve student achievement in mathematics at ABC Elementary School, what aspects of mathematics instruction should be addressed?

2. What types of professional development experiences do ABC Elementary School teachers perceive will best enable them to increase student achievement in mathematics?

Past research includes exploration of instructional practices, teachers' perspectives, and professional development efforts associated with teaching mathematics. Many experts indicate a need for improved mathematics instruction in the United States (Hiebert et al., 2005; Mann, 2006; NCTM, 2000; NMAP, 2008; Stigler & Hiebert, 1999; Wallis & Steptoe, 2006). Within the past few years, the mathematics curriculum in Georgia has undergone significant changes (Georgia Department of Education, 2005b). Standardized tests have changed to reflect the curriculum, and many students have not met minimum expectations in the area of mathematics (Georgia Department of Education, 2004, 2005a, 2006, 2007a, 2008). Educational leaders conveyed expectations for changes in teaching practices; but, teachers engaged in differing levels of training about how to teach mathematics conceptually and help students meet Georgia's revised curriculum (A. Ingram, personal communication, September 8, 2006).

Because research has linked teaching practices with student learning, teachers should be comfortable with curriculum and adequately trained in appropriate teaching methodologies if they expect to be successful (Borko & Whitcomb, 2008; Greenberg & Walsh, 2008; NCTM, 2000; NMAP, 2008). This qualitative case study was needed to address the local problem. I explored elementary school teachers' ideas about professional development as they relate to increasing teacher proficiency, student understanding, and student achievement in mathematics. The guiding questions focused the project on how to increase student achievement through appropriate professional development for teachers.

Review of the Literature

The purposes of this literature review were to describe the theoretical framework for this study, provide a recent account of mathematics education in the United States, compare and contrast traditional and conceptual pedagogical methods, and support the idea of professional development as a means to improved mathematics achievement. Search terms included Booleans *mathematics teaching*, *mathematics instruction*, *mathematics AND problem solving*, *teacher beliefs AND mathematics*, *mathematics instruction AND Japan*, *mathematics instruction AND United States*, *mathematics reform*, *mathematics AND memorization*, *procedural knowledge AND mathematics*, *student achievement AND mathematics*, *critical thinking AND mathematics*, *teacher beliefs AND mathematics*, *teacher training AND mathematics*, and *teaching mathematics for understanding*. Specific databases utilized were ERIC, Education Research Complete, and Sage. In most cases, I reviewed abstracts of articles before deciding whether to view the full text. I also examined specific sections such as introduction, problem, participants, and conclusions to determine articles' applicability to my research.

This review of literature includes the foundation of the problem, based upon the learning theories of Piaget and Vygotsky. Next, mathematics reform in the United States is described. The literature review ends with a critical analysis of traditional and conceptual methods of teaching mathematics, as well as principles suggested by mathematics reform experts.

Foundations of the Problem: Theoretical Framework

Learning theory and literature about mathematics and professional development, in combination with data, formed the framework for this doctoral project. The idea of a balanced approach to teaching mathematics is rooted in the work of Piaget and Vygotsky. Piaget (1959) asserted that learners achieve deeper levels of understanding when they construct knowledge based on their own personal backgrounds, experiences, and interpretations of information, known as prior knowledge. This has come to be known as constructivism, founded on the principle that children construct their own knowledge when given opportunities. Students are responsible for their own learning as they internalize discoveries and give them meaning (Hudson, Miller, & Butler, 2006). Exploration and discovery are important components in the context of learning. In mathematics class, this theory can be applied when teachers allow students to use manipulatives (Furner, Yahya, & Duffy, 2005; Mancil & Maynard, 2007; Van de Walle & Lovin, 2006), solve problems (Brakebill, Morley, Steinbert, & Wang, 2006; Chard et al., 2008; Pogrow, 2004; Usiskin, 2003), and make discoveries (Drickey, 2006; Marsigit, 2007; Montague, 2003; van Kraayenord & Elkins, 2004).

Vygotsky's (1978) theory of social development, or social interactionist theory, contends that talking and listening are essential components of learning. In mathematics class, Vygotsky's theory can be applied when teachers allow children to work together in groups as a regular part of instruction. The works of Furner et al. (2005), Goldsmith and Mark (1999), Hudson et al. (2006), London (2004), Mancil and Maynard (2007), Montague (2003), NCTM (2000), Saville, Zinn, and Elliott (2005), and Steele (2007) supported Vygotsky's theory about learning. These researchers noted that group work, or cooperative learning, can be beneficial to students when they are working on mathematical tasks.

Historically, mathematics in the United States has been taught in a manner that does not reflect either the constructivist or social interactionist viewpoints. Stigler and Hiebert (1999) and Hudson et al. (2006) described a typical American mathematics lesson as consisting of teacher demonstration followed by student practice. The teacher was viewed as the supreme beacon of knowledge. He or she knew the magic formula, the algorithm, and bestowed this knowledge upon pupils so that they could memorize and perform the given procedure. Mann (2006) described this U.S. phenomenon as "learning from the master" (p. 237). This conventional form of teaching, in contrast with the perspectives of Piaget (1959) and Vygotsky (1978), was the norm within ABC Elementary School before the curriculum change.

In concurrence with the historical theorists, Sarama and Clements (2006) found that young children learn naturally by asking questions and experimenting. Furthermore, Cavanagh (2006a, 2006b) promoted more teaching of mathematical relationships and less emphasis on memorizing algorithms and formulas. Mathematical foundations can be built when students use manipulatives and engage in hands on experiences (Burke & Dunn, 2002; Drickey, 2006; Furner et al., 2005; Gilliland, 2002; Mancil & Maynard, 2007; and Van de Walle & Lovin, 2006). Burns (1998) addressed the long debated issue of how to best teach mathematics by recommending an approach that infuses conceptual activities, written exercises, basic skill practice, and regular problem solving. In essence, both the problem and the project for this doctoral study were framed by the learning theories of Piaget (1959) and Vygotsky (1978), and supported by current research and literature.

A Global Perspective

Much focus on mathematics achievement in the United States centers around the concept of sustaining economic advantages within the world (NMAP, 2008, p. xi). The focus on economic competitiveness and discrepancies in student performance has led educational researchers to study differences that exist in mathematics education between students in the U.S. and Japan. International standardized test scores indicate that students in Japan have achieved success in mathematics at consistently higher levels than students in the United States (National Center for Education Statistics, 2000, 2004, 2008; NMAP, 2008). Educational leaders in the United States, and particularly in the state of Georgia, have suggested changes in U.S. mathematics expectations that reflect Japanese philosophies and instructional methodologies (Georgia Department of Education, 2005b; NMAP, 2008).

Mathematics instruction: United States v. Japan. Hiebert et al. (2005) observed “striking contrast[s]” (p. 125) between mathematics instruction in the United States and Japan. The authors indicated that while U.S. teachers wanted their students to become proficient in computation, Japanese teachers encouraged their students to think about mathematical relationships in new ways. Additionally, American textbooks contained many topics with only one or two pages devoted to each, while textbooks from other countries were not as thick and focused on fewer topics (Kennedy, 2003; NMAP, 2008; Stigler & Hiebert, 1999). Wallis & Steptoe (2006) noted the differences between U.S. textbooks and those in Japan, suggesting "depth over breadth" (p. 17) as a guiding principle for textbook reform. Stigler and Hiebert (1999) observed that teachers in Japan spent more time developing concepts, while U.S. teachers sometimes covered many topics briefly in an attempt to complete all lessons in the textbook. The authors supported this notion by stating that only 22% of the U.S. lessons they observed contained well developed mathematical ideas, in contrast to 83% of the lessons in Japan. It should be noted, however, that Stigler and Hiebert based their conclusions on a 1995 video study, which had limitations and has been followed by a more recent study (Hiebert et al., 2005).

In response to Stigler and Hiebert's (1999) implications that Japanese educators were superior to U.S. teachers in certain ways, Bracey (2000) argued that the researchers had failed to mention two factors that influence Japanese education. These are the family structure and the juku. The family structure refers to the notion that Japanese parents place a high value on education, and work with their children at home to instill memorization of facts. Bracey posed this meant that teachers would be free to facilitate deep understanding in class rather than spending time on computation and procedural drill. The juku was mentioned as an explanation for the Japanese success on standardized tests, as it is a test taking school attended by many students in addition to regular school. The observations reported by Stigler and Hiebert, along with the debate that followed, brought attention to the differences in mathematics instruction between the United States and Japan.

Teachers in Japan do spend time requiring rote memorization, just like teachers in the United States (Hiebert et al., 2005; Stigler & Hiebert, 1999). Instructional focus is on using mathematics to solve problems in addition to performing procedures. Desimone et al. (2005, p. 525) determined that a significant difference in mathematics instruction between the United States and Japan was the degree to which U.S. teachers emphasized computation specifically with low achieving students. Mathematics teachers in Japan, according to this study, incorporate computation as a part of instruction, but also give both high and low achieving students opportunities to construct and apply knowledge. Hiebert et al. (2005) observed that much mathematics instruction in the United States was "procedurally oriented" (p. 116) and of low cognitive challenge. Resnick (2006, p. 2) noted that programs of high cognitive challenge, such as those in Japan, emphasized relationships, concepts, and problem solving more than procedural computation. These instructional differences are important, as much research suggests that teaching practices affect student performance (Lubienski, 2006; NMAP, 2008; Patton et al., 2008; Schubring, 2006, p. 675; Schwartz, 2006).

Mathematics reform in the United States. Balanced mathematics instruction is beginning to take roots in schools throughout the United States. In 2006, the state of Georgia adopted a new curriculum based on the Japanese approach to teaching mathematics. Centered on ideas embedded in the Japanese style curriculum, mathematics topics are now taught in Georgia in an integrated fashion rather than as separate entities (Georgia Department of Education, 2008; Zehr, 2005). Georgia's change in curriculum represents an effort in educational reform. Another example of reform is that teachers in Boston and San Diego implemented conceptual mathematics instruction and saw great improvements in student achievement (Cavanagh, 2006a). These changes illustrate the gradual spread of mathematics reform throughout the country.

Other researchers noted the presence of conceptual mathematics instruction, at varying degrees, within U.S. classrooms. Desimone et al. (2005, p. 525) reported that the degree of conceptual teaching in the United States was similar to that of several high performing countries. They concluded that teachers in almost all participating countries devoted class time to computation as well as to conceptual activities. Hiebert et al. (2005, p. 113) observed several U.S. lessons in which students worked in small groups to solve a problem or complete a task. These findings demonstrated the NCTM (2000) principles of communication and collaboration being carried out within classrooms.

In the state of Georgia, changes in curriculum were made to reflect current research and literature about mathematics reform (Georgia Department of Education, 2008) based on observations of mathematics instruction in the United States and Japan (Desimone et al., 2005; Hiebert et al., 2005; Stigler & Hiebert, 1999). Hiebert et al. hypothesized that full adaptation of Japanese ideals within the United States educational structure would be unrealistic; however, the state of Georgia has already made changes that force educators to learn new ways of teaching. The next step is to increase teachers' understanding about mathematics reform ideas so that they can begin to incorporate meaningful instruction within classrooms (Georgia Department of Education, 2005b; Greenberg & Walsh, 2008; Mann, 2006, p. 250, NMAP, 2008).

Traditional Methods of Teaching Mathematics

Some experts attributed traditional methods that have dominated U.S. mathematics instruction to underlying philosophies about mathematics itself. Many people view mathematics as sets of tricks, rules, and procedures rather than relationships between concepts and facts (Dogan-Dunlap, 2007; Mann, 2006; Mtetwa & Garofalo, 1989; Patton et al., 2008). Some educators believe that the essence of mathematics is unyielding rules and algorithms, and tend to present new concepts by implementing repetitive strategies (Goldsmith & Mark, 1999; Mtetwa & Garofalo, 1989). However, these strategies are ineffective if students do not understand when and why to apply them (Mann, 2006; Mastropieri, Scruggs, & Shiah, 1991). In the United States public school systems, many teachers do not devote substantial time to helping students develop conceptual foundations (NCTM, 2000; Stigler & Hiebert, 1999). This, in some cases, reduces instruction to mainly procedural knowledge (Mann, 2006; Timmerman, 2004) without the development of conceptual understanding.

Some teachers have a narrow view of mathematics in the classroom, including reliance upon algorithms (Goldsmith & Mark, 1999; Stigler & Hiebert, 1999) and heavy use of textbooks (NCTM, 2000; Stigler & Hiebert, 1999). An unhealthy dependence on textbooks for mathematics teaching was pointed out as far back as 1987 (Farr et al.). One negative consequence associated with this rule oriented type of teaching is that students feel no real context for learning. They view mathematics as a meaningless daily chore or a set of equations in a book, rather than a useful tool (Mann, 2006; Mortiboys, 1984). Students who have this passive outlook on mathematics may consider it as sets of symbols, routine procedures, arbitrary rules, and memorized facts (Dogan-Dunlap, 2007;

Mann, 2006, p. 249; Pogrow, 2004, p. 298). Rather than relate learned information to prior knowledge of mathematics concepts, students may accept algorithms and formulas without pondering their origins. They may never question, and therefore may never understand, the "whys" (Dogan-Dunlap, 2007, p.1) of mathematical certainties. Pogrow's (2004) remarks summarize the dangers, warning that a strictly procedural approach to teaching mathematics could "produce another generation of math haters and mathaphobes" (p. 303).

Hiebert et al. (2005) described observations of U.S. mathematics instruction with four characteristics: low level of mathematical challenge (p. 116), emphasis on procedures (p. 119), emphasis on review (p. 122), and mathematically and pedagogically fragmented lessons, mathematically and pedagogically (p. 123). According to Hibbs (2004) and Mann (2006), a typical elementary mathematics lesson usually consists of teacher demonstration and modeling followed by student practice, and possibly a follow-up discussion. Hudson et al. (2006) referred to this strategy as "explicit teaching" (p. 22). Reinhart (2000) described this common method as a "teacher-centered, direct instruction model" (p. 54).

Traditional methods of teaching mathematics include lecturing (Saville et al., 2005), requiring rote memorization, assigning practice problems, demonstrating algorithms, and administering timed tests on basic mathematics facts (Caron, 2007; Mann, 2006; Mastropieri et al., 1991). Although these methods are appropriate in moderation, teachers who use them exclusively discard an important principle of mathematics. Understanding mathematics entails more than facts and rules (Mann, 2006; NCTM, 2000; Stigler & Hiebert, 1999). Resnick (2006, p. 20) explained that computation and procedural memorization induce lower order thinking skills, while conceptual understanding requires higher order thinking. Educators need to identify the distinction between teaching students how to perform regimented procedures and enabling them to apply mathematics in real life scenarios (Mann, 2006, p. 243), so that they can begin to facilitate meaning in mathematics classes.

In the past, teachers in the United States have required students to practice addition, subtraction, multiplication, and division (Bransford et al., 1999). They have explained, demonstrated, modeled, and then provided equations for practice (Hibbs, 2004; Mann, 2006; Stigler & Hiebert, 1999). Educators have worked under the belief that repetition of operations was a sufficient form of mathematics instruction (Patton et al., 2008). Common practices have included requiring rote memorization (Caron, 2007; Desimone et al., 2005; Goldsmith & Mark, 1999; Mann, 2006, p. 249; Montague, 2003, p. 166; Mtetwa & Garofalo, 1989; Patton et al., 2008; Stigler & Hiebert, 1999) and utilizing skill and drill techniques (Bottge, 2001; Goldsmith & Mark, 1999; Mann, 2006). Although these methods have been successful in improving procedural knowledge (Wong & Evans, 2007, p. 101), they have fallen short of teaching students how to apply the functions in problem solving situations (Chard et al., 2008; Graeber, 2005; Mann, 2006; Mastropieri et al., 1991; Mtetwa & Garofalo, 1989).

Often, word problems do not receive as much attention in the classroom as basic fact practice (Hiebert et al., 2005; Stigler & Hiebert, 1999). In the United States, one would not expect to see an entire mathematics period devoted to solving a word problem, yet this is where students are struggling to understand (Chard et al., 2008, p. 17; Graeber, 2005, p. 356). Many teachers emphasize computation and encourage practice with the unspoken belief that students will be able to apply that knowledge in authentic ways (Mann, 2006; Patton et al., 2008). The expected transfer of knowledge does not always occur, resulting in disconnect between skill and function (Bottge, 2001). As research indicates, somewhere along the way, educators in the United States have failed to educate students about the meaningful association between operation and practical application (Chard et al., 2008, p. 17; Graeber, 2005, p. 356; Office of Educational Research and Improvement, 1992; Mann, 2006; Mastriopieri et al., 1991; Yesseldyke et al., 2003). Current mathematics reform experts insist that mathematics instruction should extend beyond procedure based methods to incorporate a view of mathematics that encompasses concepts, patterns, applications, and relationships in addition to facts and procedures (Burns, 1998; Schifter, 2007, p. 22; Van de Walle & Lovin, 2006).

Conceptual Methods of Teaching Mathematics

Five interrelated themes emerged from the literature as the main features of appropriate mathematics instruction. Concepts that were repeated throughout the literature included contexts for learning (Schifter, 2007, p. 24), mathematical reasoning (Burns, 1998; Reinhart, 2000), cooperative learning (Furner et al., 2005; Goldsmith & Mark, 1999; Hudson et al., 2006; London, 2004; Mancil & Maynard, 2007; Montague, 2003; NCTM, 2000; Reinhart, 2000; Steele, 2007), integration of topics (Georgia Department of Education, 2005b, 2007b; Usiskin, 2003; Zehr, 2005), and conceptual foundations (Georgia Department of Education, 2007b; Hiebert et al., 2005; Mann, 2006; Van de Walle & Lovin, 2006). These themes correlated with the NCTM (2000) process standards, which are: Problem Solving, Reasoning and Proof, Communication, Connections, and Representations. These process standards were used to guide the development of the Georgia Performance Standards. The following review of a balanced approach to teaching mathematics is organized around the five NCTM (2000) process standards, or themes, and supplemented with other sources. The multiple facets of a balanced approach to teaching mathematics were exposed in the final project through presentation and literature.

Problem solving. Experts who insist that students should learn within specific contexts frequently emphasize the importance of problem solving (Burns, 1998; Brakebill et al., 2006; Chard et al., 2008; House, 2003; NCTM, 2000; Usiskin, 2003; Van de Walle & Lovin, 2006). Pogrow (2004) claimed that teaching students to solve word problems is one of educators' greatest challenges, and Lubienski (2006) found a positive correlation between problem solving as an instructional strategy and student achievement among fourth and eighth graders. Pogrow focused on an approach that helped students see practical applications for mathematical ideas. He created a software program that allowed students to explore, invent, and construct meaning as they solved engaging problems. The main principle of the literature he mirrored in his work was that mathematics teaching should be student centered and problem based. This provided an essential component in the struggle for mathematics achievement: a context for learning. Instead of performing the same procedure repeatedly, students applied mathematical concepts to solve problems and advance to higher levels. Teachers and students who utilized the problem solving software program reported gains in ability and enjoyment of mathematics (Pogrow, 2004, p. 303).

Usiskin (2003) wrote that the one consistency throughout the history of changes in mathematics education is an agreement that it should always be connected to real world applications. Problem solving in mathematics classes instills in students the truth that mathematics can and should be used in real situations (Brakebill et al., 2006; House, 2003; Mann, 2006; NMAP, 2008; Pogrow, 2004; Van de Walle & Lovin, 2006). Patton et al. (2008) noted that teachers should help students develop metacognition so that they can effectively engage in problem solving (p. 488). Rather than assuming that students will automatically transfer from procedural knowledge to application, teachers should make explicit efforts to teach students how to effectively apply skills to authentic contexts.

A mixture of pedagogical approaches can be applied to integrate problem solving into the curriculum. One component of teaching problem solving is requiring automaticity of basic fact answers, so that the working memory is released to contemplate more complex applications (Wong & Evans, 2007, p. 103). Another idea is to allow students to model mathematics processes using manipulatives. Schifter (2007) described students using objects such as bowls and cotton balls to illustrate the concept of multiplication, while Wong and Evans recommended traditional practice to commit facts to memory. Steele (2007, p. 60) mentioned that struggling students learn better within specific contexts. Educators must enable children to use discernment when facing authentic problems in the world so that mathematical knowledge is applied, and not simply memorized (Brakebill et al., 2006; Burns, 1998, p. 56-57; Furner et al., 2005; London, 2004; Mann, 2006, p. 243; NMAP, 2008; Pogrow, 2004; Van de Walle & Lovin, 2006).

Reasoning and proof. Reform experts have suggested that students should explain their mathematical solutions (e.g., Ediger, 2005; Furner et al., 2005; Schwartz, 2006). To facilitate reasoning and proof in classrooms, they recommended questioning, discussion, and defense of answers as regular parts of balanced mathematics instruction. Brakebill et al. (2006) emphasized the importance of "mathematical reasoning" (p. 14) as a part of preparation for higher level mathematics classes. May (1996) suggested having students generate questions and create their own mathematical scenarios. She advised asking learners to extend simple problems into more challenging ones. By having children synthesize information in this way, teachers can force them to engage in analytical thinking (Schwartz, 2006, p. 54). Reinhart (2000) recommended replacing lectures with questions. Burns (1998) wrote that students often reason and compute numerically in different ways, and should be allowed to use mental reasoning in addition to written procedures. The NCTM (2000, p. 4) indicated that students learn to justify, reason, and form conclusions by engaging in activities that push them to prove their solutions. Furthermore, the council held that mathematical reasoning can help students discover patterns within the number system, leading to a well developed understanding of mathematical ideas.

Communication. Ideas about communication in the literature promoted Vygotsky's (1978) ideas about social interaction, and involved both speaking and listening as essential components of learning. Wallis and Steptoe (2006) cited aligning classroom instruction with the modern working world as a valid reason for encouraging collaboration in mathematics classes. According to Kamii and Lewis (1993), teachers reported that elementary students who communicated regularly with their peers learned mathematics more conceptually and achieved greater understanding of mathematical processes. In an analysis of results of the National Assessment of Educational Progress (NAEP), Lubienski (2006) found that collaboration was a positive predictor of student success in both fourth and eighth grades. Lastly, students who learned by interteaching (peer collaboration) performed better than students who learned by lecture (Saville et al., 2005).

Allowing students to work together and engage in conversations about mathematical topics is beneficial (e.g., Mancil & Maynard, 2007; Steele, 2007). The NCTM (2000) reported that communication in mathematics classes forces students to reflect and clearly express their thought processes. Similarly, students learn by listening to their peers explain mathematical arguments (NCTM, 2000; Vanderhye & Zmijewski, 2008; Van de Walle & Lovin, 2006). Reinhart (2000) noted that communication within cooperative groups means that all students share responsibility for everyone's learning (p. 57).

Mathematics reform advocates favor communication in mathematics classes, as opposed to forcing students to work independently. Communication and learning cannot be interwoven if students are "sitting in rows, listening to teachers lecture" (Wallis & Steptoe, 2006, para. 2). Vanderhye and Zmijewski (2008) found that one way to encourage collaboration in mathematics classes was to establish routines and rules for respect among students. Evidence of this aspect of mathematics reform is present in the United States, at least according to the observations during one comparison. In their study of educational practices within Japan and the United States, Hiebert et al. (2005, p. 113) observed much collaboration within U.S. classrooms.

Connections. The NCTM (2000) noted that although teachers often present students with separate standards or procedures to be memorized, mathematics can be better characterized as a "coherent whole" (p. 4). This was a foundational idea upon which the Georgia Department of Education (2008) based its new mathematics standards. The idea of making connections in mathematics refers to helping students see relationships among topics and understand why certain procedures work. Many researchers hold that procedural knowledge is essential for success in mathematics, and encourage teachers to incorporate rote memorization and skills based activities into mathematics lessons to promote fluency (Burns, 1998; Chard et al., 2008; Desimone et al., 2005; Goldsmith & Mark, 1999; NCTM, 2000; NMAP, 2008). Context and connections are equally important. Steele (2007, p. 61) noted that connections between procedures and real life examples are especially advantageous for students with mild learning disabilities.

One idea for fostering mathematical connections while also increasing procedural fluency is to allow students to discover algorithms or procedures on their own. This idea traces back to Piaget's (1959) theory that learners will construct their own personal understandings based on prior knowledge. Kamii and Lewis (1993) applied Piaget's theory as they taught mathematics. In their school, teachers did not directly teach any algorithms to their students. Instead, they encouraged young learners to invent their own strategies. Teachers reported that not all students were able to construct procedures without teacher assistance, but those who did seemed to develop strength in both conceptual and procedural knowledge. Alsup (2004) found that in one instance, students of teachers who implemented constructivist strategies experienced a decrease in mathematics anxiety and an increase in confidence, encouraging them to approach mathematical tasks with ease. Finally, the NCTM (2000) and the NMAP (2008) suggested that helping students understand relationships and connections in mathematics is a cornerstone of improved instruction.

Representations. An essential element in the goal of increasing student achievement in mathematics is building a conceptual foundation for students (Hiebert et al., 2005; Mann, 2006, p. 250; Van de Walle & Lovin, 2005), beginning with their earliest formal learning experiences (Sarama & Clements, 2006). These early experiences typically involve representations, including real objects or pictures. Some researchers (e.g., Drickey, 2006; Mancil & Maynard, 2007; Usiskin, 2003) suggest helping students develop conceptual foundations through the use of manipulatives and hands-on models to facilitate understanding. The NCTM (2000) listed “pictures, concrete materials, tables, [and] graphs” (p. 4) as types of representations that facilitate understanding. Pogrow (2004) described using “mental models” (p. 300) to help students internalize concepts. Lubienski (2006) referred to “non-number curricular emphasis,” (p. 18) or conceptual models, as having a positive effect on student achievement.

Teachers who focus on the conceptual foundations of mathematics are as concerned with students’ developmental thinking processes as with their abilities to follow computational procedures (Schwartz, 2006). Representations can help students interpret the underlying processes of mechanical formulas, which is essential for their development of conceptual knowledge (NCTM, 2000) and more importantly, for their abilities to apply that knowledge. Representations can be a platform for building knowledge in mathematics for students at any age or level.

Blending Pedagogies for a Balanced Approach

Ideas supported within both traditional and conceptual teaching methods should be regularly infused in mathematics classes to provide students with a broad understanding of mathematics in general. Hiebert et al. (2005), Desimone et al. (2005, p. 515), and the NMAP (2008) dispelled the assumption that one approach must be sacrificed in order to embrace another. Instead, mathematics teachers should embrace all of the concepts of balanced mathematics instruction so that students can achieve success and deep understanding (NCTM, 2000). This includes blending traditional and conceptual strategies to help students develop deep understandings of interrelated mathematical concepts.

According to Mann (2006) and Schifter (2007), teachers should adopt the view of mathematics that has long been held by mathematicians. Rather than looking at mathematics as sets of procedures and rules to be memorized, mathematicians view it as integrated sets of complex, meaningful structures and patterns that learners can classify, understand, and apply through the venue of solving authentic problems (Bransford et al., 1999). The NCTM (2000) outlined a mathematics curriculum that encompasses a holistic view of mathematics and reflects the ideas of mathematicians. Their standards reflect ideas such as incorporating problem solving, requiring mathematical reasoning and proof, verbalizing thoughts and ideas, making connections, and utilizing multiple representations. In summary, research suggests that teachers and students should view mathematics as mathematicians do, as complex sets of related structures and patterns, and not solely as procedures and algorithms (Dogan-Dunlap, 2007; Mann, 2006; NCTM, 2000; Schifter, 2007, p. 22).

The NMAP (2008), after analyzing pertinent research, emphasized the importance of instituting a balanced approach to teaching mathematics in the U.S., including the idea that teachers should help students develop both procedural and conceptual knowledge. Implementing a balanced approach to teaching mathematics means including hands-on tools for modeling mathematical ideas (Chard et al., 2008; Gilliland, 2002; Van de Walle & Lovin, 2006), facilitating group collaboration for problem solving (Kamii & Lewis, 1993; Furner et al., 2005; Hudson et al., 2006; Lubienski, 2006), and requiring verbal and written expressions of mathematical findings (Goldsmith & Mark, 1999; Reinhart, 2000; Schifter, 2007). Also embedded in the principles of a balanced approach to teaching mathematics is the idea that students should be allowed to solve problems in a variety of ways, rather than being limited to the traditional, operational algorithms (Alsup, 2004; Burns, 1998; Furner et al., 2005; Goldsmith & Mark, 1999; NCTM, 2000; Van de Walle & Lovin, 2006). Schwartz (2006, p. 52) indicated that valuable learning occurs when students discover a way of arriving at a solution that was different from the standard procedure. Mathematics should be used to manipulate and solve authentic problems presented in the contexts of real life situations (Burns, 1998; Brakebill et al., 2006; Chard et al., 2008; House, 2003; NCTM, 2000; Pogrow, 2004; Usiskin, 2003; Van de Walle & Lovin, 2006). Children can and should internalize the logical number system and understand the connections between and among procedures and abstract realities.

In balanced mathematics classrooms, teachers serve as facilitators by equipping students with the information and tools they need to make discoveries about the number system and apply their knowledge to solve authentic problems. Lubienski's (2006) work concluded that "reform-oriented instruction" (p. 20), that which is described in this paper as a balanced approach, leads to positive results in student achievement. In Lubienski's study, students of teachers who implemented problem solving, cooperative learning, and development of logic and reasoning experienced more success in mathematics than those who concentrated on procedures alone. Many researchers conclude that an effective approach to teaching mathematics is to correlate the construction of abstract concepts with the teaching of concrete applications and procedures, essentially a balanced pedagogical approach (Alsup, 2004; Bransford et al., 1999; Burns, 1998; Chard et al., 2008; Ediger, 2005; Gersten & Chard, 1999; Mann, 2006; NCTM, 2000; NMAP, 2008; Pogrow, 2004; Schifter, 2007; Van de Walle & Lovin, 2006).

Critical Analysis of Related Literature

Although data seem to indicate that U.S. students consistently demonstrate a lack of proficiency in mathematics, Bracey (2009) found it "silly" (p. 1) to compare nations based on standardized test scores. He noted that this type of comparison is one-dimensional and ignores the disconnect between tests and reality. Holliday and Holliday (2003) mentioned several factors that discount international comparisons: students from different countries function and operate under completely different systems of communication, sampling is conducted differently by governments with various amounts of funding, countries enroll and promote students within and across grade levels differently, students in the study may have engaged in differing amounts of tutoring or remediation, and international comparisons do not take cultural differences into consideration. Bracey (2003) also explained Simpson's paradox, "the phenomenon by which the whole group shows one trend but various subgroups show another" (p. 1). When subgroups then begin to make up a larger proportion of the entire group, their gains can reduce the effect of the gains of the group even when gains within subgroups are larger. Over time, this effect can be misleading, disguising gains as losses simply because a particular subgroup increased in proportion to the total group. Bracey asserted that education critics have sometimes purposely ignored the effects of Simpson's paradox, contributing to skewed views of trends in test results.

Stigler and Hiebert's (1999) conclusions that U.S. students performed much more poorly than their Japanese counterparts sparked discussion among educational experts, with some condemning the state of U.S. education and others defending it. In a book review, Bracey (2000) disagreed with some of Stigler and Hiebert's assertions. He explained that an early TIMSS study had a biased sample and therefore could not be relied upon for a valid comparison, as was done in the 1999 report. Additionally, Bracey noted that another data source had resulted in scores that cast U.S. students more favorably. He specifically asserted that at the First in the World Consortium, Chicago students answered 70% of items correct in comparison with Japanese students, who answered 73% of items correctly. The most direct question of logic about using tests for achievement comparisons came from Bracey (2009) when he asked, "Does the fate of the nation rest on how well 9- and 13-year-olds bubble in answer sheets?" (para. 6) and answered, "I don't think so" (para. 6).

The 2008 report issued by the NMAP indicated many areas in need of improvement. This resulted in much discussion, sometimes heated, among educational researchers. The NMAP presented an image of both student and teacher performance that was somewhat negative, and some experts responded with criticism. One element of the panel's research that was questioned was the criteria for scientifically based studies used to assess student performance. Borko and Whitcomb (2008) argued that by only reviewing quantitative studies, the panel gave an incomplete portrayal of education in the United States. Thompson (2008) and Kelly (2008) noted that this approach ignored too much research literature, while Boaler (2008) argued that all types of research, including quasi-experimental and qualitative, should have been included.

Thompson (2008) asserted that the NMAP study was not scholarly, while both Thompson (2008) and Boaler (2008) suggested that certain research was ignored due to political biases. The NCTM also responded to the NMAP report. In most cases, findings from the panel coincided with previously established NCTM standards and principles. However, one distinction was the panel's emphasis on teachers' content knowledge at the exclusion of pedagogical knowledge (Borko & Whitcomb, 2008; NCTM, 2009). The NMAP did not address the need to develop teachers' understandings of how to identify conceptions or misconceptions, analyze errors, provide feedback, utilize multiple representations, or convey interconnections among concepts. One principle message from the NMAP was consistent throughout literature, however, and that was that more research in education is needed in order to inform and improve instructional practice (NCTM, 2009; NMAP, 2008).

Implications

There are meaningful implications associated with this study. Mills (2003) explained that teachers often lead research with the goal of "effecting positive changes in the school environment" (p. 5). The combination of state issued changes in mathematics instruction and low student achievement in mathematics prompted the idea for a Mathematics Professional Development Program (MPDP). "Times have changed and students now need to be able to think flexibly and creatively, solve problems and make decisions" (Donnelly, 2009, p. 57). In order for teachers to meet the challenges of an increasingly rigorous curriculum, they must engage in meaningful learning themselves.

Designed to help teachers learn mathematics reform ideas and best instructional practices, the MPDP (included as Appendix A) forms the basis of this doctoral project study. This investigation sought to find a solution to the problem of the study: how to increase student achievement in mathematics at ABC Elementary School. Results of the study were incorporated into an action plan, a mathematics professional development program, to improve practice (Creswell, 2008, p. 609; Lomax, 2002, p. 19; Mills, 2003, p. 5). The MPDP, designed for teachers in Grades 1 – 5, serves as the end product of this study, the project.

Based on findings that teachers desire collaborative professional development, the MPDP is an intensive program that can be applied in a multitude of educational settings. It is streamlined to meet participants' specific needs. Data that answered question 1 were used to determine topics for the program. Data that answered question 2 helped determine the format of the program. Although the project was developed according to the data gathered from a limited sample of teacher participants, the overall design of the MPDP is generic enough to be modified to meet faculty needs in different situations. Implications include leading participants to be self-reflective (Lomax, 2002, p. 122) and devising a project to improve an important educational issue (Creswell, 2008, p. 600).

Summary

In this section, I presented the problem of student mathematics achievement at ABC Elementary School. Within the past few years, the mathematics curriculum in

Georgia has undergone significant changes (Georgia Department of Education, 2005b). Standardized tests changed to reflect the curriculum, and many students have not met minimum expectations in the area of mathematics (Georgia Department of Education, 2007a, 2008). Educational leaders conveyed expectations for changes in teaching practices, but teachers engaged in differing levels of training about how to teach mathematics conceptually and help students meet Georgia's performance standards (A. Ingram, personal communication, September 8, 2006). Teachers expressed concerns about meeting new instructional expectations (A. Ingram, personal communication, September 8, 2006; K. Gilstrap, September 10, 2006).

The rationale was that teachers should be comfortable with the curriculum and adequately trained in appropriate teaching methodologies in order to improve student achievement (Mundry, 2005; Patton et al., 2008; Schubring, 2000; & Schwartz, 2006). This study is significant to students, teachers, and educational constituents in general because mathematics is a foundational part of the advancing world of technology and the global economy (NMAP, 2008). Literature reviewed included the historical learning theories of Piaget (1959) and Vygotsky (1978), as well as research outlining international comparisons of mathematics instruction and methods of teaching mathematics found in U.S. classrooms.

Implications of this study are that student achievement in mathematics may be addressed through the venue of specific professional development rooted in current research about mathematics content and pedagogy. Section 2 includes a description of the methodology that was utilized to collect and analyze data related to the problem and purpose of this study. Section 3 includes a description of the project as an outcome of the study, and section 4 includes reflections and conclusions.

Section 2: The Methodology

Introduction

The purpose of this study was to explore elementary school teachers' ideas about mathematics instruction and professional development, with an emphasis on increasing student achievement in mathematics. This section includes the research design and approach, participants, data collection processes, role of the researcher, data analyses, findings in relation to the guiding questions, disconfirming data, and evidence of quality. The first part includes the guiding questions, description of qualitative tradition, and justification for case study design. The second part provides justification for choosing participants, as well as measures for establishing relationships with them and methods used to ensure their ethical protection. The third part describes how data were collected and categorized for analysis. The fourth part explains the role of the researcher. The fifth part explains how and when data were analyzed and relates findings as themes. The sixth part includes outlying data that contrasts with findings. Finally, the last part lists evidence of quality. Essentially, this chapter describes the data analysis process that led to the project as an outcome of the results of the study.

Research Design and Approach

In this study, qualitative research was applied to devise a solution to a specific problem (Creswell, 2003, p. 21; 2008, p. 597; Lomax, 2002; Mills, 2003): student achievement in mathematics declined for students in Grades 1 through 5 after Georgia's curriculum changed (Georgia Department of Education, 2007a, 2008). Many teachers need professional development centered on how to help students meet new mathematics standards because of the requirement for greater depth and rigor than was required previously (A. Ingram, personal communication, May 4, 2007; Georgia Department of Education, 2007b). The case study design was derived from the goal and guiding question of the study. The goal was to explore teachers' beliefs about how they can increase student achievement in mathematics, specifically through the venue of professional development (Conderman & Morin, 2004; Edwards, 2006; Firestone, Mangin, Martinez, & Polovsky, 2005, p. 414; Matsika, 2007; Mundry, 2005; Torres-Guzman et al., 2006). The identification of guiding questions framed the study and gave it scope and limitations (Hatch, 2002). Creswell (2008, p. 143) stated that qualitative research questions are broad and open-ended. The guiding questions for this study were:

1. In order to improve student achievement in mathematics at ABC Elementary School, what aspects of mathematics instruction should be addressed?
2. What types of professional development experiences do ABC Elementary School teachers perceive will best enable them to increase student achievement in mathematics?

Description of Case Study Design

In an attempt to understand teachers' perspectives about professional development as a means to improving instruction and increasing student achievement in mathematics, I conducted a case study. Educators often conduct research to achieve organizational change through the reflective practices of teaching and learning (Greenwood, 2007, p. 249; Greenwood, Brydon-Miller, & Shafer, 2006). My intention was to improve mathematics education in the local environment, which is ABC Elementary School.

Researchers conduct qualitative studies when the goal is to understand or discover teachers' perspectives about educational issues (Blecher-Sass, 2008; Eakin, 2008; Palladino, 2009; Theriot & Tice, 2009; Timberlake, 2009). Case studies are often ideal in attempting to elicit teachers' ideas because they occur in the natural environment without variables being inserted into or deleted from a situation. Hancock and Algozzine (2006) explained that case studies often focus on a particular phenomenon bound by "space and time" (p. 15). In this study, the phenomenon, or case, was mathematics instruction and professional development at ABC Elementary School. Factors that influenced the case were the changed curriculum and decreased standardized test scores. This study was bound by the location (ABC Elementary School) and the time (the duration of the study, which was 14 weeks). In this exploratory case study, I studied the topic within the natural context by accessing different sources of information (Hancock & Algozzine, 2006, p. 16; Yin, 2009).

Hatch (2002) listed several qualities that characterize qualitative work. Seven qualities included in this doctoral study were natural settings, participant perspectives, researcher as data gathering instrument, subjectivity, emergent design, inductive data analysis, and reflexivity. Each element is subsequently described and related specifically to this study to support and describe the choice of the research design.

The quality of natural settings refers to studying "real people in real settings" (Hatch, 2002, p. 6). The setting in this study was ABC Elementary School. Creswell (2003, p. 181) wrote that researchers frequently collect data in participants' homes or offices, where context is authentic. In this study, I interviewed teachers at the school where they teach. The quality of participant perspectives refers to trying to relate human experiences as perceived by the participants. In this study, teachers answered interview questions according to their own lived experiences. Merriam (2002) explained that researchers try to “understand the meaning” (p. 4) of specific events or experiences.

Researcher as data gathering instrument is the distinctive nature of qualitative data collection to involve human interaction rather than instruments such as questionnaires or tests (Hatch, 2002; Kacen & Chaitin, 2006; Merriam, 2002, p. 5). In this study, I served as the researcher, or the data gathering instrument as I collected data through interviews, documents, and a research journal. Subjectivity refers to the nature of data analysis in qualitative studies. Qualitative researchers acknowledge that “subjective judgment” (Hatch, 2002, p. 9) is inevitable during data interpretation. In relation to this study, subjectivity was minimized through bracketing within a research journal, which was included in triangulation of data (Kacen & Chaitin, 2006). Emergent design (Creswell (2003, p. 181; 2008, p. 141; Hatch, 2002) refers to the notion that the exact direction of qualitative studies is unpredictable in nature. Details of a study emerge during the course of data collection. This study demonstrated the element of emergent design naturally, as the design of the final project emerged from the data that were collected and analyzed.

Inductive data analysis refers to the fact that, unlike quantitative researchers, qualitative investigators do not pose hypotheses. Instead, they gather information and then look for patterns within the data. I carried out the action of inductive data analysis as I examined and reexamined data to identify themes and subthemes. Reflexivity refers to the “existential fact” (Hatch, 2002, p. 10) that researchers carry biases and influences that can affect the topic(s) being studied. Therefore, it is common in qualitative studies for researchers to monitor and report self-reflections or personal connections to the study (Brown, 2008; Creswell, 2003, p. 182; Gunasekara, 2007; Hatch, 2002; Hoskins & Stoltz, 2005; Kacen & Chaitin, 2006; Ortlipp, 2008). For this study, reflections and personal connections were documented in the research journal. Merriam (2002, p. 5) noted that words are used, as opposed to numbers, to provide rich description in qualitative studies. The design of this case study informed the development of the final project through description provided by teachers themselves.

Justification of Research Design

The qualitative case study made the most sense for answering the guiding questions and fulfilling the purposes of this study. The best way to gain teacher input about how to improve student achievement in mathematics through professional development was to speak directly with teachers involved in this particular case. Case studies are appropriate when researchers seek to explain or understand a specific case or set of cases (Creswell, 2003, 2008; Hancock & Algozzine, 2006; Merriam, 2002). This qualitative inquiry allowed me to ask probing questions and clarify ideas throughout the study, gaining an in-depth glimpse at the mathematics situation at ABC Elementary School. Results were interpreted through the formation of categories and themes.

A case study was more effective than other choices based on the interpretive nature (Auerbach, 2003; Creswell, 2003) of the study and its goal of resulting in a product (Creswell, 2008; Lomax, 2002; Mills, 2003). The rich, descriptive data (Hancock & Algozzine, 2006; Ponterotto, 2006) gathered during the study informed the development of the final product. This ensured that I had the best possible information from which I designed an appropriate program.

Other types of qualitative designs were considered, including phenomenology, grounded theory, and narrative research. Phenomenology was ruled out because it did not align with the goal of this study. I did not intend to describe a particular experience shared by participants. It is true that the participants did all live the experience of the curriculum change; but, describing that experience would not have necessarily enabled me to develop a project from the data. I decided against grounded theory for similar reasons. I could conduct similar data collection and analysis to reveal a particular theory, but it would be less informative for the project to evolve from one theory than from several themes and subthemes (as resulted from the case study). Finally, narrative research was overruled because the concept of telling life stories did not apply exactly to the objectives of this study. Most of the choices for qualitative design were nearly fitted to work within the boundaries of this study, but the case study design was chosen because it would result in the best quality and quantity of data for the purposes of developing a project based on final results and conclusions of the study.

Ideas for quantitative and mixed methods analysis were overruled because of specific circumstances. I considered the idea of quantitatively comparing student test scores before and after Georgia's curriculum changed, but decided that it was inappropriate to compare pretest and posttest scores from tests with different items and scales of scoring (Georgia Department of Education, 2006). I also considered asking participants to respond to a survey, but determined that more detailed and accurate information could be obtained through face-to-face interviews. A mixed methods study, including both qualitative and quantitative methods, was considered. However, it was overruled because of the lack of quantitative information available, desire to get in-depth, personal accounts from teachers over a period of time, and skepticism associated with anonymous surveys taken by this particular teacher population. Having taught at ABC Elementary School for 5 years, I have witnessed several survey studies conducted with the teachers there. Often, teachers have manipulated and changed answers to survey items based on whether or not they think specific answers will result in more work required from them. Instead of answering items by reflecting thoughtfully, they sometimes chose their responses based on their preconceived ideas about the survey, no matter what the disclaimer said. Rather than risk the possibility of skewed results, I decided to conduct a case study with a few select participants, intending to gain insight about the types of professional development that may help teachers facilitate their students' increased achievement in mathematics. Once the goals and guiding questions for this study were determined it was clear that the qualitative tradition, and a case study design, in particular, were logical choices for data collection and analysis. The following section describes information pertaining to the participants of the study.

Participants

The participants for this study included nine "purposefully selected" (Creswell, 2003, p. 185) teachers and administrators from ABC Elementary School. Although the population of regular education teachers at the school was 20, there were only seven mathematics teachers in Grades 1 through 5. Other teachers specialized in different subjects, such as reading, writing, and language arts. For this reason, I invited all seven mathematics teachers, as well as the principal and the academic coach, to participate in this study. The academic coach and principal were included to provide additional perspectives (Creswell, 2008). They contributed ideas gained from observing teachers during mathematics classes, whereas teachers themselves were limited to their own personal experiences. In total, nine adults participated in the study.

Criteria and Justification for Selecting Participants

Participants were selected from the teaching and administrative staff at ABC Elementary School, which is a relatively young group of dedicated professionals. Twenty-seven percent of teachers have more than 20 years of experience while 38% have less than 10 years of experience. Of this population, more than 60% of the teachers have an advanced degree. Thirty percent have earned master’s degrees, while 33% have earned specialist’s degrees. All teachers currently meet criteria for being highly qualified, as established by NCLB (2001). This means that at ABC Elementary School, teachers meet all of the state's certification requirements and are assigned appropriately for the field in which they are teaching.

Qualitative researchers frequently select participants whose knowledge or insights will enable them to answer the research question (Creswell, 2003, p. 185; 2008, p. 214; Hancock & Algozzine, 2006, p. 39). Participant selection is deliberate, not random, and highlights a key difference between quantitative and qualitative research. Creswell (2003, 2008) and Hatch (2002) explained that participant selection for qualitative studies does not involve large sample sizes or random sampling, as expected within the quantitative tradition. Creswell (2003) also noted that sample size should be balanced with depth of inquiry. The sample size for this study is limited; therefore I conducted in-depth interviews with each participant (Hoskins & Stoltz, 2005). Creswell (2008) explained that while sample sizes vary, qualitative studies typically involve few cases or people. The goal during this study was to describe or understand meanings constructed by a select group of people (Creswell, 2008, p. 213; Hatch, 2002). For these reasons, nine deliberately chosen educators comprised the participants of this case study at ABC Elementary School.

Procedures for Gaining Access to Participants

Establishing access to participants is an important step in any qualitative study (Creswell, 2008; Hancock & Algozzine, 2006; Yin, 2009). In my case, this process began long before I conducted the study, as I worked with the educators involved for several years prior to beginning my study. When I first initiated the data collection process, I emailed all nine potential participants. Participants were invited to be part of the case study based on the following criteria: familiarity with the recent changes in mathematics instructional expectations in Georgia and experience teaching or observing elementary mathematics classes within the last 2 years. Candidates who represented certain vulnerable populations, as defined by the Walden University Institutional Review Board (IRB), were excluded from the study, such as people who were less than fluent in the English language or over the age of 65. This selection process was guaranteed because none of the mathematics teachers at the school were non-native English speakers or over the age of 65. After making initial contact with the teachers I held an informational meeting during which I explained the study and expectations in greater detail and asked for a final commitment to participate.

Establishing a Researcher-Participant Relationship

I took appropriate measures to establish a working relationship with each participant. Hatch (2002) noted that establishing and maintaining a stable researcher-participant relationship is important in qualitative studies. Creswell (2008, p. 283) described using nondiscriminatory language as a way to develop a scholarly rapport. Researchers are strangers in many studies and must work to create a comfortable environment for participants (Rubin & Rubin, 2005, p. 13); however, in this study I was not a stranger to the participants. During this study, I found a private setting for every interview (such as the participant's classroom, my classroom, or a conference room) and asked each if he or she felt comfortable with the arrangements. Hatch (2002) recommended using "background questions" (p. 3) to put participants at ease before beginning the formal process. Each interview began with a few informal questions designed to make the participant feel comfortable. Although the informal questions were not expected to provide valuable data, they helped to affirm a working relationship between the participants and myself.

The researcher-participant relationship was also strengthened by providing transparency about the study. Participants remained informed about multiple aspects of their participation, including their participation in interviews, their submission of lesson plans or other documents for data analysis, and their feedback during the member checking process. Creswell (2003, 2008), Hancock and Algozzine (2006), Hatch (2002, p. 46), and Yin (2009) asserted that participants should know about their rights, the intentions of the study, and expectations for the researcher and participants prior to the study. Participants were informed that their identities would remain anonymous and their responses confidential. All participants signed a consent form prior to participating in the study.

Ethical Considerations

I considered ethical concerns during this study. Creswell (2003, p. 64; 2008, p. 218), Hatch (2002, p. 60), and Merriam (2002) pointed out the necessity of having research plans reviewed by the IRB prior to conducting any study. For this study, data were collected after the proposal was approved by the University Research Reviewer (URR) and the Walden University IRB. The IRB approval number for this study was 02-08-10-0340120.

I protected participants' privacy and confidentiality through specific measures. Interviewees signed an informed consent form acknowledging the voluntary and confidential nature of the study. No one was pressured to participate, and I clarified that participants could withdraw from the study at any time. In the interview transcripts and within the final doctoral study, participants' identities were kept confidential by referring to them with pseudonyms. Additionally, results of the study were written so that readers who might be familiar with the circumstances of the study would not be able to infer participants' identities. All participants were protected from harm to the greatest extent. There were no known risks associated with participation in this study. Guidelines were in place to ensure that data are dependable and worthy of attention and so that participants' rights were protected.

Data Collection

Qualitative data collection helps researchers understand experiences through the lens of the participants (Merriam, 2002) and leads to meaningful findings embedded within data (Ponterotto, 2006). In many qualitative studies, a researcher chooses one primary data collection method with supporting evidence from another type (Merriam, 2002, p. 12). For the purposes of this study, the primary data sources were teacher interviews and documents, while the secondary source of data was the reflective research journal (Creswell, 2003, 2008; Hancock & Algozzine, 2006; Hatch, 2002; Merriam, 2002; Yin, 2009). Documents and interviews were used to answer the first guiding question, regarding mathematics instruction, while interviews alone were used to answer the second guiding question, regarding professional development. The following subsections describe and justify each form of data collection. Figure 1 provides a model of data collection strategies and illustrates how data were triangulated.

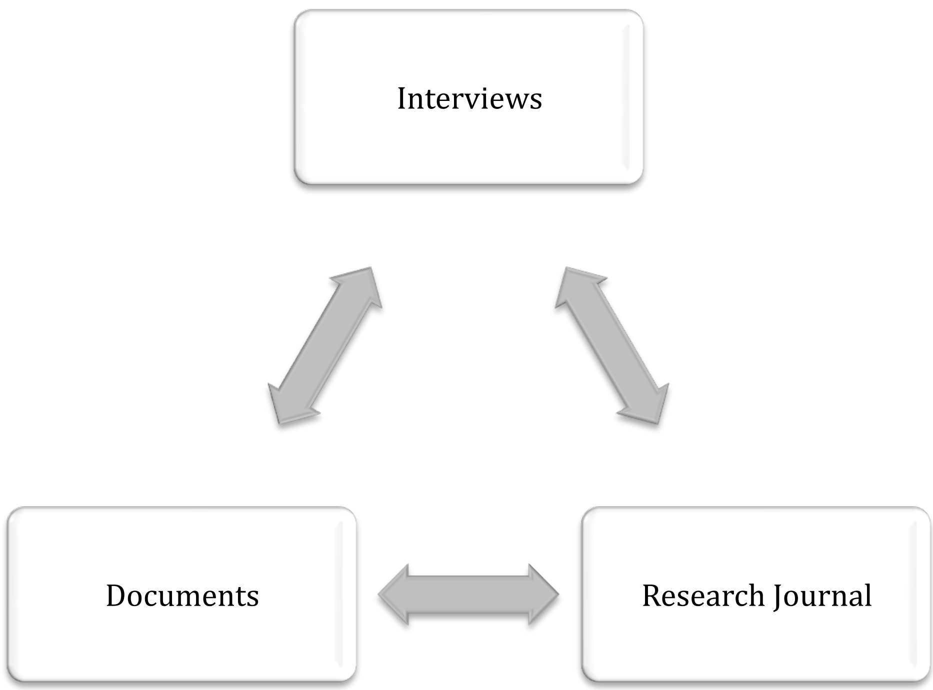

Figure 1. Triangulation of data

In-Depth Interviews

In this case study, I engaged nine teachers or administrators in face-to-face, semistructured interviews. There was one set of interview questions for teachers, and a modified set of questions for administrators. Data from the interviews were used to answer both guiding questions. Face-to-face interviews are appropriate to the qualitative tradition (Creswell, 2003, 2008; Hatch, 2002; Parker, 2004, p. 53; Rubin & Rubin, 2005), as well as to the case study design (Hancock & Algozzine, 2006; Yin, 2009). Hatch (2002) explained that interviews are often the primary source of data in a qualitative project, and Ponterotto (2006) noted that interviews result in the "thick description" (p. 538) that is unique to qualitative work. Semistructured interviews are specifically appropriate for case studies because they allow researchers to probe for deeper meaning as they collect data (Hancock & Algozzine, 2006).

Initially, I conducted one in-depth interview with each participant. In some cases, interviews yielded enough data to adequately answer the guiding questions. In other cases, however, I sought to gain additional insight from participants. Follow-up interviews were scheduled with six participants, as needed, to clarify or extend discussions based on the transcripts and resulting analysis of the first interviews. For example, I asked Annabel (a pseudonym) to clarify a statement about wanting to learn how to "match the curriculum to the learner." Another example is that I asked Fiona (a pseudonym) to explain an answer to a question that referenced "level one" and "level two" questions. I asked Cal (a pseudonym) to elaborate on the type of homework that is assigned at his particular grade level; this helped me establish the theme of computation as an area in need of improvement. The goal of the interviews was to elicit responses to open-ended questions about professional development in relation to increasing student achievement in mathematics. I asked participants questions such as, "What aspects of math instruction do you personally need to learn more about" and "If you could design your own professional development program to improve math instruction at this school, what would it look like?"

Merriam (2002) explained that asking important questions can help people articulate the meanings they have acquired by living through specific circumstances, an idea reinforced by Greenwood et al. (2006) when they discussed the aspect of "mutual respect" (p. 81). Janesick (2004) explained that interviews are structured exchanges between two people who communicate through questions and answers. Questions were predetermined (see Appendices A and B), but probing questions emerged during the course of the study and during individual interviews (Creswell, 2003, 2008; Hancock & Algozzine, 2006; Hatch, 2002; Yin, 2009).

Documents

Documents are a common source of qualitative data (Creswell, 2003, 2008; Hancock & Algozzine, 2006; Hatch, 2002; Merriam, 2002). In this study, I used documents such as teachers' lesson plans and newsletters to answer the first guiding question. Specifically, I examined teachers' lesson plans in order to find evidence, or lack thereof, of research based strategies that align or conflict with current research about balanced mathematics instruction.

This included looking for evidence of both traditional and conceptual methods of teaching mathematics. Traditional methods are those that result in procedural knowledge, such as rote memorization, basic skill practice, demonstration of algorithms, teaching tricks or rules, and use of textbooks (Caron, 2007; Patton, Fry, & Klages, 2008; Timmerman, 2004). Evidence of this included lesson plans that focused on direct instruction or worksheets. Conceptual methods are those that result in conceptual understanding, such as problem solving, reasoning and proof, communication, connections, and representations (Desimone et al., 2005; Schwartz, 2006; & Van de Walle & Lovin, 2005). Evidence of this included lesson plans that focused on cooperative learning and working with manipulatives.

Other documents, including newsletters, teacher blogs, email messages between participants, email messages from participants to me, or other appropriate documents that emerged, were also collected (Creswell, 2003, p. 187; 2008, p. 230). These documents were analyzed and coded for original themes, as well as used to support or dispute themes that emerged from other data. This type of data contributed to the overall themes reported in the results of the study.

Only documents that came from participants were included in this study, and some of these were private. I asked participants to provide me with examples of their mathematics lesson plans from the current school year or last school year, and in the cases of email messages and blogs I printed them directly with permission of the participants. Documents can include a multitude of written artifacts, formal and informal, private and public. Creswell (2008, p. 231) noted that documents often produce rich text data that can be analyzed immediately, and Merriam (2002, p. 13) pointed out that documents do not change the dynamics of a research setting in the same way that a human researcher might. The data gathered from documents supplemented the study, ensuring that saturation was reached in data collection.

Research Journal

Throughout this study, I kept a research journal by which ideas were continually cross-referenced or verified for accuracy. For example, I noted that George (a pseudonym) believed that efficiency in mathematics is of utmost importance, possibly even more important than understanding the processes involved in mathematical applications. He stated,

> This is a pet peeve . . . when they do repeated addition for multiplication, or they do trailing quotient for division, there are so many places for error that it's not efficient. And especially in the world of timed tests, you know . . . Just on a paper this week I had a child add 25 fifteen times instead of multiplying it. Well, on a timed test, it takes a long time to [add] 25, and there's fifteen places they can make errors; whereas if they use the traditional algorithm, their [chance of] error is down to six. You know, it cuts their percentage for error down by at least half.

I also wrote, "Emmie does not believe that collaborative professional development will work at this school, but I know that it is because of past conflicts that occurred between her and another teacher." I also noted that while many participants lamented the lack of fluency among students for basic facts, Cal and David (pseudonyms) "seemed to devote very little class time or homework opportunities to reinforce fact memorization."

The use of a research journal added stability to the study by forcing me to openly accept personal opinions and responses, and make a purposeful effort to keep them separate from data (Hatch, 2002, p. 8; Ortlipp, 2008). Specifically, if a theme emerged from interview or document analysis, I checked the research journal for either support or negation of that theme. Similarly, I used the research journal to make sure I was not inserting my own ideas or self-reflections into the data analysis process. For example, I acknowledged that due to our working relationship, I am aware that George (a pseudonym) favors traditional approaches for teaching mathematics above conceptual methods.

The nature of qualitative research is such that objectivity is difficult to ascertain (Creswell, 2003, 2008; Hatch, 2002, p. 9; Merriam, 2002) and tendency toward bias must be acknowledged (Hancock & Algozzine, 2006). Qualitative researchers embrace the fact that their personal experiences and beliefs may influence their interpretation of data, and write this into the study accordingly (Gunasekara, 2007; Ortlipp, 2008). Kacen and Chaitin (2006) described this action as bracketing one's thoughts and experiences. Creswell (2003) and Brown (2008) described qualitative researchers as having an awareness of how their personalities may shape the study in different ways. I used a research journal to accomplish these purposes throughout the study.

Researchers can overcome the potential for biased results by "articulat[ing] and clarify[ing] their assumptions, experiences, worldview, and theoretical orientation to the study" (Merriam, 2002, p. 26). Merriam recommended using a journal to reflect on thoughts, questions, or experiences during data collection and analysis. This helps balance researcher biases or opinions with actual data (Hatch, 2002, p. 87). The research journal was recorded in the form of a word processing document, and was stored on a laptop computer and backed up on a portable flash drive. The research journal served as a secondary source of data and was used to cross reference emergent ideas.

Data Collection Processes

Data collection emerged naturally during the course of the study. The first step was to conduct a pilot study for the purposes of evaluating and refining data collection and analysis methods (Seidman, 2006). I videotaped myself interviewing two nonparticipants. These were special education teachers at ABC Elementary School. They were familiar with the changes in mathematics instruction and had taught mathematics in the past, but they did not teach mathematics at the time of the pilot study. They were able to competently answer interview questions due to their previous experience with elementary mathematics.

Within 3 days of the interviews, I transcribed the interviews and coded the data for themes. I then met with the pilot study participants, and they assisted me in determining the sufficiency of the interview questions for answering the guiding questions. The pilot study participants also engaged in member checking by critiquing the accuracy of my interview transcripts and giving me feedback on whether my findings reflected their perspectives. During that meeting, the pilot study participants and I watched the video together, and I solicited their evaluation. They pointed out ways in which interview questions should be reframed and interview techniques could be improved. For example, all instances of the word mathematics, in the interview questions, were changed to math. Both pilot study participants felt that the interview would be more authentic if the word math was used, since that is the commonly used term for all of the participants. I incorporated results of the pilot study into my interview protocol, and requested changes in procedures from the Walden IRB office. The interview protocol is included as Appendix B. A modified version, used with administrators, is included as Appendix C.

Additionally, I requested historical mathematics lesson plans from the pilot study participants. I coded these documents using the same procedures that I planned to use during the actual study, including open coding, color-coding, and selective coding. From this analysis, I determined that lesson plan data would be sufficient to contribute to answering the guiding questions. I asked the pilot study participants to engage in member checking to evaluate whether my findings aligned with their perceptions. At this point, one change was made to document procedures. Rather than asking participants for all of their mathematics lesson plans, I decided to ask for 1 week of lesson plans per unit of study. The pilot study increased the validity and improved the quality of the study by allowing me to facilitate a trial version of the study before beginning formalized data collection.

When the formal data collection process began, I conducted nine initial interviews using the full interview protocol. Seven of these were with teachers, and the other two were conducted with administrators. After the second phase of coding, I held follow-up interviews with six participants to clarify or add to ideas conceptualized in their initial interviews. I did not need to conduct follow-up interviews with three participants because I gained clear and sufficient data from their first interviews. Two of the follow-up interviews led to third and final interviews just to clarify a few ideas. Interviews were conducted until saturation was reached. Guest, Bunce, and Johnson (2006) found that themes generally begin to overlap and repeat after 12 interviews, when saturation is reached. In this study, I conducted a total of 17 interviews.

I anticipated that initial interviews would last 45 to 60 minutes, but they actually lasted 25 to 50 minutes. The initial interviews were audio recorded and transcribed within 3 days. I coded the data before making decisions about the next phase of data collection. I conducted follow-up interviews with individual participants, while simultaneously reexamining data and relating ideas. This method was synchronous with Merriam's

(2002, p. 14) and Hatch's (2002, p. 89) assertions that data analysis and data collection are interwoven in qualitative studies.

The interviewing procedure allowed me to ensure that the data being collected would be useful in answering my original guiding questions (Hatch, 2002). Interview questions were not modified during the study because appropriate data emerged from the interviews. After participants completed their interviews I sent copies of the transcripts to them for verification or negation of accuracy. This also gave participants a chance to clarify any particular points they wanted to make.

The process of (a) interviewing, (b) transcribing, (c) coding, (d) finding themes, and (e) verifying with other data sources, was repeated until no new themes appeared. The transcripts of the in-depth interviews served as one of the main sources of data for this study. Interview questions are included as Appendices B and C. I collected and analyzed documents throughout the study, and these documents served as another main source of data. Specifically, I obtained copies of teachers' lesson plans in order to learn about their application of content and pedagogy related to teaching mathematics. Other documents collected from participants, such as email messages, statements from blogs, and newsletters emerged as the study grew. These documents were collected on a weekly basis in a face-to-face or online format. Documents were analyzed and cataloged within 3 days of collection, excluding lesson plans, which I analyzed over a period of several weeks.

Lastly, I kept an electronic research journal that also served as a source of data for this study. The research journal was an ongoing data collection tool, accumulating new data frequently as I recorded self-reflections and thoughts related to the study. These reflections included statements such as, “Fiona was the only one who felt strongly that teachers do not need professional development in content, so I will include that as disconfirming data” and “George acknowledges his independence as a teacher and I get the impression he is not interested in collaborating with others.” All data were stored securely throughout the study in password protected files and in a locked file cabinet.

Role of the Researcher

In qualitative research, the researcher serves as “the primary instrument for data collection and analysis” (Merriam, 2002, p. 5). Throughout the study my role as the researcher was to collect, organize, and analyze data. This included conducting and transcribing interviews, keeping a research journal, and coding and analyzing documents. In this case, I had a prior working relationship and positive rapport with all of the participants.

A common practice in qualitative work, I acknowledge that personal biases can affect interpretation of results. To minimize the likelihood of bias in the study, I asked the interview questions in a prescribed order during every interview, excluding follow-up questions that emerged from the semistructured interview format (Gunasekara, 2007; Hancock & Algozzine, 2006). I framed interview questions in an objective manner, and did not comment about personal preferences or beliefs. The additional procedure of keeping a research journal also minimized the chance for bias by forcing me to separate my opinions from data. All ethical procedures for conducting interviews were followed.

Experts in qualitative research recommend that researchers acknowledge their personal connections to the study upfront, rather than pretending they do not exist (Creswell, 2003, 2008; Hancock & Algozzine, 2006; Hatch, 2002; Merriam, 2002). I therefore acknowledge my opinions about the topic of study: how to improve student achievement in mathematics through professional development. As a teacher in Georgia, I experienced the changes associated with the new curriculum. I have experienced personally the need for professional development to coincide with changes in instructional expectations. I perceive that teachers need assistance in both content and pedagogy. I think they need more knowledge in how lower level mathematics skills evolve in the upper elementary grades. I believe teachers need and want professional development in the area of mathematics reform. Finally, I acknowledge that results of the data analysis are subject to interpretation. However, measures of ensuring accurate and true results were taken to keep my role as the researcher as neutral as possible throughout the study.

Data Analyses

I coded and analyzed data throughout the duration of the study, as well as at the conclusion. I used tables within a word processing program to organize and document data. I coded and looked for emergent themes within data by hand to ensure that I did not overlook any important details (Hatch, 2002, p. 57). In qualitative research, data analysis is iterative (Creswell, 2008; p. 245). It is not done all at once at the end of the data collection period but is rather a continual process that occurs throughout the data collection process (Hancock & Algozzine, 2006; Seidel, 1998). To further strengthen the processes of data collection and analysis, I purposefully sought patterns among different sources of information, an idea known as multiple perspectives (Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005). The multiple perspectives for this study included lesson plans, interviews with teachers and administrators, research journal entries, and miscellaneous informal documents.

I began analysis by applying open coding to look for broad themes within interview transcripts and lesson plans (Creswell, 2003, p. 191; 2008, p. 434; Merriam, 2002, p. 148). Hatch (2002) referred to this process as reading the data "for a sense of the whole" (p. 181). Specifically, I read through data looking for information that would answer the guiding questions (Foss & Waters, 2003). As I examined teachers' lesson plans and interview transcripts, I kept the two guiding questions in mind. This first step in data analysis resulted in several general points of reference for analyses to follow.

After broad themes were identified, I rearranged data by placing specific statements into separate categories (Merriam, 2002, p. 149) and reexamining for relationships or patterns. At this point I developed initial codes, using a color-coding system, by highlighting passages that seemed to revolve around the same main idea or ideas (Seidel, 1998). I used hard copies of documents to physically cut apart transcripts and place chunks of data into separate piles. I found that some of these secondary categories overlapped; for example, some chunks of data could have been placed into two different piles. When discussing a previous professional development experience, Annabel said,

> They would give us tasks. I think we did mostly third and fourth grade level tasks in the training. And we were put into groups just as though we were math students, fourth graders or third graders, we were given the manipulatives. We had to solve the problem or task and we had to present our solutions.

I determined that this statement could fall under the heading of engagement, because they completed tasks, or collaboration, because they worked together in groups. Additionally, some piles were too small to justify significance, so they were discarded. For example, Annabel enthusiastically supported learning through videos, but this idea did not emerge from any other interviews. I consolidated some of the piles to form overarching themes that described the relationships among subtopics (Foss & Waters, 2003). In the beginning, for example, technology was set apart as an independent theme. Throughout the reexamination process, however, I discovered that it more appropriately belonged under the larger heading of literature and research. I also reassessed my analysis by ensuring that everything in each pile actually belonged there, and I omitted some chunks of data after determining that they did not relate to the guiding questions.

I finalized results by reexamining themes in light of developing a "conceptual schema" (Foss & Waters, 2003) in which I would report my findings. This consisted of relating categories, organizing themes, and identifying central ideas (Creswell, 2003, p. 191; 2008, p. 437; Merriam, 2002, p. 149). I tried several different ways of organizing themes, with the underlying goal of finding a logical thread among themes and their relationship to the guiding questions (Foss & Waters, 2003). I aimed to discover patterns within and across categories of data (Seidel, 1998). This recursive process of "noticing, collecting, and thinking" (Seidel, 1998, p. 2) resulted in themes that appropriately answered the guiding questions for this case study.

I reexamined data for emerging findings at two checkpoints: after the initial interviews and after the first examination of lesson plans. As information was reduced into categories and themes, I cataloged results and compared them to other sources of data. I continually reexamined themes to verify or modify for accuracy (Hancock & Algozzine, 2006). For example, the original theme of content expanded to include several subthemes as data collection and analysis progressed. I realized during open coding that teachers would like content to be a component of professional development, but then found evidence of subtopics within the theme of content. These included number sense, computation, problem solving, geometry, measurement, algebra, and data analysis. Throughout the data collection period as well as at the conclusion, I triangulated findings with the research journal and pertinent documents collected during the study.

At each stage of data collection, I applied the member checking strategy to verify findings with participants (Creswell, 2003, 2008; Hatch, 2002; Merriam, 2002). This ensured that participants' beliefs were portrayed accurately. The first level of member checking, as described by Brantlinger et al. (2005), took place after data collection but prior to analysis. I asked participants to confirm the accuracy or inaccuracy of interview transcripts and incorporated their feedback into data analysis. The second level of member checking occurred after data analysis, and involved asking participants to evaluate interpretations of data (Brantlinger et al., 2005). During data analysis, I sent an outline of preliminary findings to all participants and asked for their feedback. This process allowed participants to verify or disconfirm results through their responses (Creswell, 2003, 2008; Hatch, 2002; Merriam, 2002).

Discrepant cases were reported as such, included in data analysis, and integrated into the results and conclusions. After I determined preliminary themes or categories, I reviewed raw data to look for outlying evidence that did not align with these themes. This practice is referred to as negative or discrepant case analysis (Brantlinger et al., 2005).

Validity was strengthened by the inclusion of both complementary and disconfirming evidence. By making deliberate efforts to include discrepant cases, I attempted to present unbiased and accurate results. Figure 2 demonstrates the data analysis process for this study.

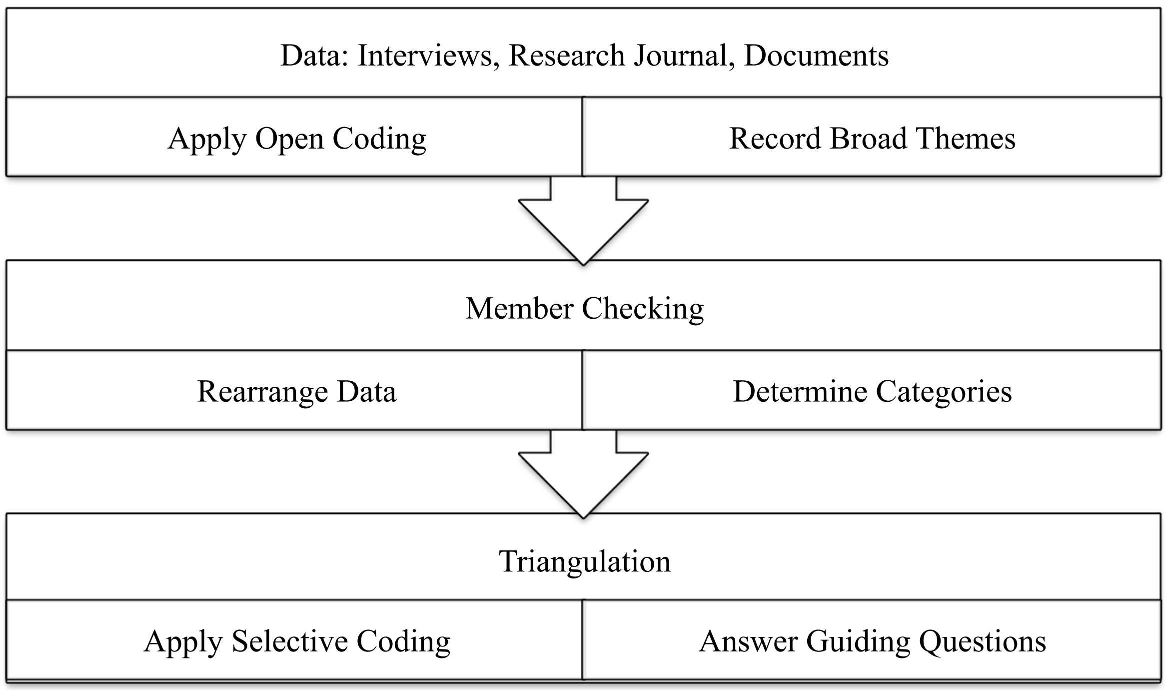

Figure 2. Data analysis process

Data Cataloging System

I collected data from participants on a weekly basis in the form of documents and interviews. These data were saved or scanned into files that were stored on a laptop computer and backed up on a portable flash drive. Some hard copies of data were stored in a locked file cabinet. A cataloging system, in the form of a word processing table, was used to keep track of themes and categories that continued to emerge throughout the study. This cataloging system, or database (Yin, 2009), preserved data and allowed for organization during data collection and analysis. Results from interview transcriptions, the researcher's journal, and documents were continually cross referenced to verify accuracy of codes and themes, and were triangulated at the conclusion of the study.

Findings

Findings of this study related directly to the problem: how to increase student achievement in mathematics at ABC Elementary School through the venue of professional development. Themes were derived through an examination of patterns and relationships within data and used to answer the guiding questions for this study. The findings formed the foundation of the doctoral project and are discussed in the following subsections. Certain information is bracketed to ensure the confidentiality of participants, including grade level references. Utterances such as "um" and "uh" were omitted to make the data more readable. I assigned pseudonyms to participants in order to make the discussion of findings more conversational. The pseudonyms are Annabel, Betsy, Cal, David, Emmie, Fiona, George, Hollie, and Iris.

Guiding Question 1: Mathematics Instruction

The answer to the first guiding question, "In order to improve student achievement in mathematics at ABC Elementary School, what aspects of mathematics instruction should be addressed?" can be explained with two main themes and seven subthemes. Data indicated that both content and pedagogy should be addressed to result in better mathematics instruction, confirmed by Iris, "My ideal professional development situation would . . . involve a professional learning community . . . looking at pedagogy, but also looking at content." The area of content resulted in four subthemes and the area of pedagogy resulted in three subthemes.

Content

Data definitively pointed to a need to address mathematics content areas. Evidence justified specific mathematics topics among data gathered from both interview transcripts and lesson plans. This resulted in an array of content areas that generally correlated with state curriculum or reflected weaknesses perceived by teachers at different grade levels. The variety of topics could be due to differences in content knowledge and preparation among participants, or personal opinions about what is most important within mathematics instruction.

I interpreted the content area data to mean that teachers would benefit from a project that targeted the main content areas included in the state curriculum, with more time being devoted to some and less attention being given to others. The recurring themes of number sense, computation, and problem solving were justified as separate entities because they were evidenced across grade levels and among data from several participants. The remaining four areas of measurement, geometry, algebra, and data analysis were placed into one category due to their appearance within data and their alignment with state standards. This was essential because participants repeatedly mentioned working with standards as essential to effective instruction.

Number sense. Number sense, or numbers and operations, emerged as the strongest content area theme. Five out of eight participants directly named number sense as an area that should be addressed, and others inferred it. When asked to identify an area of weakness among students, David stated, “Number sense, definitely. It comes back low every time [on the CRCT] . . . they seem to be so weak in number sense.” Emmie explained, “These children are not developing . . . a good understanding of numbers,” adding, “If students cannot estimate or reason, then I feel like they don’t understand numbers.” A strong sense of numbers is a foundational part of understanding mathematical concepts, and data from this case study certainly indicated it as an area to be included in a professional development effort.

Other data indicated that room for improvement exists in the way teachers provide scaffolding from lower grades to higher grades in the area of number sense. This included both vocabulary and instructional strategies utilized by teachers. Lesson plans revealed that teachers approach number sense in different ways, some more traditional and others more conceptual. For example, David and Fiona used direct instruction to teach rounding, focusing on looking at digits individually to determine whether a digit is greater or less than five. In contrast, Emmie taught students to look at the whole number and consider how it related to values of tens, hundreds, thousands, and so on. One set of lesson plans contained evidence that students were required to estimate as a part of mathematics instruction (Emmie), but there was no evidence of that same requirement in any other grade levels. Additionally, Fiona expressed a need for conformity, continuity, and consistency of mathematics vocabulary throughout grade levels so that students maintain clear connections among concepts from year to year. When teachers use varying terms to refer to the same mathematical ideas it could be confusing to students. Number sense prevailed as a content area that could potentially be addressed through streamlining vocabulary and teaching strategies.

Fiona’s perspective reinforced the idea that teachers should facilitate progression of number sense throughout grade levels, “Some of the things that were rudimentary or fundamental in [one grade lower] now have a broader application in [the grade I teach] and [the students] just conceptually aren't there." Hollie claimed that the greatest need for improvement lies in facilitation of number sense, and that need is exacerbated because of the expansion of number sense from Kindergarten to Grade 5,

> Little kids [should] know that they have five fingers and not to go, "one, two, three, four, five" every time. And that starts in Kindergarten and it builds us to fifth grade. Number sense is such a huge area, that like in fifth grade it covers fractions and decimals.

What she meant by this statement was that students should have a strong understanding of whole numbers in the lower grades so that they can expand their knowledge, when they reach upper elementary grades, to include concepts of numbers that are less than one. Perhaps the most compelling argument for offering professional development in this content area came from Iris, who described numbers and operations as "our glaring weakness across the board."

Computation. The idea of computation emerged as a recurring content theme. Six participants discussed to some degree the need for students to be more proficient in the four basic operations: addition, subtraction, multiplication, and division. This was significant, even though educators varied in their opinions about the most important elements of computation. While Betsy, Cal, David, and George stressed memorization as imperative, Emmie and Fiona focused on conceptual understanding as the cornerstone of computational mastery.

Computation as its own entity differs slightly from the construction of the state standards. In Georgia's state curriculum, the area of computation is enveloped within the broader category of numbers and operations. For the purposes of this study, however, I identified it as a separate category. This was important because it reflected teachers' natural ideas about teaching mathematics, without the overarching influence of state mandates.

Overwhelmingly, teachers believed that students should achieve automaticity, or fluency, of their basic mathematics facts. This idea echoes education research literature (Burns, 1998; Chard et al., 2008; Desimone et al., 2005; Goldsmith & Mark, 1999; NCTM, 2000; NMAP, 2008; Wong & Evans, 2007). George listed "basic skills, learning those multiplication tables, memorizing those basic facts and learning processes" as essential elements for mathematical success. Cal noted that many students struggle with knowing their basic facts, and emphasized that this deficiency could lead to more struggles in higher grades. Lastly, David explained, "We do a lot of flashcard practice to try to get those basic facts because they do not have the basic addition and basic subtraction when they come to me."

Time seemed to be a factor in the content area of computation. Data, specifically from lesson plans, showed that very little class time was devoted to practicing simple computation in certain grade levels. Although teachers seemed to work with students on developing ideas embedded within operations (Annabel, Betsy, Cal, David, & Emmie), they did not appear to spend much time on rote memorization. In follow-up interviews, I discovered that homework in one particular grade level included "five to seven" (Cal) mathematics problems per week, and that students "are tested monthly on the [addition] facts" (Annabel). Perhaps more rigorous requirements would result in students becoming more fluent with their basic facts, as well as limiting challenges that students encounter as they progress through different grades.

Some teachers expressed that problems with computation could stem from a lack of conceptual understanding. Emmie stated, "I don't think [students] are developing the concepts behind the operations as well as they should. Like not really understanding, 'What is addition? What is subtraction?'" Additionally, Fiona said, "There's no question that students have a difficult time with the . . . abstract concepts still with subtraction. For whatever reason, they still are very rule-bound and not concept-driven on the idea of taking away and breaking apart." A fitting solution to this problem came from Hollie in a follow-up interview, "The teacher needs to make sure that both areas have been taught: conceptual and traditional."

Problem solving. The content area of problem solving in mathematics is tricky. When students are struggling it can be difficult for teachers to discern exactly where the misunderstandings occur: Is the child having trouble reading the problem? Can the child comprehend what the problem is asking? Is the child performing the correct operation? Is the child making computational errors? When word problems transition from simple to complex around second or third grade, there are even more opportunities for misunderstanding. Is the child performing all necessary steps? Does the child know how to get started? Does the child have all of the necessary background knowledge to proceed? For all of these reasons, as Cal put it, "Word problems . . . [are] a big, big issue [for students]."

Reasoning and higher order thinking likely play large roles in students' attempts to solve mathematical problems. Annabel explained,

> In our grade, or with my students, they seem to be competent if the problem seems forthright, as to what to do . . . But when we go to a [more complex]

> problem . . . that's where things kind of fall apart. And I just, I would imagine that that's magnified on up through the following grade levels. That if, if higher order, maybe, maybe you'd call it higher order thinking is involved, that doesn't always click.

Annabel also explained that the process for solving problems was presented to students as a series of steps that included drawing a picture, writing a number sentence, and then computing. Lesson plans indicated that students engaged in problem solving, but that it often occurred in groups. Consequently, students may not get much practice solving problems independently and thus, may not be developing abilities to reason or think at deep cognitive levels without peer support.

Measurement, geometry, algebra, and data analysis. This last content area category coincides with Georgia's state curriculum. Measurement, geometry, algebra, and data analysis emerged from the data as content areas in which teachers might benefit from additional support. In some cases, these were identified as areas of weakness among students, and in others, participants expressed a desire to learn more in a particular area. They are compiled as one subtheme and included as a module of the project. Because the areas may vary in importance at different grade levels and to different individuals, teachers will be able to choose the depth at which they study each topic.

The content areas of measurement, geometry, algebra, and data analysis emerged during interviews and were also found during analysis of documents that included lesson plans and archived test synopses. They were also included because they are a part of the curriculum that participants repeatedly mentioned as an integral part of their instruction. All four of the areas emerged as weaknesses in one or more grade levels over the course of the past two years according to standardized test results. Iris confirmed this finding during a follow-up interview. Additionally, Hollie explained that students' quarterly benchmark test results showed these areas in need of improvement at various times during the past 2 years. These data justified the inclusion of these four areas as a content area subtheme.

The state curriculum for Georgia lists measurement, geometry, algebra, and data analysis as separate categories. Participants in this study indicated interest in learning about all of these content areas, and measurement appeared in various forms, including length, money, time, capacity, and volume. David stated, "I'd like to know more ways of teaching time and money, because [students] struggle with that so much," and Cal noted that measurement of time and length proved to be challenging for students. Fiona may have pinpointed an explanation for this struggle by stating, "The whole world of measurement is a real challenge in [the grade I teach] and part of that's because we live in this bifurcated society of ours between meter-, metric and imperial or standard." CRCT data for 2010 substantiated concerns about measurement. In Grades 3 and 5, an average of only 67% of measurement problems were answered correctly (Georgia Department of Education, 2010). Measurement also emerged as the domain in which first graders performed least successfully, although 81% of problems were answered correctly.

A cross-reference analysis of lesson plans indicated that very little time was allocated for teachers to cover multiple units of measurement, which may contribute to the problem. For example, one grade level's lesson plans included 1 day to teach length using nonstandard units, 1 day to teach length using centimeters and inches, 1 day to teach weight, and 1 day to teach capacity. In a follow-up interview, Betsy clarified that the reason for this was so that teachers could maintain the appropriate pace as outlined by the state-generated curriculum map. She also said, “We need more time to be able to cover measurement at a deeper level.”

Measurement and geometry are related, and some participants specifically indicated geometry as a content area that could be addressed. In answering a question about what teachers might benefit from learning in professional development, Iris explained that teachers should know “when [students have] developed more skills and visualization that would benefit them in, in certain areas of geometry.” Fiona stated, “Concepts of geometry . . . seem to be abstract at [my] grade level.” Hollie agreed when discussing student achievement in the geometry domain.

Fourth graders have consistently struggled with geometry during the past three years. In 2008, an average of only 58% of geometry questions were answered correctly. Improvement was made the following year, with 72% correct answers, on average. In 2010, however, 64% of geometry problems were answered correctly (Georgia Department of Education, 2010). Similarly, in fifth grade in 2010, a mean of 69% of geometry problems received correct answers. These data indicated that geometry is a content area that needs improvement at ABC Elementary School.

Data analysis was also an area of concern. Fiona noted that students had not performed well on a benchmark assessment in the area of data analysis earlier in the school year, leading her to consult with colleagues for additional support. Interestingly, Fiona’s students achieved the school’s second highest success rate in the domain of data analysis in 2010. Other grade levels, however, achieved percentages that indicate improvement is needed. In first grade, a mean of 83% of data analysis questions were answered correctly and in second grade this number was 79% (Georgia Department of Education, 2010). In Grade 5, students answered an average of 75% of data analysis problems correctly.

David mentioned a disconnect between data analysis standards and assessment, “In the lower grades, students are supposed to create graphs, but on the CRCT they have to answer multiple choice questions.” Emmie concurred, mentioning an additional aspect of data analysis that is often overlooked,

> When students interpret data, they . . . have to do a lot more than just read numbers. They have to add and subtract . . . answer how many more and how many less, and if they can’t do those operations, then it looks as if they can’t do data analysis.

In order to better address the area of data analysis content, it was included as a theme and within a module of the MPDP.

Iris named “algebra and algebraic reasoning” as areas in great need of improvement, according to her perceptions of standardized test results. Algebra standards are assessed only for Grades 3 through 5, although algebraic concepts are embedded within standards in the lower grades.

> Algebra is in everything we do . . . and I don’t think all teachers understand that you can incorporate algebra into addition, subtraction, multiplication, division, everything. [This should be done] as you teach it, not as a separate unit. (Emmie)

Student performance on the CRCT showed that the content area of algebra could be addressed in order to improve achievement. An average of 73% of algebra questions were answered correctly by third graders in 2010, and 80% and 79% in Grades 4 and 5, respectively (Georgia Department of Education, 2010). Although students seem to be stronger in different domains and at different grade levels, I concluded that all content areas from the standards should be addressed. Therefore, the content areas of measurement, geometry, algebra, and data analysis are included in the findings and will be addressed through the project of this study.

Pedagogy

Pedagogy emerged naturally as a theme, even though only one participant directly used the term. It was clear that teachers were eager to develop and grow in the way they approach mathematics instruction. They readily identified topics about which they would like to learn and expressed the importance of being open-minded and willing to engage in an effort to change (Annabel, Cal, Emmie, & Fiona). These topics included differentiation, remediation and enrichment, and teaching strategies.

Differentiation. This subtheme evolved from the analysis of several statements made by participants in response to interview questions, as well as data gathered from lesson plans. Differentiation refers to the technique of varying instruction based on factors such as gender, learning styles, and personality types (Patterson, Conolly, & Ritter, 2009). Emmie expressed a desire to learn “how to better differentiate.” Other participants expressed needs that fell under the heading of differentiation. For example, Annabel identified “matching the curriculum up to the learner” as an area in which she personally needed to learn more. In a follow-up interview, Annabel clarified that she was referring to learning more about the developmental levels of students in order to better meet their needs. Analysis of lesson plans confirmed the presence of differentiation, but it was not consistent as an element of planning throughout all grade levels. While Betsy’s lesson plans showed deliberate efforts toward reaching different learners, others' plans showed limited application of differentiation.

Fiona mentioned the struggle with how to plan for differentiation, "I think probably the greatest challenge that I've found in, in doing . . . math [in the grade I teach] is . . . to teach a workshop lesson and also be able to serve individual groups of students at their need." When asked what teachers should learn more about regarding mathematics instruction, Iris indicated that a better understanding of students, developmentally, would empower teachers to employ the most appropriate teaching strategies, adding,

> [Teachers] need to learn more about . . . milestones that [children] reach at various ages, so that they know when they're re-, when they should be ready . . . and all students are different, but, but typically when should a student be ready to move from the concrete into the abstract with various things?"

Additionally, Betsy repeatedly spoke about wanting to increase expertise in the area of instructing students in small groups to meet their different learning styles. Differentiation seemed to be a common area of concern for teachers interested in improving their teaching methods.

Remediation and enrichment. Remediation and enrichment refer to working with students who achieve at different levels. Participants indicated that learning about remediation and enrichment would enable them to improve their mathematics pedagogy. Emphasis seemed to be on finding a balance between giving some students extra time to internalize concepts and giving others the benefit of being challenged by more advanced concepts. Teachers were interested in learning how to get all students to achieve at or above predetermined levels set forth by state standards.

Helping struggling learners was a common concern, and extending learning to higher levels was also found within the data. Teachers wanted to know, basically, how to appropriately scaffold students in order to help them achieve their greatest potential. Annabel expressed the problem as a disconnect between expectations and abilities, "There's a struggle sometimes, in learners who seem to be just cognitively not really at a place where they can handle more abstract concepts. And that's . . . hard to match that learner up with concepts that seem beyond them, developmentally." Participants' lesson plans showed that while one grade level planned regularly for remediation and enrichment, four grade levels did not. Interestingly, two of the participants whose lesson plans included remediation and enrichment did not mention it as an area in need of improvement.

Some teachers stated a desire to be able to help students achieve their full potential by serving them in the appropriate capacity. This could include reteaching concepts or skills from a previous grade level or scaffolding students from concrete to abstract learning. David claimed, "[I need help] working with those kids who just don't get it" and Emmie said, "I need to know how to help those low kids." Understandably, the idea of teachers struggling to help students achieve can be a source of frustration. "I can show them five different ways and they still have absolutely no clue what we're doing" (David). There seemed to be a consensus that because remediation required so much time and effort, little attention was given to enrichment.

Serving students appropriately also includes enriching mathematics instruction to help students develop higher order thinking, such as teaching them to apply and synthesize mathematical ideas at higher cognitive levels. David stated, "I need to work on the children who are more advanced, how to take them further." Fiona offered a suggestion for how to work toward this goal, and that was to use the last four weeks of school to introduce the next year's core mathematical concepts.

Teaching strategies. The most prominent theme in the area of pedagogy was teaching strategies. "There needs to be that core and that core is good teaching, good strategies" (George). Specifically, seven out of the nine interviewees contributed views that resulted in this theme. Betsy targeted the bigger idea behind the need for teachers to learn teaching strategies, "I want my students to understand what they are doing and why. It's just not having the correct answer; I want to know how and what they are processing." Hollie echoed this finding, "Some teachers . . . concentrate on 'that's right, that's wrong' and don't look at the process that the students are going through." Perhaps Fiona made the most compelling argument for acquiring new pedagogical strategies, "If I'm going to increase my knowledge, I want it to be how I do what I do." Fiona said this in the context of discussing a particularly ineffective professional development experience that focused on mathematical content and utilized lecture as the format. Fiona suggested that professional development should increase expertise in how to teach effectively, as opposed to focusing on abstract ideas that do not relate to everyday realities.

Participants' responses showed eagerness and optimism about learning different and additional ways of teaching. "I think different ways to solve problems, different strategies, different manipulatives that we could use. Any reinforcement or new strategies is, it's always positive, you know, to, to try and change and learn stuff new" (Cal). Betsy and David both noted that they would like to learn new ideas for presenting information, and Fiona asserted a desire to learn “techniques or processes, things that give me the leg up.” Analysis of documents revealed that teachers employ a variety of teaching strategies. In response to this finding, I wrote in my research journal, “It is encouraging to find that teachers remain interested in adopting and learning more about how to teach.”

While many participants maintained a willingness to learn teaching strategies, I noted in my research journal that only Fiona mentioned allowing students to construct their own knowledge. “The goal is self-discovery” (Fiona). This could indicate that teachers need time and opportunities to practice giving more responsibility for learning to the students themselves. Analysis of documents seemed to support this claim, with many lesson plans involving students using predetermined methods for computation and problem solving. For example, Betsy’s lesson plans for introducing addition of double digit numbers began by stating, “Model adding two digit numbers.” In another case, students were given several choices for which method they would use (David). Overall, data indicated that students were not engaging in much construction of their own ideas.

Perhaps the first step would be to target teachers’ knowledge about how to facilitate conceptual understanding within their classrooms. “I think some more knowledge in content of conceptual learning would help” (Hollie). Fiona added that developing a “common language” or “core vocabulary” is a strategy in and of itself that could enhance mathematics instruction at ABC Elementary School. Emmie alluded to the idea of increasing student’s foundational mathematics knowledge, “I want to know how to, without just coming right out and having to give them that algorithm . . . how can I help them understand it?” These data illustrate the crux of the problem of this study and support the theme of teaching strategies. Fortunately, they also demonstrate participants’ openness to professional development experiences like those that comprise the project of this study.

Guiding Question 2: Professional Development

The second guiding question, "What types of professional development experiences do ABC Elementary School teachers perceive will best enable them to increase student achievement in mathematics?" was addressed in seven themes and two subthemes. The seven main themes were collaboration, literature and research, observation, vertical alignment, engagement, relevance, and support (CLOVERS). Evidence for the themes was found in recurring patterns within and across categories formed during data analysis. It was obvious that participants held strong beliefs about effective professional development, and in most cases there was a general consensus about main issues.

Collaboration

Participants believed that collaboration among mathematics teachers would ultimately enable them to improve instruction. "My ideal professional development situation would . . . involve a professional learning community" (Iris). All nine participants contributed to the theme of collaboration, either by describing successful past professional development experiences or indicating what they perceived would help them in the future. "I really like the idea of teacher study groups because you have other people to work with, [to talk] about things that they do and how they teach" (David). George noted how teachers can learn new strategies "from other teachers, from other systems."

Collaboration can enable teachers to gain new perspectives about pedagogy or curriculum. Fiona noted the value of "spend[ing] time with people who really do this well" in order to "pick their brains, see what they do, pull from their ideas, [and] take those back and leverage them." Cal stated that teachers can meet to discuss "concerns . . . what you think may work, what may not" and use collaborative opportunities to "really dive into [the curriculum]." Lastly, when asked how teachers can increase knowledge, Hollie said, "Work together as a team constantly."

Literature and Research

An integral part of professional development is the inclusion of appropriate literature and research, including books, journal articles, and online resources. "If there's a book, I'm happy to get that or read up on that, articles. I guess, you know, we just need to stay abreast of all the changes that seem to be happening" (Annabel). Eight of the nine participants indicated that they engaged in varying degrees of research, either formally for graduate school or informally to assist them in the classroom.

> Doing research has helped. As you know, I just finished a master's program and I had to do a lot of research. And I learned a lot in that research that I honestly didn't think there was a whole lot left about pedagogy. Content, yes, but I really learned some different strategies. So I think researching and keeping an open mind. (Emmie)

George noted that research should be catered toward practical use, asking "What, what books would help us? What materials can we find to help us?" Annabel, Emmie, and Hollie identified a particular book, *Teaching Student-Centered Mathematics* written by Van de Walle and Lovin (2006), as a potentially helpful resource in the area of literature and research.

Participants discussed data as sources of knowledge. “Looking at other studies and how, you know, they’ve helped, how they haven’t helped and just kind of seeing, you know, what could work for this school or your specific class” (Cal). Fiona discussed authenticity as an important consideration in reviewing data. She stated that professional learning for teachers should be “sprinkle[d] . . . with some current data, but not, not boat and bucketloads of research data. I want data that’s coming out of schools and classrooms.” This statement indicated that data, if used within the context of professional development, should be practical and meaningful to the teachers involved.

Using multiple sources of technology as venues for learning was a recurrent idea. These sources included videos and the Internet. Annabel spoke of a mathematics professional development program she attended 3 years ago, “The videos [of classroom mathematics lessons] were the things that I remember the most and made it click for me.” Five participants specifically mentioned the Internet as a source they frequently consulted. Cal said, “All that takes is a matter of sitting down and you know, looking stuff up, kind of familiarizing yourself by doing that.” The Internet can be used to find lessons, games, assessments, etc. “I do a lot of, I just look on, online and in different places to find different things that will go with our new standards” (David). It can also be used to help teachers develop broader perspectives of mathematics instruction across the state, nation, or world. “I do a lot of research on the Internet. I look at a lot of different systems, the way their standards are written, the way they interpret standards” (George). Many teachers felt comfortable using online resources to enhance their mathematics instruction.

Coincidentally, during the time period in which I was conducting this study, school administrators provided each mathematics teacher at ABC Elementary School with an interactive whiteboard, including wireless Internet capabilities. Teachers also participated in a training seminar utilizing a mathematics software program. Some teachers participated in a small group focused on the interactive whiteboard, explained by Iris, “From the pedagogy standpoint, [some teachers] have looked at incorporating technology in the classrooms . . . through a book study, or a professional group, and using technology to support math instruction.” The uses of technology for locating literature and research and supporting instruction were important factors in the quest to improve achievement through professional development.

Observation

Teachers in this study believed that observing other teachers would help them improve their own practice. In fact, seven out of nine participants commented on the perceived benefits of observation. Considering that none of the interview questions alluded to observing other teachers, the amount of data pointing to this theme indicated a strong desire generated wholly by participants. “I would spend the preponderance of my professional development time in other teachers’ classrooms observing. I want to go see what they’re doing” (Fiona). When speaking of a previous professional development experience, Annabel said, “I think watching somebody teach . . . was the most helpful for me.” Perhaps Hollie provided the most solid rationale for observation when comparing it to a lecture format, “If I go into a classroom where the teacher is teaching math, I get so much more out of it because I’m actually seeing it done.” Observation certainly presented as an activity in which participants found great benefit.

Some participants seemed to be interested in observing instruction within the local context. “I enjoy also going in and watching the other teach-, some of the other people teach, to get ideas; that’s always a good thing” (David). Emmie expressed an interest in watching teachers who “have been implementing the same types of instructional strategies for a period of time,” in order to benefit from their experience. Lastly, Cal noted the importance that teachers become familiar with mathematics instruction in the grades below and above the one in which they teach. These ideas suggest a structure for observation that includes multiple opportunities for teachers to watch and learn from each other, with the common goal of improving mathematics instruction schoolwide.

Other participants expressed potential or realized benefits of observing outside the context of ABC Elementary School.

> We have taken several teachers this year and sent them on site visits to other schools where they can see model classrooms, classrooms where they have strategies that they’re using that are very, very effective, classrooms where their test scores show that student achievement has improved classrooms where we have been on walk-throughs and we’ve just been really impressed. (Iris)

Hollie suggested “being able to go off-campus” to observe good mathematics instruction, and Cal expressed that when teachers “go out into other schools in the county” they can bring new ideas “back to our school.” Finally, Hollie noted the importance of follow-up associated with observation in order to make it meaningful for everyone involved.

> If teachers could, not necessarily go and evaluate, but go into a classroom and observe. You know, this is their strength, whether it’s verbal feedback or whether

> it's math groups, so teachers can go in and observe the other teacher and see what they're doing so they can go and try to implement it in their classroom. Or, on the other hand, go in, see how they're doing, and to get that feedback from another teacher, 'You did this great.' You know? Or 'These are some areas I saw that you could try this,' or 'You could try this.'

These concepts point toward a framework for teacher observation both within and beyond ABC Elementary School, including opportunities for constructive feedback among professionals.

Vertical Alignment

Eight out of nine participants discussed the significance of vertical alignment of professional development. In this case, vertical alignment refers to the flow of mathematical curricula and expectations throughout multiple grade levels. Vertical alignment could be achieved through a "professional learning community" (Iris), or "vertical team of K through 5 math" (Hollie). Cal suggested that teachers "talk to your staff, talk to your team and other grade levels. See what the grade levels before you are doing. See what's expected next year, and work towards that." As far as what teachers could accomplish in a vertical team,

> They would took a, take a look at what each grade level is expected to know and look at the grade above them and keep going all the way to fifth grade so they got that overall view of math instruction and vertical alignment and then see where there're holes or gaps. (Hollie)

Emmie provided a rationale for working vertically, "When they come to me they need to have had the understanding in [one grade lower] . . . I really need that support because you can hit the ground running if they've had the background they need." David alluded to this same concept when discussing how to increase knowledge, "I've worked with [the teachers at one grade higher] to know what they need, what I need to do to get the kids ready for next year."

> I want to do it vertically. I want to go see . . . just a little where the kids are going next . . . If I understand with some depth where they came from and understand the teaching techniques that were employed there . . . understand and, and see and benefit from the way when they were conceptually not as developed . . . their abstract skills were not as developed and they were introduced as core concepts, grouping, regrouping, putting together, taking apart, whatever, and the methods behind that, it would benefit me significantly, I think, to then take that same concept to that next level. (Fiona)

Vertical alignment of curriculum and pedagogy is a significant facet of professional development designed to improve instruction.

Engagement

The theme of engagement emerged from perspectives suggesting teachers want to engage in mathematical tasks as part of increasing their knowledge and improving their instruction. Some participants mentioned past experiences in which they had benefitted from engaging in such tasks, while others claimed that they learn best through active participation. Annabel described a previous professional development experience that was particularly meaningful,

> The instructor gave us the manipulatives and I worked through it myself, just as though I were a third grader or a first grader or whatever the grade might be. So

> for me, hands-on, just like the students. We were put into groups just as though we were math students, fourth graders or third graders. We were given the manipulatives. We had to solve the problem or task and we had to present our solutions.

Fiona concurred with the importance of teachers familiarizing themselves with the practical aspects of completing mathematical tasks. When asked what characteristics generally make professional development meaningful, he or she answered, “Doing . . . not only seeing [students] do the lesson but doing it with them.” Hollie summarized this point directly, “I learn more by doing than just by sitting and listening.”

Facilitating engagement with mathematical tasks can provide opportunities for teachers to gain experience and discuss pertinent issues with colleagues. Iris noted that teachers “can familiarize themselves . . . with experience. The more you do it, the better you are with that strategy or the more comfortable you are with that instructional approach.” Fiona spoke favorably of a time she had benefitted from engagement,

> Someone came in, and one of the first things he did was pass out the activity and the scissors and the markers and say, “Alright, everybody, here’s the task.” He did his minilesson, we did worktime, and we presented and then we shared. ‘What have you seen? Have you done this? If you have, what was the pitfall? That didn’t work. This worked.’ It was in the doing that I came away remembering what I had seen, and therefore I learned it, as opposed to the reading about it, the hearing about it . . . Basically it’s just reading, trying, and applying those, those n-, new concepts.

When teachers engage in tasks by "putting [themselves] in the place of the students" (Annabel), it can result in increased understanding of what is required instructionally. When discussing how to work toward improved instruction at ABC Elementary School, Hollie stated, "I think getting the teachers involved [in doing mathematical tasks] would help tremendously."

Relevance

The importance of relevance was evident within participants' viewpoints. Relevance, in this case, refers to the relationship between professional development and what teachers do on a daily basis. Participants wanted their professional development experiences to result in applicable knowledge. George gave an example of relevance in this sense when discussing a successful professional learning endeavor, "Everything we did was centered around, 'How is this applicable to your classroom? What's going on in your classroom? How could this fit into your classroom?'" Fiona reinforced this idea, "[Meaningful professional development involves] interaction, specific application and relevance." Finally, David implored, "Just make it real world, applicable to an elementary, true elementary classroom setting." Teachers valued professional development most when it pertained to strategies they could reasonably implement.

Relevance also takes into consideration "real issues that [teachers] face" (Annabel), such as large class sizes and diversity among students. David elaborated,

> [I like professional development] if it's actually something I can use in my classroom. Something I can take back and do with my kids that I'm going to be able to see some results . . . not something that's kind of out of the realm of possibility for me to do. Um, by that I mean, you know, a group of two kids that

> are… nobody else in the room; I can't do that and a lot of times when you watch the videos and stuff there's four kids and there's never a behavior problem. Well, I don't have that luxury; I have eighteen kids and four behavior problems, so I need something that actually works in the real world.

When professional development presented ideas that would be difficult or impossible to implement, participants viewed them as having little value. "It's a perfect classroom on all the videos and it always looks great and there's never any behavior problem and there's always so much time and space and, and we don't have all that" (David). Fiona found little value or relevance in playing the passive role of listener,

> I went to [a professional development class] this summer, and honestly, we sat and were talked to for two weeks . . . I had to go back and . . . reread it to remember what it was or how it might work.

Instead, Fiona expressed that she wanted to be an active participant in her own learning. In sum, teachers didn't want a program that seemed to be designed by people who were unfamiliar with the realities of being an elementary school teacher. They wanted professional development that resulted in real, sustainable improvements.

Support

Any successful professional development program needs appropriate support in order to be perceived as meaningful to those involved. While this reference to support generally includes ways to aid teachers as they engage in learning, it can also include giving them freedom to apply what they learn. As George explained, "I think that we need to be treated like professionals that are trained to do our job and let us do our job instead of dictating how we do it, every day, all day long." All facets of support are imperative to success. A support system that balances participants' needs with expected achievement outcomes contributes to the success or detriment of any given program. The two areas of support that emerged as important to teachers in this study were parental and administrative.

Parental support. Participants expressed the benefits of a home-school partnership by generating the theme of parental support. They expressed a need for the support of parents in their quest to improve student achievement in mathematics, even if the main venue was professional development. When asked what teachers could do to increase student achievement on the CRCT, Annabel stated, "I think probably a big component would be parent [support]." She further explained, "There are many parents who view math, the math their students are doing, their children are doing now, as the same math they did in school. And it, it really isn't." David expanded on how parents could support teachers by "working with kids to make sure they're learning those basic math facts [in the lower grades]." Family involvement can have positive impacts on children's educational successes, so parental support "would be really helpful" (Annabel) in an endeavor targeting increased student achievement.

Iris expressed, "Any improvement effort . . . should include outreach to parents." Parents can provide support in many ways, including "understanding the way math instruction has changed and the math curricular demands have changed for their children" (Annabel). Cal and Emmie both expressed that parents should be regularly helping their children with mathematics homework in order to support teachers and students. Additionally, parents can support teachers by attending school functions and teacher conferences. They can remain aware of classroom happenings by reading newsletters or checking the school website. According to participants' perspectives, parental support could be a meaningful asset for professional development at ABC Elementary School.

Administrative support. Participants seemed to agree that administrative support is a necessary element in effective professional development, although they differed in their use of the term. In discussing the concept of support, participants mentioned state, county, and school administrations. "I think we need support also from the state for them to realize that a lot of the things that we are mandated to do, [are] a lot more developmental than what our kids can achieve" (Cal). Along that same line, participants would appreciate more flexibility about how they teach.

> I need the administration and the county to understand that everything doesn't fit in a box and every lesson that I do is not going to fall within the math workshop model. Some of it's not going to be in that lovely little layout that they want. (David)

The recurrence of the support theme could stem from the perception that teachers have endured several top-down mandates over the past few years as Georgia's curriculum changed.

The notion of support was also referenced concerning teaching methods. George expressed regret that his freedom to teach in the way that he feels is best has been taken away, "I think that we are so afraid somebody's going to walk in and catch us doing something out of a textbook or catch our kids actually sitting in their seat and doing work, that we don't do it." Administrative support, including open and honest communication between teachers and leaders, would be a pivotal part of a successful mathematics professional development program.

Disconfirming Data

A purposeful search for data that did not conform to emergent themes revealed evidence to support differences of opinion on some key results. Although themes generally emerged from overlapping and recurring patterns within data, not every participant agreed with ideas that have been presented as findings from this case study. The presence of disconfirming data was expected (Brantlinger et al., 2005; Creswell, 2003, 2008; Hatch, 2002; Merriam, 2002).

Areas in which disconfirming data existed were content, collaboration, literature and research, and vertical alignment. In answer to the first guiding question, I found that content and pedagogy should be addressed in order to improve mathematics instruction. Fiona held a different idea, “I guess what I’m going to be most interested in increasing my knowledge is not in content . . . Content doesn’t help me much.” Fiona went on to say that pedagogy would be the most important priority in professional development. In answering the second guiding question, Emmie noted that problems might arise if collaborative professional development is pursued, “I think at this school, the small group, the teacher study, the collaborative learning community, the book studies, they don’t work as well because we have too many differing personalities.”

Some participants also differed in their perceptions of value regarding literature and research, as well as vertical alignment. Annabel and David both stated that book studies have not proven helpful to them in the past, although Annabel followed her statement by naming the book by John Van de Walle as a “really great book . . . that was a huge help.” David also asserted that in the past, videos used in professional development programs were “a waste of time” and “not realistic at all.” This comment does not necessarily disconfirm the literature and research theme, but it does illustrate a different viewpoint about videos. Additionally, David's statement can be interpreted as support for the theme of relevance. Lastly, vertical alignment was a point of contention for George, "Teachers in [one grade lower] "[don't] need the same thing I do, so it doesn't really do me any good to work with [those teachers]." Even though there were outlying pieces of data, participants understood that themes resulted from analysis of the data as a whole. When they engaged in member checking by reviewing an outline of findings, they confirmed that the results accurately reflected their perceptions.

Evidence of Quality

Specific steps were taken to provide evidence of quality for this study, making the results both trustworthy and credible. Mills (2003, p. 77) explained trustworthiness, or validity, as the way of determining whether a study effectively measures what it claims to measure. Mills (2003) described credibility, or reliability, as the "the consistency with which our data measures what we are attempting to measure over time" (p. 87). Creswell (2003) explained that reliability is a less valid consideration in qualitative studies. Another way to think of credibility is repeatability of results. The following subsections identify threats to the trustworthiness and credibility of this study and measures that were taken to reduce these threats.

Trustworthiness

Polkinghorne (2007) explained that qualitative researchers must argue that their claims are strong enough to justify action. They can do this by identifying and addressing threats to the study. Limitations of the study include threats to trustworthiness. For this study, threats to trustworthiness included the potential for researcher bias in interpretation of data (Hoskins & Stoltz, 2005) and personal or professional conflicts that could have obstructed progress.

Because I had a personal connection to the context of this study, specific actions were taken to avoid interpretive bias (Yin, 2009). These actions included adopting a reflexive approach to the study by bracketing thoughts (Kacen & Chaitin, 2006). I kept a research journal throughout the study and consulted it regularly as part of the data analysis process. Conflicts that arose were addressed professionally and with minimal disruption to the study. Even though I worked to prevent bias, I acknowledge that my perspective necessarily influenced my interpretation of data to some degree.

Other threats to trustworthiness included the possibilities that participants would cancel interviews, or drop out of the study. I confronted this threat early in the study. Prior to the study, I made expectations clear and asked participants if they were willing to commit to participating. Trustworthiness for this study was established through multiple perspectives, member checking, triangulation of results, and inclusion of discrepant cases and disconfirming evidence (Brantlinger et al., 2005; Creswell, 2003, 2008; Hatch, 2002; Merriam, 2002). Although in two cases I had to reschedule interviews, all participants who originally agreed to participate followed through with their commitments.

Credibility

Creswell (2003) asserted that credibility is insignificant in qualitative studies, but should still be addressed. One threat to the credibility of this study included the possibility that participants may misunderstand interview questions. This threat was reduced by an “expert panel[’s]” (Creswell, 2003, p. 50) evaluation and revision of the interview questions prior to the preparation of the proposal.

Additionally, I conducted a pilot study by interviewing two teachers who were not participants in the case study. These teachers engaged in mock interviews, and then evaluated the interview questions to assist me in clarifying or refining them. For example, one original interview item asked participants to explain their use of rules, procedures, or algorithms in teaching mathematics. This item was revised because of confusion associated with the phrase rules and procedures. ABC Elementary School uses a model of teaching that includes standard rules and procedures, but is not related to this study. Both pilot study participants suggested rewording the interview question to eliminate confusion. The revised question, “Can you think of math topics in which learning an algorithm, or memorizing a specific strategy, is necessary?” gauged teachers’ beliefs about procedural teaching. After I modified this and other interview questions, I requested and received permission for a change in procedures before beginning data collection.

Another threat to credibility was that participants possessed varying degrees of understanding or experience. I addressed this threat by asking probing questions and holding follow-up interviews for extended discussions. Additionally, during interviews, I made purposeful efforts to present questions in a prescribed, neutral manner (Gunasekara, 2007). Confronting threats to credibility was an effective way to ensure that interviews yielded results that could be used to accurately answer the guiding questions, an approach recommended by Creswell (2002), Janesick (2004), Mills (2003), and Hatch (2002).

Conclusion

This section included an overview of the case study methodology and findings of this doctoral study. The research approach stemmed logically from the problem of the study and goals of the project. Participants were described. Procedures for data collection and analysis, as well as methods for establishing reliability and validity, were related. In-depth interviews, research journal entries, and documents served as data sources that were interpreted qualitatively.

Results were presented logically and systematically in relation to the problem and guiding questions. The first guiding question was answered with two main themes: content and pedagogy. The theme of content was expanded with four subthemes: number sense; computation; problem solving; and geometry, measurement, data analysis, and algebra. The theme of pedagogy included three subthemes: differentiation, remediation and enrichment, and teaching strategies. The second guiding question was addressed through seven themes: collaboration, literature and research, observation, vertical alignment, engagement, relevance, and support. The theme of support included both administrative support and parental support as subthemes. Findings were used to guide the design of the project: a Mathematics Professional Development Program (MPDP). Section 3 includes a complete description of the project, and section 4 includes reflections and conclusions. The MPDP is included as Appendix A.

Section 3: The Project

Introduction

To effect real change in the mathematics achievement of students, educational leaders must provide opportunities for teachers to become familiar with current research about best practices in this area. Through this doctoral project study, I constructed an original Mathematics Professional Development Program (MPDP) to help teachers improve their practice. I incorporated results from a case study at ABC Elementary School, described in section 2, and recent literature about effective professional development. The MPDP is based on the idea that professional development will lead to better instruction, which in turn will result in increased student achievement in mathematics. This section describes and frames the project as a result of this doctoral study. Figure 3 illustrates how the problem of this study, student achievement in mathematics, is addressed through professional development for teachers.

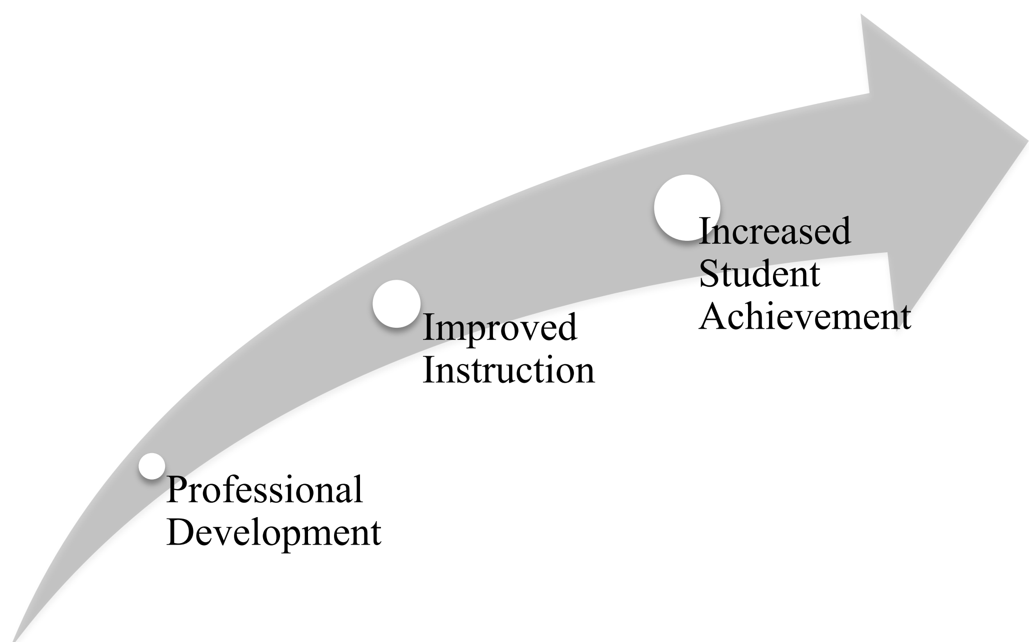

Figure 3. Relationship of problem and project.

Historically, educational leaders held a view of professional development that was dominated by "one-shot" (American Federation of Teachers, 2002; Hawley & Valli, 1999) workshops and top-down mandates (Lefever-Davis, Wilson, Moore, Kent, & Hopkins, 2003; Mundry, 2005; Torres-Guzman et al., 2006; Vandeweghe & Varney, 2006). Hill (2007, p. 111) reported that these types of mass trainings tended to be limited in their depth and relevancy. Vandeweghe and Varney (2006) furthered this notion by explaining that many teachers viewed typical professional development meetings as a "waste of . . . time" (p. 283) and felt that there was little or no connection between what they learned and what they could genuinely apply in their classrooms. Workshop-style professional development was often unrelated to the actual work that teachers performed (Wildman, Hable, Preston, & Magliaro 2000, p. 248). Finally, workshops tended to be limited and did not benefit all teachers or students. These findings reinforced the ineffectiveness of this system, the "old paradigm of staff development" (Mizell, 2007, p. 2). More recently, this traditional style of professional development has been replaced with ideas that value teachers as competent professionals who can take responsibility for their own learning.

Many experts claimed that effective forms of professional learning allow teachers to collaborate (Hill, 2007; Lefever-Davis et al., 2003; Mizell, 2007, 2008; Mundry, 2005; Naidoo & Naidoo, 2007; NSDC, 2001) as they study research and literature related to subject matter or pedagogy (American Federation of Teachers, 2002; Hill, 2007; Wildman et al., 2000). Dantonio (2001) promoted professional development opportunities that are led by teachers themselves, as the results of such experiences are more personalized and meaningful. This literature, in combination with findings that emerged through data analysis of the case study described in section 2, guided the design of the MPDP to educate teachers about effective mathematics instruction.

Description

The idea for this project evolved in response to a need within the local context, ABC Elementary School. Better professional development in mathematics for teachers at the school is imperative to meet the needs of both students and teachers. I conducted a case study to address the problems of substandard mathematics achievement and desire for teacher training. The response was an authentic, meaningful program that correlates with the Georgia Performance Standards and attempts to fulfill teachers' expectations. The framework for the project is based upon NSDC professional development standards. Plans for assessment of the project are included, including evaluation of the project at its conclusion based on its alignment with the NSDC standards according to the Standards Assessment Inventory.

The framework for the MPDP consists of 12 research-based standards for professional development (NSDC, 2001). These standards form the underlying principles of the project, and can be paraphrased as follows:

1. Learning Communities: Effective professional development includes learning communities made up of educators who work to achieve school or district goals.

2. Leadership: Effective professional development demands competent leaders who strive for improvement in teaching.

3. Resources: Effective professional development necessitates appropriate resources to facilitate adult communication and learning.

4. Data Driven: Effective professional development depends upon student data to guide purposes and directions of professional learning.

5. Evaluation: Effective professional development measures its impact based on many sources of evaluation and uses this information to determine future directions.

6. Research Based: Effective professional development primes teachers to discern and synthesize research.

7. Designs and Strategies: Effective professional development matches the design of professional development strategies with ultimate outcomes.

8. Learning: Effective professional development includes considerations of appropriate conditions for learning and changing.

9. Collaboration Skills: Effective professional development prepares and allows teacher collaboration to fulfill professional purposes.

10. Equity: Effective professional development helps teachers appreciate diversity and foster equity while supporting student achievement in low-risk environments.

11. Quality Teaching: Effective professional development familiarizes educators with concepts of quality teaching: content, pedagogy, and assessments related to achieving academic expectations.

12. Family Involvement: Effective professional development enables teachers to increase community and family involvement.

Meeting all of the concepts outlined above, I developed the MPDP as a collaborative learning program that focuses on quality teaching of mathematics. The program reflects the NSDC standards and targets the themes that emerged from the case study at ABC Elementary School.

The MPDP consists of seven learning modules, each of which includes tasks, discussion questions, homework assignments, literature and research, and online resources. The module topics are derived from the content and pedagogy subthemes that addressed the first guiding question in the case study. Table 5 relates the mathematics instruction subthemes with example activities from the MPDP. The first four are content subthemes and the last three are pedagogy subthemes.

Table 5

Connection of Mathematics Instruction Subthemes and MPDP Activities

Mathematics Instruction Subthemes	Example Activities for Participants in the MPDP
Number Sense	Read and discuss relevant research and literature about number sense As a group, cut apart number sense standards from Grades 1-5 and discuss how they relate or build across grade levels
Computation	Share strategies for improving students' computation Explore online resources for reinforcing computational proficiency
Problem Solving	Observe and evaluate a problem solving lesson at a different grade level than the one in which you teach
Geometry, Measurement, Algebra, and Data Analysis	Complete an online geometry tutorial as if you were a student Brainstorm ways to integrate measurement standards into other subject areas Explore algebra manipulatives: number balance, hands-on equations kit, weighted blocks with balance scale Search the internet for relevant uses of data analysis and graphs
Differentiation	Take online multiple intelligence inventory Use learning style chart to characterize your students and design some activities to match different learning styles
Remediation and Enrichment	Interview teachers at grade levels above and below the one you teach to discuss remediation and enrichment Explore websites to find ideas about remediating and enriching
Teaching Strategies	Keep an ongoing portfolio of teaching strategies organized by mathematics domains

The professional development activities within the modules are based upon the seven concepts outlined by participants during the case study, referred to by the acronym CLOVERS. For example, discussion questions focus on how standards and concepts span across multiple grade levels and how to make knowledge applicable within daily instruction, addressing the themes of vertical alignment and relevance. Also, collaboration is fostered through engaging tasks and discussions. Teachers' perceptions about professional development form the underlying foundation of the MPDP. Table 6 relates the professional development themes with example activities from the MPDP.

Table 6

Connection of Professional Development Themes and MPDP Activities

Professional Development Themes	Example Activities for Participants in the MPDP
Collaboration	Complete group projects and tasks Participate in discussions
Literature and Research	Review literature and share findings/applications Review websites and share findings/application Create resource binders or electronic portfolios
Observation	Observe within the school Observe outside the school Observe at local colleges
Vertical Alignment	Put multi-grade level standards in order with no labels Find activities to expand across grade level standards Observe lessons across grade levels Complete tutorials across grade levels Align mathematics vocabulary across grade levels
Engagement	Play instructional games Complete online tutorials Explore manipulatives
Relevance	Apply new ideas and share findings Discuss instructional applications for knowledge Demonstrate lessons during learning community sessions Share results of teacher observations
Support	Invite others to attend learning community sessions Create home resource such as handbook or DVD Organize and host family involvement night

Goals

The main goal of this project, in relation to the problem of the study, was to increase student achievement in mathematics at ABC Elementary School through the venue of professional development for teachers. The MPDP provides opportunities for teachers at the school to collaborate professionally as they explore pedagogy and strategies related to helping students master the Georgia Performance Standards in mathematics. Other secondary goals are to empower teachers as learners, expose teachers to current literature about mathematics, and deepen teachers' content and pedagogical knowledge in mathematical concepts. Finally, one long-term goal of this project is to support teachers as they take on new roles, enabling them to support themselves as leaders after the professional development program has ended. In summary, this MPDP will support teachers in their quests to become professional learners, and should positively impact student achievement in mathematics.

Rationale

The rationale for this project stemmed from a local problem at ABC Elementary School in northwest Georgia and is supported by state, national, and international data, discussed in section 1. I developed this project in response to data collected and analyzed during a case study, described in section 2. Results indicated a need for professional development in mathematics and opportunities for collaboration among teachers. Literary support for the project centers on research that promotes a comprehensive, balanced approach for teaching mathematics and implicates teacher collaboration as an effective form of professional development.

Support for the rationale of this project was derived from data indicating that teachers believe training in the area of mathematics instruction would enable them to facilitate increased student achievement. Specifically, participants believed that content and pedagogy should be addressed, as indicated through the themes addressing the first guiding question. All nine participants expressed optimism regarding professional learning opportunities in the area of mathematics. “I need continuing training in math, and I’m very open to that” (Annabel). Hollie and Iris insisted that professional development is an ideal way for teachers to increase knowledge.

Participants had varying ideas about what types of professional development would work best, although in most cases their ideas were interrelated. George contributed, “It’s almost like you [would] want to do a first year education class where, you know, ‘This is one way to teach; this is another way to teach.’ Allow teachers to look at different teaching strategies.” Emmie’s idea was similar, “What I think would work overall is having . . . a leader . . . a, a master teacher come in and show better ways, show different ways.” Others seemed more comfortable with going off-campus or attending educational sessions. “[I need] more training, more planning, going to different schools, going to different [places] like somewhere where you could, you know, take classes” (Cal). One thing participants agreed upon is that professional development should be immediately applicable, an idea reinforced by literature (American Federation of Teachers, 2002; Fullan, 2006; Hill, 2007). “I don’t mind at all going to a workshop if it’s something useful that can actually be applied. I enjoy going to get new ideas” (David). These findings supported an eclectic, interactive program.

A Mathematics Professional Development Program (MPDP) that coincides with the changes in instructional expectations brought about by the recently adopted Georgia Performance Standards is timely and relevant within ABC Elementary School. Further, this program could be used as a statewide or as a national model for professional development. The effects of such a project, including the potential for improved student achievement in mathematics through instruction aligned with current research about effective mathematics instruction and pedagogy, could contribute greatly to the field of education.

This project has the potential to effect positive social change, such as achieving improved mathematics instruction by empowering teachers to increase their own knowledge through engaging in a sustained professional development program. This effort, therefore, has the potential to extend students' mathematical understanding in meaningful ways. Broadly, economical and technological advances are dependent on these students' abilities to apply mathematical concepts to solve problems. This project is socially significant because of its potential impact on our economic competitiveness with other nations through students' increased understandings of mathematics.

Review of the Literature

Within the past several decades, U.S. schools have undergone great changes in teacher development (American Federation of Teachers, 2002; Borko, 2004; Hill, 2007; Lefever-Davis et al., 2003; Matsika, 2007; Mundry, 2005; Torres-Guzman et al., 2006; Vandeweghe & Varney, 2006; Wells & Keane, 2008; Wildman et al., 2000). Historically, there have been days built into a teacher's work year that were designated for professional development, but the time has not been consistently used for that purpose. In some school districts the days have been known as opportunities to work in the classroom or conduct various meetings (Richardson, 2007). Other districts have required teachers to attend seminars or training workshops (Hill, 2007; Lefever-Davis et al., 2003; Mundry, 2005; Vandeweghe & Varney, 2006). Often, decisions were made based on time or money, instead of on data (Richardson, 1997). This resulted in how-to training sessions with little or no relevance to the school or group of teachers (Hill, 2007; Vandeweghe & Varney, 2006; Wildman et al., 2000). It appeared that educators were doing very little reflection of value or formal learning about teaching and learning (Hill, 2007). Dantonio (2001) found that few teachers actually implemented new strategies gained from workshop-style sessions.

These findings are not surprising when one realizes that the former tradition of inservice education required teachers to be passive listeners, and that teachers had no personal investment in the training (Mizell, 2007; Richardson, 2007). This type of mass professional development ignored the supposition that teachers are competent and able to construct and produce knowledge instead of just receive it (Borko, 2004; Mizell, 2007; Torres-Guzman et al., 2006; Vandeweghe & Varney, 2006; Wells & Keane, 2008). With today’s educational buzzwords centering on the concepts of collaboration and self-inquiry, the inservice model of the past does not meet expectations. Recent researchers on teacher development painted a different portrait of how teachers’ professional days should be spent. Within the past few years, professional development for teachers has started to look less like the static, passive inservice opportunities of the past and more like meaningful learning (Mizell, 2007; Mundry, 2005; NSDC, 2001).

In contrast with mandatory workshops of the past, educational researchers more recently explained that effective teacher development is self-directed, ongoing, and based on data rather than availability of time and money (American Federation of Teachers, 2002; Hill, 2007; Mundry, 2005; NSDC, 2001). It includes collaboration and collegial interaction among staff (Edwards, 2006; Mizell, 2007; 2008; Torres-Guzman et al., 2006). Appropriate professional development is inquiry based, teacher led, and self-reflective (Lefever-Davis et al., 2003; Wells & Keane, 2008). According to this contemporary model, implementation and refinement of instructional practices are the responsibility of teachers, rather than requirements handed down from school leaders (Dantonio, 2001). Many research-based models for collegial interaction and school community participation exist. This review of literature incorporates analysis of research and theory to explain the development of a MPDP for teachers at ABC Elementary School in northwest Georgia.

The following review of literature is organized around the NSDC's context, process, and content standards for professional development. According to its website, the NSDC, of which most members are educators, "is the largest nonprofit professional association committed to ensuring success for all students through staff development and school improvement" (2010). Spanning throughout the United States and Canada, the NSDC is composed of 35 affiliates who provide local connections for members. Its mission will best be accomplished, according to its more than 10,000 members, by implementing high standards for teacher learning.

The NSDC operates under 12 standards. These standards outline expectations for professional development and hold educators to high levels of performance. These affiliates form a network to provide information for those who wish to connect with other professionals, programs for those interested in expanding professional development in their area, and services for NSDC members throughout North America. Search efforts to find research related to the 12 NSDC standards included the following Booleans: *staff development*, *teacher development*, *teacher research*, *teacher training*, *professional development*, *teacher leadership*, *learning communities*, *teacher collaboration*, *professional development AND learning communities*, *professional development AND leadership*, *professional development AND resources*, *professional development AND data driven*, *professional development AND evaluation*, *professional development AND research based*, *professional development AND design*, *professional development AND learning*, *professional development AND collaboration*, *professional development AND equity*, *professional development AND quality teaching*, pro*fessional development AND family involvement*, *teacher-directed staff development*, *teacher-led staff development*, and *teacher leadership*. I used research databases such as Academic Search Complete, ERIC, Education Research Complete, and Sage. I scanned abstracts and full texts for research related to professional development.

The NSDC (2001) held that teachers should be involved in professional development on a daily basis in order to facilitate student success. The council regarded teacher development as an essential component in schools committed to continual improvement. The NSDC bases its decisions and actions on six core beliefs that can be paraphrased as follows:

1. Professional development for teachers results in student learning.

2. Collaboration among educators is the best way to solve problems in schools.

3. Professional development starts with student-centered goals.

4. Diversity enhances the direction of professional development.

5. Effective leadership is an integral part of ongoing learning.

6. To impact student learning, professional development should include opportunities for teachers to reflect upon practice and relate knowledge to student achievement.

These beliefs summarize the findings of current research and literature about teacher learning, upon which the NSDC is founded. From these beliefs, the NSDC has developed context standards, process standards, and content standards. The standards, revised in 2001, provide details about each component of effective professional development. Every standard has a rationale that explains its significance in the field of professional development. The following sections are framed by the NSDC standard topics, and supported by current literature from various sources that uphold the core beliefs regarding effective professional development for teachers.

The Context of Professional Development

The context standards are centered on professional learning that results in student learning through learning communities, leadership, and resources (NSDC, 2001). The council holds that this type of professional development: includes learning communities made up of educators who work to achieve school or district goals, demands competent leaders who strive for improvement in teaching, and necessitates appropriate resources to facilitate adult communication and learning. These context standards reflect the vision and principles for effective professional development.

Learning communities. The first context standard focuses on adult learning communities. In order to improve student learning, teachers can form communities of learners committed to working toward school and district goals (Fullan, 2006; Hill, 2007). A learning community, also referred to as a "teacher study group" (Lefever-Davis et al., 2003) or "learning team" (Mizell, 2007), in this sense is different from the historical model of teacher training. Learning communities include teachers engaging with one another to focus on significant goals (Firestone, Mangin, Martinez, & Polovsky, 2005; NSDC, 2001), particularly when the goals are connected to student achievement (Lefever-Davis et al., 2003). Learning communities can motivate teachers as learners, leading to increases in learning (Mizell, 2007) and improvements in instruction (Borko, 2004).

Learning occurs when ongoing teams of teachers meet regularly to learn, plan, and solve problems (Mizell, 2008; NSDC, 2001). Vandeweghe and Varney (2006) reported that learning communities help teachers become inquirers, and "inquiry motivates change" (p. 285). In their 6-year investigation of study groups at a middle school, Vandeweghe and Varney found that collaboration among school constituents grew to foster a community of learners beyond the school. Learning communities can provide opportunities for teachers to grow as individuals and within the context of a group of professionals all working toward the same goal: improving student achievement.

There is no predetermined size or purpose for learning communities; they should instead meet the specific needs of the particular school population (NSDC, 2001).

Suggested activities for learning communities include reading and discussing literature, attending courses, observing one another, examining learning standards, analyzing student work, planning lessons, and engaging in reflection. With the assistance of school administrators, learning teams may also disaggregate data in order to plan future endeavors (NSDC, 2001). If learning communities are flexible, they can cover a wide range of educational issues depending on the specific circumstances of the school, faculty, or students.

Once educators begin to build the idea of learning communities into the school culture (Fullan, 2006), teachers within those communities have opportunities to form networks connecting them with other schools or individuals having similar goals. With the continual growth of technology, these virtual networks can expand across the globe. Members of learning communities can benefit from participating in professional consortia, joining educational organizations, or attending professional conferences. According to the NSDC (2001), learning communities within schools bring teachers together with a common mission: to improve student learning.

Leadership. The second context standard focuses on leadership as a means to improve student learning. Leadership is a necessary element for school improvement, including levels that range from the community to the classroom (NSDC, 2001). Waddle and Murphy (2007) noted that school administrators need to engage in professional development, as well as facilitate it within their schools. The NSDC's view of leadership empowers teachers as leaders in schools, rather than looking to administrators as having singular responsibility for this role. Professional development leaders in schools can include an array of constituents, such as community stakeholders, board members, educators, administrators, and other school employees.

Principals and superintendents, in this model of leadership, lead from within rather than from an authoritative position. Good leaders maintain organizational structures to sustain development initiatives, while also fairly distributing resources that allow learning communities to reach school and district goals (American Federation of Teachers, 2002; NSDC, 2001). This view of leadership puts teachers in control of their own professional development, allowing them to internalize ideas about student learning and teacher leadership, and ultimately leading to improved student achievement.

Resources. The third context standard focuses on resources as a necessary component in professional development. The NSDC stance on this issue was that student learning depends on adult learning and collaboration, and support of adult learning requires resources. These resources can include time, support, and funding (American Federation of Teachers, 2002; Mann, 2006; NSDC, 2001; Vandeweghe & Varney, 2006). Vandeweghe and Varney found that teachers value time as a resource for observing others and reflecting upon instruction, and Mann (2006) noted that teachers need encouragement and opportunities to expand their “mathematical creativity” (p. 254).

Many resources that exist naturally in schools can be tapped to allow teachers to develop professionally from within (Torres-Guzman et al., 2006). These include teachers themselves, textbooks that teachers have accumulated during graduate courses, and databases of educational resources such as websites. Others must be purchased.

The NSDC (2001) viewed professional learning as an investment and acknowledged that adequate funding can provide well-designed, effective professional development. Funding can pay for trainers, coaches, or consultants who help teachers with various projects leading to school improvement; however, Vandeweghe and Varney (2006) found that teachers often resist "outside experts" (p. 282) being brought in to facilitate change. Professional development funds may also pay for substitute teachers while regular teachers attend state or national conferences, or provide stipends to encourage lead teachers to serve as mentors or training facilitators (NSDC, 2001).

The NSDC (2001) recommended that school districts use "ten percent of their budgets" (para. 4) for the purpose of professional development, although it acknowledged that in many cases, less than one percent is actually used for this purpose. Hill (2007) noted that professional development funds are often "misspent" (p. 124). Some districts provide incentives to teachers, such as salary upgrades for teachers who earn graduate degrees, as a way of allocating resources for professional learning (NSDC, 2001). Resources play a huge role in determining the depth and reach of professional learning within any particular school district.

The Process of Professional Development

The process standards are centered on professional learning that results in student learning through data, evaluation, research, design, learning, and collaboration (NSDC, 2001). The council holds that this type of professional development: depends upon student data to guide purposes and directions of professional learning, measures its impact based on many sources of evaluation and uses this information to determine future directions, primes teachers to discern and synthesize research, matches the design of professional development strategies with ultimate outcomes, includes considerations of appropriate conditions for learning and changing, and prepares and allows teacher collaboration to fulfill professional purposes. These process standards reflect the vision and principles for effective professional development according to the NSDC.

Data driven. The first process standard focuses on using data from a multitude of sources to inform and guide professional development (NSDC, 2001). The NCLB Act of 2001 has put accountability at the top of the priority list for educators. It includes, among other things, requirements for more gathering and aggregation of student data, such as standardized test results. Although data may be abundant in many schools, Wayman (2005) noted that such information is only valuable if teachers are taught how to interpret and use it to improve instruction.

Mertler (2002) reported that data, specifically that which stems from standardized test results, can be used by teachers to guide instruction. He recommended that teachers first disaggregate test scores to look for patterns of deficiency, and then analyze curriculum, instruction, and assessment as a means of working toward revisions that will lead to increased student achievement. Mertler also suggested that leaders condense large amounts of data to include only what is most relevant, and then create and employ a plan of action for classes or individual students.

Schools that have begun to implement data-driven decision making have reported more professionalism and collaboration among staff (Feldman & Tung, 2001). Additionally, teachers have reported improvements in student achievement on nationally normed tests after participating in professional development centered gathering data effectively, identifying curricular gaps, and creating action plans based on district-wide monitoring and feedback (Panettieri, 2006).

Student-generated data, including that from standardized tests, work samples, and informal assessments such as worksheets, provide useful information to help school leaders develop improvement goals (NSDC, 2001). Disaggregated data can be analyzed to determine areas or subgroups in need of attention. Individual teachers can also use student-generated data to plan for instruction. Matsika (2007) and Torres-Guzman et al. (2006) argued that teachers enhance learning, and potentially increase student achievement, when they engage in data collection to evaluate their own practice. This is especially true in light of the connection between instruction and student achievement.

Integration of data is a process that requires cooperation from both teachers and administrators to be successful in promoting increases in student achievement (Petrides, 2006). Classroom teachers can and typically do rely upon data for assessments (NSDC, 2001). Types of classroom data include tests, portfolios, and projects. Teachers can use informal data like these to determine the impact of specific instructional strategies on student learning, and can also informally measure the impact of their own development as it relates to student achievement (Wells & Keane, 2008). Examining student work and using results to guide instruction is a form of professional development on its own. Data play important roles as teachers collect, analyze, and evaluate the effects of different strategies in their classrooms, all as part of their own professional learning.

While many professionals who have begun to use data to inform school practice have reported benefits, one cannot focus exclusively on the outcomes without considering the barriers of such a significant undertaking. For example, many schools are not equipped with the advanced technology required to organize and store large amounts of student information (Wayman, Stringfield, & Yakimowski, 2004). In addition, budget constraints can have a damaging effect on the ideas of projects such as purchasing computer software to store data or funding professional development to train teachers about how to use this information (Panettieri, 2006). Lastly, schools can run into problems if access to student-level data is limited to administrative personnel. Wayman (2005) held that teachers must be involved and allowed unlimited access to information in order for data-driven decision making to be successful.

Evaluation. The second process standard highlights the importance of evaluation as a part of meaningful professional development (NSDC, 2001). Evaluation can refer to teachers' perceptions of professional development programs, as well as to the effect of those programs on student learning and performance (Mundry, 2005). Conderman and Morin (2004) recommended several strategies to help teachers engage in evaluation. These include examining standards in light of practice, recording and analyzing lessons, interviewing or conferencing with other teachers, creating a portfolio, and conducting action research. In learning communities, teachers can use results of evaluation to determine directions of study that will give relevance to the team's work (Mizell, 2007).

The ultimate goal of professional development is to improve student learning, so naturally school constituents want to know if student learning is indeed improving as a result of particular professional development movements (Hill, 2007; NSDC, 2001). Many times, teachers make changes to their instruction that can be challenging, and they wonder if their hard work is paying off. In addition, school board members and state legislators allocate money for school reform, and they wonder if their investments are leading to desired results. The concept of evaluation is addressed through professional development initiatives that contribute to measurable outcomes (American Federation of

Teachers, 2002). Evaluation is an excellent tool for seeking correlations between practice and improvement.

In the past, efforts to evaluate professional development initiatives have sometimes resulted in conflicting outcomes (NSDC, 2001). This has caused many leaders to feel increasingly less confident in the value of professional development. The NSDC addresses this problem by encouraging school officials to evaluate professional development programs over a span of time, being careful not to drop a reform effort simply because positive results are not immediately evident. Hill (2007) found that these conflicts can be partly resolved if schools and districts implement programs that have already been evaluated and proven effective. Another option is to use formative and summative assessments to measure outcomes of particular initiatives. Meaningful evaluation is an essential part of ongoing, consequential professional development (Matsika, 2007; Mizell, 2007; NSDC, 2001).

Research based. The third process standard insists that school improvement efforts be grounded in research-based findings. This matter is complicated because the term research based is often afforded to literature that presents itself as fact when it could be biased (NSDC, 2001), as in cases pointed out by Boaler (2008), Bracey (2000, 2003), and Thompson (2008). Instructional practices that have not been scientifically investigated are sometimes given the same consideration as more formal studies that have undergone rigorous testing (American Federation of Teachers, 2002; NSDC, 2001). Published journal articles sometimes contain information and claims that have no foundation in research (NSDC, 2001). Educators who have little understanding of this notion, however, may read an article and assume that the ideas presented are backed by evidentiary findings. When the educator repeats this information to other educators, the cycle of misinformation continues. This compilation of confusing ideas makes research based a term that means different things to different people.

Professional development should be based on solid, current, peer-reviewed research (American Federation of Teachers, 2002; Matsika, 2007) or properly analyzed student achievement results (Wells & Keane, 2008). It is imperative also that schools train teachers in the concepts surrounding sound research so that educators equip themselves with the ability to engage in critical analysis of current literature. The NSDC (2001) advocated that schools implement pilot studies to test new ideas before fully adopting a new approach. Hill (2007) explained that in-depth research could help school leaders choose professional development programs appropriately suited for their local educational situations.

Design. The fourth process standard focuses on learning strategies of teachers, ensuring that appropriate designs govern professional development programs. "For many educators, staff development is synonymous with training, workshops, courses, and large group presentations" (NSDC, 2001). However, meaningful learning also occurs through the venue of small group collaboration (Borko, 2004; Edwards, 2006; Hill, 2007; Lefever-Davis et al., 2003; Mizell, 2007; 2008; Torres-Guzman et al., 2006; Vandeweghe & Varney, 2006; Wells & Keane, 2008; Wildman et al., 2000). Strategies making up the design of a professional development program could include designing lessons, studying concepts or content, critiquing student work, developing curricula, or engaging in action research. According to Marsigit (2007), teachers can also engage in learning tasks just as students do, in order to gain perspective.

The design of professional development should match the needs and goals of the particular learning community (Mundry, 2005; Wells & Keane, 2008). Prior knowledge and experience of participants should be considered as well as the intended student achievement outcomes (Torrez-Guzman et al., 2006). Both content and pedagogy should be addressed for a coherent experience (American Federation of Teachers, 2002; Firestone et al., 2005; Mundry, 2005). Sometimes learning strategies are combined for professional development that reaches different learners in positive ways (NSCD, 2001). The design of programs should align with the curriculum and resources that teachers use on a daily basis (American Federation of Teachers, 2002; Hill, 2007). Ensuring the appropriate design for particular learning communities is an integral part of a powerful professional development effort.

Learning. The fifth process standard addresses ideas about human learning and change associated with professional development. This standard signifies that certain principles guide "human learning" (NSCD, 2001). Just like children, adults have different learning styles, strengths, and weaknesses (Sprenger, 2008). Effective professional development opportunities allow participants to take in information through various modalities. Mizell (2007) noted that adult learning often leads to student learning. When teachers engage in learning, or scholarship, they enable themselves to face future challenges (Matsika, 2007). Teacher learning can be addressed through frequent opportunities for observation, practice, reflection, problem solving, and discussion (Borko, 2004; Conderman & Morin, 2004; Edwards, 2006; Wildman et al., 2000).

Differentiating instruction within professional development also includes addressing the feelings of individuals regarding change. "Even under the best of circumstances, pressure for change, no matter what its source, may produce feelings of anxiety, fear, and anger" (NSDC, 2001). School leaders and professional development facilitators should acknowledge and respect these feelings to create a culture of togetherness within the school (Mizell, 2008). In many instances, teachers want to be guaranteed that change will be lasting, rather than another passing fad (American Federation of Teachers, 2002, p. 3). This understanding makes the ease toward change more bearable for all involved. Meaningful professional development occurs best when leaders accept the feelings, preferences, strengths, and weaknesses of teachers who are learning together.

Collaboration. The sixth and final process standard set forth by the NSDC revolves around collaboration. When educators collaborate to solve problems, they interact in ways that create synergy and promote a structure of social, professional support (NSDC, 2001). According to Torres-Guzman et al. (2006), collaboration gives teachers "spaces of freedom" (p. 28) to find support and develop creativity. This idea is in stark contrast with the tradition of teaching independently while maintaining minimal interaction with other teachers (Mizell, 2008).

Collaboration is a top priority for effective teacher development, and collegial interaction among staff marks a school culture committed to student learning (Mizell, 2008; NSDC, 2001). Examples of collaboration include teams, committees, and departments within schools that function to meet specific needs or make decisions (American Federation of Teachers, 2002; Mizell, 2007; Wells & Keane, 2008). Teachers also collaborate in study groups where they inquire and find solutions to complex problems (Lefever-Davis et al., 2003, p. 783).

Schools in which collaboration is prevalent assume a collective responsibility for staff and student learning (NSDC, 2001). In a study involving preservice teachers, Edwards (2006) found that participants who participated in collaborative learning tasks were able to increase their knowledge in mathematics content and pedagogy. Collaboration as a centerpiece to professional development ensures that teachers are exposed to different ideas and strategies associated with teaching.

Reflection is a natural effect of collaboration. When teachers share with one another, they reflect on their own teaching practices (Conderman & Morin, 2004; Torres-Guzman et al., 2006; Wildman et al., 2000). They also open up avenues to receive feedback from colleagues about their daily instruction. This kind of interaction may cause conflict, and conflict can serve as a catalyst for change (Vandeweghe & Varney, 2006). The NSDC suggests that teachers speak openly and honestly about their fundamental beliefs as they collaborate. Teachers working together for the benefit of students can build strength within schools and learning communities.

The Content of Professional Development

The content standards are centered on professional learning that results in student learning through equity, quality teaching, and family involvement (NSDC, 2001). The council holds that this type of professional development: helps teachers appreciate diversity and foster equity while supporting student achievement in low-risk environments, familiarizes educators with concepts of quality teaching (content, pedagogy, and assessments related to achieving academic expectations), and enables teachers to increase community and family involvement. These content standards reflect the vision and principles for effective professional development according to the NSDC.

Equity. The first content standard focuses on equity. The NSDC uses the term equity to refer to appreciation of all students. This appreciation is an imperative part of teachers' ability to reach all learners successfully (NSDC, 2001). Effective professional development equips teachers with ways of differentiating instruction for students of various backgrounds (Mizell, 2007). This could include using various instructional strategies to meet the needs of particular learners (Herner & Lee, 2005). Edwards (2006) found that having teachers complete "open-ended, authentic mathematical tasks" (p. 390) helps them become familiar with differentiation, equipping them with firsthand knowledge about equitably meeting the needs of students at various levels.

Competent educators value and respect students' cultures and life experiences, conveying the message that everyone has potential for understanding (NCTM, 2000; NSDC, 2001). Teachers should confront their ideas about race, social status, and culture, and ways these attitudes shape their expectations for students. Understanding the special needs of children enables teachers to be supportive of students' varying capacities for learning content (Firestone et al., 2005). Applying this knowledge in the classroom creates an environment of acceptance and respect, building a foundation of fairness and equity among children (NSDC, 2001).

In a study of race-related disparities associated with mathematics instruction, Lubienski (2006) found that teachers addressed equity in their classrooms by scaffolding a common experience for all students using manipulatives. Professional development programs that include equity as an element can have far-reaching effects, influencing academic, social, and interpersonal growth of students (NSDC, 2001). Equity, in the sense of accepting cultural and historical differences of children, did not present itself within the ABC Elementary School case study data. Instead, participants seemed to be more concerned with academic differences among students.

Quality teaching. The second content standard focuses on quality teaching. Because teaching and learning are interrelated, students should have "access [to the] best possible teaching" (Mundry, 2005, p. 9). In mathematics specifically, quality teaching includes promoting conceptual foundations rather than focusing strictly on computation (Desimone et al., 2005; Mann, 2006). Teachers should understand how to reach learners in multiple ways rather than expecting all students to conform to a single method (Edwards, 2006; Hiebert et al., 2005; Herner & Lee, 2005;).

Teachers should understand content, pedagogy, and assessment in relation to what they teach (American Federation of Teachers, 2002; Firestone et al., 2005; Hill, 2007; NSDC, 2001). Hill (2007) and Mundry (2005) argued that good professional development is subject focused, such as a program that centers on mathematics specifically. Finally, Marsigit (2007) concluded that teachers who engage in professional development increase their abilities to help students construct knowledge in mathematics.

Mann (2006) explained that teachers must "explore the world of mathematics before they can help their students discover it" (p. 250). Professional development that reinforces these fundamental basics of good teaching is valuable to school constituents, including teachers, administrators, and parents (NSDC, 2001) and even fundamental for our nation's success (Borko, 2004). Teachers encounter ideas about quality teaching through graduate courses, educational conferences, professional organizations, and teacher study groups (Hill, 2007; Lefever-Davis et al., 2003; Marsigit, 2007; Mizell, 2007; 2008; NSDC, 2001; Wildman et al., 2000). Quality teaching is often a direct result of quality professional development.

Family involvement. The third and final content standard targets the necessity of professional development to help teachers become better at eliciting community and family involvement (NSDC, 2001). Centered on the idea of partnership between school and home, this standard encourages teachers to acquire skills to extend learning into the homes and communities of students. Mann (2006) recommended "promoting mathematics as a creative endeavor within the community" (p. 254) as an important element to enhancing mathematics education. Another way for teachers to extend learning into the family and community is to assign homework such as finding relevant applications for mathematics in the world outside of school (Conderman & Morin, 2004). Teachers who establish clear lines of communication with parents open up at-home support systems that can be of great benefit to students and to themselves (Fullan, 2006).

Fostering family involvement, or enlisting parental support, is not an easy task. Barriers to family involvement include language differences, attitudes about education, and willingness of involved parties (Chen, Kyle, & McIntyre, 2008; NSDC, 2001). Teachers who overcome barriers forge strong relationships upon which to build a community of respect and understanding. Many teachers are unsure of how to approach the task of family involvement, and this is where professional development can be helpful (Chen, Kyle, & McIntyre; Freeman & Knopf, 2007; Fullan, 2006). Teachers who learn about family involvement develop skills such as communicating effectively and conducting meetings with parents or caregivers. Appropriate professional development equips teachers with the skills they need to make learning a family and community affair (Epstein, 2005).

Critical Analysis of Related Literature

Although the literature reviewed for this project was appropriate for the genre of professional development, it does merit a critical analysis. One assumption of the literature is that professional development will lead to mathematics instruction that results in increased understanding by students, and that this improvement will become evident in test data. Bracey (2000) and Skourdoumbis (2009) noted that researchers cannot solidly link instruction with student performance. Even if change does occur in mathematics instruction, and even if student achievement does rise, it would be impossible to pinpoint the exact catalyst of the success.

Another limitation is the way in which student achievement is measured and reported. Currently, students in the United States are tested primarily with closed, multiple-choice questions. This pass or fail system provides a limited way to assess student achievement, as it does not take into account additional complex factors that impact achievement (Skourdoumbis, 2009). In order for researchers to ascertain students' true understandings, performance-based assessments would be necessary. Students would need to defend their answers with words, so that their thoughts and misconceptions could be examined as data. While research implies that professional development in conceptual mathematics has led to improved student achievement (Cavanagh, 2006a), it is inappropriate to give full credit for improved achievement to the professional development itself without a more comprehensive understanding of the educational context. Consequently, professional development cannot be definitively linked to either improved instruction or student achievement.

Grouws and Cebulla (2000) suggested that the complexity of teaching and learning mathematics makes measuring understanding a subjective task. Variable factors in mathematics instruction include supplemental activities and context of learning, both of which can affect the degree of comprehension by students. Another concern is that professional development initiatives can be superficial, leading to little lasting change (Fullan, 2006), or as Hill (2007) stated, “of marginal use” (p. 121). These factors, along with biased opinions, cultural and educational differences, inability to correlate professional development with student achievement, and data discrepancies make developing an indisputable conclusion impossible (Skourdoumbis, 2009). However, for the purposes of this study, literature related to mathematics instruction and professional development was reviewed to provide context for the study and resulting project.

Implementation

Hill (2007) stated, “Fostering continuing teacher education is a significant undertaking, and constitutes a significant expenditure, in the U.S. educational system” (p. 124). This statement, in essence, underscores the importance of resources in the quest to create meaningful professional development for teachers. Planning for potential resources is a significant step for any school leader to take before launching a new idea, such as this project. A part of project planning that is equally as important as gathering resources and supports, however, is anticipating barriers. The following subsections outline resources and barriers to the MPDP.

Potential Resources and Existing Supports

The NSDC (2001) maintained that effective professional development "requires resources to support adult learning and collaboration." Fortunately, the necessary resources for this project are available at ABC Elementary School. For the purposes of this project, these resources and supports can be divided into five main categories: people and location, funding, time, technology, and mathematics materials. The five areas of resources are essential to the project's success. Along with administrative support, resources are an extremely important consideration for this effort.

People and location. The first category of resources, people and location, is one that will be easy to access. The people necessary for this program are mathematics teachers at ABC Elementary School, who will form a learning community (LC) that completes the MPDP. They will participate in this program as part of their annual professional development plan unless they choose to participate in a different study group or professional development initiative within the school or district. Teachers will not be forced to participate in the program, as this would be a top-down approach that contrasts with the rationale of the MPDP. Another key person in the program is the project facilitator (PF). At ABC Elementary School, I will function as the PF and will perform appropriate duties. Other key people in the study are the leadership members at the school, who include the principal, assistant principal, and academic coach. They may be directly involved, or may serve as support staff for the project. The entire project will take place at the school, due to convenience for the participants. The participants will be those who volunteer and naturally have a vested interest in the location, ABC Elementary School.

Funding. Funding is necessary for many parts of the project. Sources of funding include professional development funds, Title I funds, and classroom instructional funds. Professional development funds, awarded by the district and allocated by the school principal, will be the primary source of funding for this project. Title I funds, which consist of money provided for the school due to its population of students who receive free and reduced lunch services, will be used secondarily to supplement the project in the event that professional development funds are spent or become unavailable. If both the primary and secondary sources of funding become unavailable, classroom instructional money can be accessed to fund the project.

Funds will be used to support different aspects of the MPDP. One important use for funds is to ensure that teachers complete the MPDP with a product that helps them retain useful elements, such as literature, anecdotal notes, and lists or databases of online resources. This could be accomplished through hard copies kept in a resource binder, for which funding would cover the costs of paper, ink, copier toner, and binders. Alternately, funds could be used to support software that enables teachers to create electronic portfolios of resources. Advantages to this option include ability to search keywords, authentic means to learning new technologies, and expanded outreach to other teachers. In another school, using a modified version of this project, money might be needed to purchase manipulatives, books, or mathematics programs; however, at ABC Elementary School the participants already have access to a vast array of manipulatives, books, and mathematics programs to aid learning. Funding could also be managed through fundraising efforts if necessary.

One additional consideration for funding would be if the PF were added on as a part- or full-time faculty position, either at the school or district level. This is not a necessity, but might better ensure the program's sustainability. At ABC Elementary School, there are only seven mathematics teachers who would form a learning community (LC) to complete the MPDP. In this case, the PF would be managing only one group; therefore it would not require funding for an extra faculty position. The job of PF at ABC Elementary School would be made easier by the fact that the MPDP contains compilations of literature, research, and online resources geared toward specific topics. The PF, then, would not be required to locate these items. At a different school with a larger population of mathematics teachers, the job of PF might expand to possibly include several LC functioning simultaneously, thus necessitating additional funding.

Time. Time is an important resource and will prove to be an integral part of the project's success. Monthly meetings can occur either during teachers' planning times during the school day or in the afternoons when school has ended. Participants can expect to engage in 18 to 20 meetings the first year, but will be able to increase or decrease the frequency of meetings after the first year, depending on the circumstances. Time spent collaborating with the LC will be added to the teachers' accumulated professional learning units, which are needed for continued certification. Time may be spent evaluating the project at the end of each phase to determine how to progress the following year. The second and third years would consist of roughly 10 to 15 meetings, depending on decisions made by program participants. In the second and third years, frequency of meetings may decrease for a number of reasons: teachers may be more likely to participate in a program if it requires less of a time commitment as it progresses, teachers may feel that they need a break after an intense first year, and teachers would presumably be comfortable with the learning format by the second and third years.

Technology. Technology use will vary. There were some changes in technology at ABC Elementary School that occurred while the study was being conducted but were not a part of the study itself. School administrators provided each mathematics teacher an interactive whiteboard. All teachers have used their whiteboards to some extent, but some feel more comfortable with them than others. Similarly, during the MPDP, some LC members may require or request more use of technology than others.

A meeting place for the LC has already been established at the school. The room is equipped with an interactive whiteboard with wireless Internet capabilities. The interactive whiteboard will be utilized throughout the study for reviewing websites, playing interactive mathematics games, and demonstrating instructional strategies. Every mathematics teacher at ABC Elementary School also has an interactive whiteboard in his or her classroom. The MPDP includes opportunities for teachers to engage in online learning tutorials aligned to Georgia's Performance Standards, play online mathematics games to expand content knowledge, explore websites with manipulatives or teaching tools, and view videos related to instruction.

Additionally, all participants possess school-purchased laptop computers that may be used to enhance technological aspects of some LC sessions. The school web server will be an integral part of the project, because the PF will use email to correspond with participants. Email may also be used to elicit feedback from teachers. Technology will be an integral part of the project, including the facilitation of many of the LC sessions.

Mathematics materials. The MPDP has been written to include several mathematics books, manipulatives, and programs that have been purchased in previous years and belong to ABC Elementary School. These include:

- Mathematics Navigator Intervention Series (America's Choice, 2006)
- Teaching Student-Centered Mathematics Volumes One and Two (Van de Walle & Lovin, 2005)
- Mathematics Investigations Kits (Technical Education Research Centers, 1998)

Additional materials include various games and websites, and manipulatives such as number balances and base ten blocks. Some schools may not have all of these resources, but there are many alternative activities outlined in each learning module. Several of these can be accessed free of charge via the Internet. Mathematics materials, then, are important but not essential to the project's implementation.

Potential Barriers

Predicting potential barriers is an imperative part of planning any large-scale event. By looking ahead to probable challenges, one can spend time beforehand devising solutions and ways to overcome difficulties. In anticipating barriers for this professional development project, I sought the help of the school principal. We brainstormed about all the different problems that might arise and cause detriment to the progress or outcomes of the program. Together, we generated a list of potential barriers that can be divided into four categories: teacher negativity, teacher turnover, scheduling conflicts, and time constraints.

Teacher resistance. Teachers' attitudes can impact their progress within a professional development program. After years of subscribing to top-down authority, some teachers at ABC Elementary School have grown resistant to professional development mandates. Some teachers may view professional development as extra work and opt to participate the bare minimum. To minimize this, the PF will introduce the project with literature that promotes teacher empowerment in favor of top-down management techniques. Additionally, participation in the program will be voluntary. Teachers who choose not to participate will not endure any negative consequences. Participants will also be free to discontinue participating at any time or engage in tasks and homework at whatever degree they feel comfortable. However, they must provide some evidence of participation (i.e., lesson plans, homework, meeting minutes) in order to earn professional learning units for certification purposes. Specific and deliberate efforts should be made to help teachers view the project as a positive experience in which they contribute to the overall learning of the community.

One aspect of the MPDP that may contribute to teacher resistance is the inclusion of homework assignments. Homework assignments include tasks such as reviewing literature, exploring websites, and observing lessons that teachers complete between LC sessions to enhance their professional development experiences. These assignments will make the program more meaningful; however, if homework becomes a source of frustration for teachers then the plan for completing tasks should be modified. Homework assignments can be omitted altogether if necessary, but there is another option that may be more beneficial. Homework assignments can be divided among LC members so that each person only has to do one assignment. This would work especially well if an electronic portfolio were utilized, as teachers could post homework reflections that all LC members could access. LC members should work as a team to make decisions about homework and other such issues that arise during the course of the program.

Although some teachers may resist implementation of the MPDP, several may be excited at the prospect. Some teachers are likely to respond positively to the idea of being in charge of their own learning. I have established working relationships with many of the participants, so the barrier of teacher negativity may not turn out to be such a defining factor in the success of the MPDP at ABC Elementary School. If I am able to overcome the barrier of teacher negativity, this could be a valuable and meaningful form of professional development for all participants. To overcome the barrier of teacher negativity at other schools, the project facilitator should introduce the program with literature that empowers teachers as professionals, ensure that the program is implemented on a voluntary basis, remember that flexibility is key in the program's success, and maintain a positive attitude throughout the program.

Teacher turnover. It is likely that some teachers will resign or new teachers will be hired during the span of the MPDP. Teachers may transfer to or from ABC Elementary School, or change grade levels or subject areas. If teachers leave the school before completing the MPDP, they will most likely end their participation in the LC. However, they would have the option to continue their own learning through engaging in the remaining tasks and homework assignments or reviewing the literature and research associated with each module. Teachers who decide to specialize in subject areas other than mathematics would have the same options. In the cases of teachers changing grade levels, their participation in the MPDP could continue because the LC spans Grades 1 through 5. For teachers who transfer in during the second or third years, the plausible choice is for them to join the LC and participate in the remaining modules. Early activities in the MPDP, such as tasks and homework assignments, can be completed later without the benefit of group collaboration and discussions. The MPDP is designed in such a way that conflicts such as these can be minimized or easily resolved.

Scheduling conflicts. Scheduling conflicts, unplanned events that will inevitably crop up during the school year and may take precedence over the planned monthly mathematics meetings, are bound to occur. These might include district-level meetings, parent conferences, or personal emergencies. Inevitably, some LC will need to reschedule session meeting times. In extreme cases, an entire day of sessions may be placed second in priority to another event.

To prepare for scheduling conflicts, the PF will develop and maintain a mindset of flexibility and ask team members to do the same. This should be clarified during the introduction meeting. The PF should explain that the MPDP has a flexible format. There are activities that can be arranged in different orders and completed at varying intensities, depending on the needs of the LC.

All participants must understand that scheduling conflicts will likely arise throughout the project. The PF, in conjunction with participants and school leaders, will reschedule missed sessions for the closest time thereafter that is convenient for everyone. The barrier of scheduling conflicts can be easily overcome with a little effort.

Time constraints. The final type of potential barrier that might affect the project is time constraints. Time is a precious commodity at ABC Elementary School, and teachers place a high value on using their time productively. If LC sessions take place during teacher planning times, they will last 40 minutes at the most. In order for these sessions to be successful, every minute of time needs to be utilized. To handle this issue, there will be structured agendas prepared in advance for each session, and the PF will ensure that the team does not deviate from the predetermined schedule, aside from times when fruitful discussion takes a different direction. If sessions take place after school, time constraints will be easier to manage. The PF will also ask participants upfront to be cognizant of the time constraints and respectful of the need to keep the meeting moving in a meaningful direction. If necessary, the PF will utilize a digital timer to help keep the meetings running smoothly.

Summary of Resources and Barriers

Part of mentally preparing to undertake any major project involves prior planning. Anticipating potential resources and barriers can help make a project successful. By engaging in early problem solving, I have identified resources to aid in the eventual implementation of the project and devised strategies to alleviate potential problems. This lessens the likelihood of having to overcome obstacles after the program has already begun. Articulating needs, apprehensions, and solutions makes me relatively confident that the MPDP will proceed as planned and will conclude within the designated timeframe, whether it is implemented at ABC Elementary School or modified for use in a different setting.

Proposal for Implementation and Timetable

The MPDP consists of three distinct phases that occur during three consecutive years called Phases 1, 2, and 3, respectively. The length of the program is based on several factors. Hill (2007) found that in order for professional development to be effective, it must be continuing. Hill asserted that more time invested usually transitions into more profound changes. Vandeweghe and Varney (2006) documented the “intellectual stimulation, collegiality, and professional growth” (p. 282) of teachers involved in a study group over the course of six years.

The timeframe of the MPDP is designed to give teachers necessary time to become comfortable working in a LC, permit flexibility in pacing of module completion, and lead to sustained improvements in mathematics instruction. In the past, ABC Elementary School teachers have been discouraged by the tendency of administrators to change direction or focus before they have had time to adapt (M. Rollinson, personal communication, July 17, 2010). Just when they start to feel comfortable with a new approach, teachers are once again asked to implement something new. The MPDP will give teachers ample time to construct understandings of mathematical and pedagogical content while simultaneously integrating new ideas into their classroom instruction.

Phase 1 will be introductory, during which members of LC get accustomed to meeting and sharing openly with one another. The PF will be deeply involved in the project during Phase 1, which will include explaining the philosophy behind the design, method of operation, expectations of participants and the facilitator, timeline for completion, and plans for assessment and review. The focus for Phase 1 will be mathematical concepts and instructional methods. Participants will study current literature and engage in professional collaboration with colleagues in a nonthreatening atmosphere. They may also observe each other informally. These activities are built into the first module of the MPDP, which focuses on number sense.

Phase 2 will be a transitional period during which teachers observe one another and report findings, as well as continue to study ideas about teaching math. They will make decisions about the format and frequency of LC meetings as the program progresses. They may complete modules as they are presented in the MPDP, or they may choose to combine elements of different modules. For example, teachers may decide that they liked the format and pace of the number sense module and therefore choose to construct the problem solving module in a similar fashion. Conversely, they may want to complete some activities from the computation module, but also begin to explore literature and research from the differentiation module.

Toward the end of Phase 2, LC should evolve to include teachers developing their leadership skills and taking charge of their own professional development as they make more and more decisions about how to move forward in the MPDP. They may generate additional activities to include in the modules. Lastly, during this second year, the PF will invite teachers from other schools within the county to observe LC meetings in order to broaden the scope and outreach of the MPDP.

Phase 3 will be the final year of the project, and will be a year in which teachers take on even more ownership of the how the LC functions to meet the needs of the school. The role of the PF should decrease during this phase. Topics of study will include any of the MPDP modules that teachers have not yet explored, as well as other subjects generated by teachers during the program. Teachers may engage in their own search for literature on meaningful topics. Additionally, teachers may choose to conduct action research in their own classrooms and share findings with the group.

Members of the LC will work together during this third year to organize and hold a Family Involvement Night. This will include inviting school and community stakeholders, such as parents and teachers from other schools, to learn about ways to become more involved with school and student affairs. This will allow results of the MPDP to reach a larger audience, thus giving it the potential to have an impact outside the local context. A more detailed explanation of each phase of the MPDP follows the timeline for implementation in Table 7:

Table 7

Timeline for Project Implementation

Phase 1 / Year 1	Teachers form LC to meet approximately twice per month
	LC members determine sequence of study for topics
	Suggested topics of study: number sense, computation, problem solving, geometry, measurement, algebra, data analysis
	LC members are given resource binders or trained to use electronic portfolio software, begin to collect artifacts
	PF outlines expectations and goals of MPDP
	LC members observe each other locally
Phase 2 / Year 2	LC members decide how frequently they want to meet, increasingly taking an open forum format
	Suggested topics of study: differentiation, remediation and enrichment, teaching strategies
	LC members continue to accumulate artifacts and research for binders or portfolios
	Continued teacher observations
	Scope of MPDP broadens: teachers from other schools are invited to observe LC sessions
Phase 3 / Year 3	Teachers begin facilitating sessions
	LC members decide how frequently they want to meet
	Suggested topics of study: continuation of previous topics or new ideas generated by teachers
	LC members continue to accumulate artifacts and research for binders or portfolios
	Scope of MPDP broadens further: LC plans and hosts Family Involvement Night

Phase 1. The first step in the project will be to conduct an introductory meeting. At this meeting, the PF will outline the goals and parameters of the project. This presentation will be held with the entire faculty rather than with the school's seven mathematics teachers. The purpose of including the entire faculty is to make them aware of the MPDP, should they want to initiate a similar project in their specialty subject area such as reading or language arts.

After this, the mathematics teachers who volunteer to participate will form the LC that implements the MPDP. The LC will determine the order in which members will engage in studying the different topics. This will give teachers some level of personal investment in the training. Once the foundation for the project is laid, the LC will meet approximately twice per month for the duration of one school year. The rationale for meeting twice per month is that it will allow time to complete several modules. LC members can choose to meet more or less often, however, as they decide what best meets their needs. Meetings will follow a structure that includes tasks, discussions, homework, literature, and research. A major focus will be how to apply what is learned in the LC to participants' classrooms. This adds the important dimension of authenticity to MPDP and addresses the theme of relevance that emerged from the case study.

During monthly meetings, teachers will engage in self-reflection and collaboration. The PF will lead each meeting, guided by an agenda prepared beforehand. Every meeting will include time for reflection, collaboration, and study. Meetings will begin with an open discussion of suggestions and feedback from the previous meeting. This format allows opportunities to acknowledge disparate ideas and work toward resolutions about what should be happening in LC sessions. Feedback, then, can be incorporated as the project facilitator prepares the agenda for the following session.

After discussion, sessions will usually begin with a themed task designed to get teachers thinking. For example, if the current module is number sense, the task will be based on number sense. This task could be a word problem, a graphic organizer, an online mathematics game, and so on. Then participants will spend some time discussing what has and has not been working in their classrooms, regarding the particular topic such as number sense, during mathematics instruction. This will also be a time for participants to seek advice about any specific challenges they have been experiencing. The facilitator will review current literature and research regarding the mathematics topic of focus for that particular meeting. If LC members feel comfortable, they may also share thoughts or findings during this time. Teachers may also pose questions, engage in discussions, or take notes.

Sessions will continue as the PF leads the group through planned activities. Modes of presentation may include online tutorials, model lessons, discussions, group projects, interactive games, or website reviews. These are all outlined in the modules of the MPDP. If a particular learning strategy lends itself to the use of manipulatives, teachers will explore and practice using them. Some activities may include partner or group activities for teachers to complete. Other activities may include time for teachers to model lessons and elicit feedback from the group. At the conclusion of each session, participants will write comments and place them in a suggestion box. This feedback should indicate whether they perceived the session as valuable and include suggestions for improvements of future sessions. Thus, the last few minutes of each session will be used to plan for the next session. This will allow the PF to adequately prepare ahead of time.

At the conclusion of Phase 1, participants will complete the Standards Assessment Inventory (SAI), a questionnaire assessing the project according to whether it met, did not meet, or is in progress of meeting the NSDC (2001) standards for professional development. This feedback will allow the PF and school leaders to plan for Phase 2 of the project, as well as for the future of mathematics-related professional development at the school.

Phase 2. It is difficult to anticipate the details of Phase 2 because it will be largely influenced by teacher input at the conclusion of Phase 1. It will likely be impossible for teachers to complete all seven modules of the MPDP during one year, so Phase 2 will be necessary. However, it will be up to LC members to determine how to progress through additional modules. Participants will make decisions such as how often to meet during Phase 2, whether to attempt more or less activities during sessions, whether to eliminate some activities altogether, and whether to add different activities perceived as beneficial.

During this second year, teachers will be in the process of becoming more comfortable with the design and purpose of the LC, and the sessions will continue throughout the year. The sessions can be conducted in the same format as during Phase 1, giving participants more opportunities to study literature, investigate teaching materials, explore technology, and collaborate professionally. Alternately, teachers may decide to modify the structure of learning community. The flexible format allows teachers to use the program modules in different ways to accomplish the same purposes.

Phase 2 of the project will also include times for teachers to observe one another during mathematics lessons. Teachers will have the option to observe other teachers at their own grade level or to engage in vertical observations, meaning they may observe teachers of grade levels above or below the one in which they teach. Every teacher will take anecdotal notes during their observation times, and will report findings to the LC during regular monthly sessions.

Model lessons will continue, and the LC will begin to take on more of an open-forum style, with teachers gradually taking on leadership roles while the project facilitator steps back and begins to serve as an overseer and moderator, rather than a leader and manager. This transition will be accomplished gradually. The PF will ask for a volunteer from the LC to lead a specific activity during a session. This might include leading the opening discussion or facilitating one of the online tutorials and will be written into the agenda ahead of time. At the next session, the PF will ask for two volunteers to help facilitate. After that, three volunteers will be enlisted. By the end of Phase 2, LC members will be working together to conduct sessions with little assistance by the PF.

Additionally, teachers throughout the county will be invited to participate in LC during the second year. The goal is for teachers to realize their own potential as leaders rather than looking to others for leadership, as has been common practice in the past at ABC Elementary School. Phase 2 of the MPDP will continue to empower teachers as learners and leaders, and build up their roles as competent professionals. This will prepare them for Phase 3, when they take control of LC sessions and make decisions about the future of their own professional development.

Phase 3. This year will mark the conclusion of the MPDP as outlined in this doctoral study. It is my aspiration, however, that the LC will continue even after the program has been completed. For this reason, Phase 3 will be a preparation stage to ensure that teachers feel comfortable leading and managing their own continued development. The PF will play a less significant role as teachers continue to lead in ways such as facilitating LC sessions, conducting research and exploring literature, observing outside the local context, generating topics of study, and sharing ideas with constituents.

During Phase 3, teachers will study literature to better understand how to involve families and other school stakeholders in the learning process. The LC will host a Family Involvement Night in which they educate families on how to help their children better learn mathematics, addressing the theme of support that emerged during the ABC Elementary School case study. LC members will make all decisions regarding the Family Involvement Night, including who to invite, what to present, and how to proceed. They may choose to invite teachers and administrators from other schools in order to showcase the work of the LC and broaden the community outreach of the MPDP. This will give participants hands-on experience at fulfilling leadership roles and helping others understand our mission as teachers of mathematics.

LC will continue to meet, and topics of study will include those determined by participants or those already established in the program modules. Technology will continue to be an integral part of the design of the project, and teachers will continue using different technologies effectively in educational endeavors. The LC sessions during this last year will focus on helping teachers manage their own professional development, and should involve much reading and analyzing of current literature on these subjects.

Mathematics teaching methods will still be a prevalent source of investigation, but an overarching emphasis on teacher leadership and pedagogy will provide teachers will the skills that enable them to continue learning after the formal MPDP is complete.

Roles and Responsibilities of Student and Others

Thus far, I have served as a case study researcher and the developer of the Mathematics Professional Development Program. This role placed me in the position of teacher leader. For the purposes of this doctoral study, I focused only on designing and developing the project. This included drafting a layout of the 3-year plan, but did not include actually beginning the implementation stage of the plan. I have done extensive work to develop the MPDP in accordance with national standards of professional development and emergent themes from the case study at ABC Elementary School. This included compiling current literature geared toward specific topics, organizing information into manageable modules for teachers, and preparing meaningful activities for LC sessions. My work was based on peer-reviewed journal articles and current scholarly references about appropriate mathematics instruction and effective professional development. The MPDP also coincides with the Georgia mathematics standards that guide teachers in planning for instruction.

When implementation phase begins in the local context, I will volunteer to be the PF at ABC Elementary School. Responsibilities will expand to include budgeting, planning sessions, allocating time for collaboration, guiding discussions, providing current and relevant literature, preparing handouts, scheduling and facilitating sessions, eliciting feedback, and evaluating the project. As PF, I will prepare and make plans to provide each participant with a binder at the beginning of the project. These binders will be organized by mathematics topic, and will include a section for related literature.

I will continue to serve as a full time faculty member of ABC Elementary School, but will work as PF to fulfill my own professional learning requirements for certification purposes. The MPDP includes necessary literature and resources, and I will use it to guide me in my role as PF. I will work closely with the school principal and academic coach, both of whom are enthusiastic about the prospect of implementing the MPDP and will help with expanding the program to reach audiences outside the local context.

Other schools or districts that might want to implement something similar would need a committed volunteer PF and a small source of funds. In order to make the implementation feasible, the school or district would need a copy of the MPDP or something very similar. Otherwise, the PF would have to locate resources and literature as the program progressed. This would be possible but extremely time-consuming. Monetarily, another school or district could implement such a project even on a tight budget by choosing specific activities from each module that would be free of charge. With appropriate resources, other schools or districts would be able to successfully implement the MPDP or something very similar.

Participants will complete the MPDP with new knowledge, new literature, and a new mathematics resource binder or electronic portfolio full of information. The notebook, or binder, will be a tangible product resulting from implementation of the MPDP. Another product will be the establishment of a mathematics-focused LC in a school where teachers clearly desire an intervention to improve mathematics achievement, as evidence by the case study. At the conclusion of the project, I will collect and analyze data, report findings, and verify results with selected participants. For the purposes of this doctoral study, my roles and responsibilities included conducting a case study, analyzing data, reporting findings, and designing the MPDP.

Project Evaluation

Part of project development includes making plans for review or assessment of the project. In this way, one can determine what worked and what did not work in order to make modifications for future similar or related projects. For the purposes of this doctoral study, I included plans for project assessment as part of the MPDP. Plans for evaluation include collecting both formative and summative data.

Formative Evaluation

The source of formative data for this project will be ongoing formal and informal interviews and focus group sessions with LC members. The PF will interview all participants to elicit informal feedback about multiple aspects of the project. During each phase of the program, the PF will interview LC members after approximately five to seven LC sessions and will facilitate two or three focus group sessions at quarterly intervals.

Ongoing dialogue between the facilitator and participants will allow the facilitator to make critical adjustments during the project, to eliminate elements of the project that teachers do not find useful, and to make the learning process more valuable to everyone involved. Anecdotal evidence, such as notes taken by both the PF and participants, electronic mail messages between the PF and participants, and notes taken during observations of mathematics lessons might also inform the direction of the MPDP.

In these ways, the PF and school administrators can determine what kinds of professional development activities teachers find more and less helpful, in addition to what they perceive as unhelpful. Plans for project assessment are an integral part of this doctoral study and its implications for future research. Both positive and negative outcomes can be used to plan for future professional development efforts at ABC Elementary School. District or state administrators may also use participant feedback to determine the applicability of this project to other settings, such as other schools within the district or state.

Summative Evaluation

The sources of summative data will be the Standards Assessment Inventory (SAI) and the Criterion-Referenced Competency Test (CRCT). These two instruments measure different aspects of the MPDP. Participants, who will be teachers or administrators, will complete the SAI at the end of Phases One and Three of the project. Students will complete the CRCT, a test that measures student achievement, as they do at the end of every school year.

The SAI is a 60-item questionnaire designed to help educational leaders assess the degrees of alignment between schools' professional development plans and the National Staff Development Council's (NSDC) Standards for Professional Development. School leaders can use results of the SAI both to evaluate past professional learning programs and to plan for future opportunities. The SAI allows teachers to provide feedback about the current professional development plan, as well as present input for the following year's program. The SAI is one of the most informative tools available for assessing the perceived value of professional development (A. Ingram, personal communication, September 1, 2007).

Questions included on the SAI were derived from the NSDC standards, and were chosen carefully based on the overarching goal of measuring the degrees that school professional development programs reflect the ideas portrayed in the standards. SAI questions cover the following 12 areas of professional development: learning communities, leadership, resources, data-driven decisions, evaluation, research-based practices, design, learning, collaboration, equity, quality teaching, and family involvement. Because each of these areas is an integral part of teacher learning, participants would answer all 60 survey items.

The CRCT is an instrument used in Georgia to assess students' understandings of reading, language arts, mathematics, science, and social studies (Georgia Department of Education, 2001). For the purposes of evaluation of the MPDP, only mathematics scores would be used. The PF and MPDP participants will examine descriptive statistics over the course of several years, with attention being given to notable increases or decreases. Teachers will also look at scores within specific mathematics domains, such as numbers and operations, data analysis, measurement, geometry, and algebra. These data could provide insight into areas of mathematics content that warrant additional professional development for teachers. Results will be used to determine modifications that could be made to the MPDP to make it more effective in accomplishing long-term goals.

Rationale for Project Evaluation

The rationale for using both formative and summative forms of evaluation is to ensure that MPDP participants are empowered as leaders of their own professional development. Additionally, using both types of evaluation provides more information with which the PF and program participants can work to make informed decisions. Formative evaluation, specifically interviews and focus groups, allows participants to express their ideas and opinions (Andrade & Cizek, 2009). In turn, their feedback should be incorporated as much as possible into the direction of the MPDP. The PF should use results of formative evaluation to modify the format, pacing, or content of modules.

Summative evaluation gives additional information about specific elements of the project. For example, the SAI gives teachers an opportunity to rate the project's effectiveness in meeting the NSDC (2001) standards for professional development. The rationale for the administration of the SAI is rooted in the theory that professional development is directly connected to student learning (Southwest Educational Development Laboratory Evaluation Services, 2003). This research-based assumption forms the foundation of the MPDP. Results of the SAI will help me determine how to modify the project and address weaknesses, in order to improve the perceived value of the project according to participants. In the event that another school wants to implement the MPDP, the PF can use SAI results to modify certain aspects of the MPDP before implementing it in his or her local context.

The long-term goal of the MPDP is to improve student achievement in mathematics, so the CRCT is included as a part of the evaluation plan that tracks student performance. The rationale for this summative evaluation is founded in research that connects professional development with improved instruction, and improved instruction with increased student achievement. Ideally, teachers and administrators would see an upward trend in student mathematics scores over the course of several years during and after implementation of the MPDP. Findings could be used to confirm the success of the MPDP or make changes in order to improve its effectiveness.

Implications Including Social Change

According to Firestone et al. (2005), “District leadership can influence teaching practice using one important pathway – professional development – to improve teaching” (p. 414). In this way, social change is accomplished when teachers improve their practices in order to provide meaningful learning opportunities for students in elementary schools. This MPDP combines elements of contemporary models of professional development to provide risk-free opportunities for teachers to increase their understandings of mathematical and pedagogical concepts.

The program includes time for teachers to work together as LC engaging in interactive learning sessions, fueled by topics generated during case study interviews. Their learning will be deep and authentic. When teachers see connections between their students and the subject matter they are studying, the entire experience will become more meaningful for everyone involved.

I strengthened the project by interweaving elements of the NSDC (2001) standards throughout the design of the project, as well as the findings that emerged through the case study I conducted. Modules include content and pedagogy topics that teachers generated, and activities include ideas and learning preferences based on case study themes and concepts presented in current literature and research. Implications for the MPDP include positive social change that is both localized and far-reaching.

Local Community

This program was designed with the intent of having far-reaching and long-lasting positive effects in the local community. The MPDP, when implemented, could be quite significant to the participants. Teachers who participate in the program should directly benefit from professional collaboration and from learning new ideas about teaching mathematics. When teachers implement new strategies, students may also recognize the significance of this project. Learning will occur for students within classrooms and for teachers throughout the school. By learning together and striving for improvement, teachers will be able to reach into the minds and homes of students, forming communities of learners who are dedicated to social change through student improvement in mathematics.

The long-term intended outcome, which could be measured annually, would be increased student achievement on the Criterion-Referenced Competency Test (CRCT). However, teachers would need time to integrate new ideas into instruction before this increase could be expected. By improving instruction through high quality professional development, the MPDP holds the potential to prepare ABC Elementary School students for higher level mathematics courses and greater success in the world outside of school.

Far-Reaching

In addition to having educational significance to teachers and students within the local context, the MPDP could have widespread implications. Because student performance reflects to some degree the effectiveness of their teachers' instruction (Bransford et al., 1999; Graeber, 2005, p. 356), it is the responsibility of educators to increase student achievement in mathematics by aligning instruction with current curricula and expectations (Greenberg & Walsh, 2008). This project has far-reaching implications in that it works toward creating change in mathematics instruction through fundamental teacher education, or professional development.

Knowledge of teacher development helps educators grow professionally in many ways. Levin and Rock (2003) found that teachers become more aware of their students' needs and their own teaching when they engage in scholarly research. Teachers are more motivated, satisfied, and confident when they participate in self-directed professional development (Beatty, 2000). Henson (2001) asserted that teacher research leads to an increased sense of efficacy, and Kershner (1999) held that teachers who engage in research learn more about educational issues and therefore work toward change in practice. Ultimately, this change in practice is what will serve as a catalyst for social change in the education of America's students.

"Teacher inquirers support each other and contribute to the creation of a larger learning community" (Torres-Guzman et al., 2006). This statement summarizes the outreach that can be achieved through a study such as this one. Professional development and teacher collaboration can lead to better instructional practice and ultimately, to improved learning for students and educators alike. This project has the potential to impact social change in the United States by leading to increased student achievement in mathematics as a result of professional development by teachers for teachers.

The NCTM (2000, p. 1) emphasized the social significance of mathematics by explaining that learning and communicating mathematics is an ongoing, evolutionary process. The council also expressed that the need for mathematics will continue to emerge in the working world and economy. Skourdoumbis (2009) noted that the "globally interconnected economy" (p. 223) requires students to meet increasing demands using higher order thinking. This study has significant implications because it addresses an identified educational problem through the study of mathematics instruction and professional development for teachers.

Conclusion

This section described the project portion of this doctoral study. Framed by the NSDC (2001) standards for professional development, this Mathematics Professional Development Program will provide opportunities for genuine, relevant learning experiences for teachers in place of random inservice workshops typical of years past. In turn, teachers will be equipped with the understanding of how to create higher order thinking tasks for their students.

The design of the MPDP reflects elements of learning communities, leadership, and resources to ensure meaningful implications. The program will help teachers form learning communities as they work together to achieve school and district goals. The LC provide a unique platform in which teachers can engage in professional discourse. This nonthreatening environment will project an attitude of openness among the groups that will make the experience more meaningful to the participants. Together, school administrators and I will fulfill leadership roles by creating the project to work toward the ultimate goal of school improvement and fostering leadership skills within teacher participants. The NSDC emphasizes the importance of resources for effective professional development. In the case of this project, resources are abundant. These resources include people, time, funds, technology, and mathematics materials, all of which are readily available at ABC Elementary School.

I incorporated the principles of data-driven, evaluation, research-based, design, learning, and collaboration into the MPDP. The project design was informed by data from a case study and will be evaluated to plan for future professional development endeavors, meeting the standards of data and evaluation. During each session, participants will engage in research-based learning. This might take the form of reviewing websites, discussing literature, or exploring research-based strategies for teaching particular concepts.

Every session will involve a literary component that will contribute to the collection of research for participants' resource binders or electronic portfolios. The standard of design refers to the idea of allowing teachers to experience learning in the same format that they will utilize with students. This will be accomplished during sessions as teachers engage in mathematics problems, investigate manipulatives, model lessons, and work with partners or groups.

The fifth idea, knowledge about human learning, is an overarching theme of the project. Activities are designed to help teachers acknowledge their own capacity for learning as well as the potential their students hold for learning. Finally, the entire MPDP encompasses the standard of collaboration as a form of professional development. Times are designated for participants to collaborate professionally throughout the duration of the project. This collaboration could take on many forms, such as discussing, studying, reviewing with peers, planning, exploring, discovering, and learning.

Finally, I ensured that the MPDP focused on the concepts of equity, quality teaching, and family involvement. Equity refers to preparing educators to view and treat all students fairly while maintaining high academic standards. This is accomplished through the MPDP as teachers discuss strategies to meet individual students' needs through differentiation. Family involvement is rather self-explanatory. Educators' appropriate communications with family and school community partners will be addressed during the project in several ways. For example, during Phase 3 of the MPDP, teachers will organize and hold a Family Involvement Night. Teachers may choose to expand the idea of family involvement by creating a product such as a resource book or DVD to reach out to parents.

Quality teaching is emphasized as an ongoing goal of the MPDP. This refers to increasing the content knowledge of teachers through research, allowing them to achieve high expectations for themselves and for their students. Within the MPDP, I included opportunities for teachers to learn about research-based instructional strategies that would increase their content knowledge in mathematics. Participants will also work together to build content knowledge by sharing with the group during LC sessions. The twelve standards of professional development, as described by the NSDC, are important components of this project. Next, section 4 describes reflections and conclusions, infused with literary support of multiple aspects of this doctoral study. The MPDP is included as Appendix A.

Section 4: Reflections and Conclusions

Introduction

In this study, I focused on improving mathematics instruction through the venue of professional development for teachers. Although there are many factors (student effort, teacher knowledge, instructional practice, effective assessment, appropriate research) that influence mathematics achievement in the United States (NMAP, 2008), the first step in facilitating better mathematics instruction is to educate teachers about current research on content and pedagogy (Ediger, 2009; Greenberg & Walsh, 2008; Mann, 2006, p. 250; NMAP, 2008). Mann indicated that teachers should be familiar with underlying mathematical concepts so that they can enable their students to engage in discovery-based learning. He noted that currently, many teachers are doing what they have always done, mimicking mathematics lessons they remember from being elementary students themselves. Some of them may not have developed conceptual understandings in mathematics and therefore cannot effectively engage children in activities that will allow them to construct their own understandings. It is imperative that teachers achieve depth of understanding in mathematics content and pedagogy so that they can then facilitate meaningful learning within their classrooms.

This section includes the project's strengths and limitations, and contains reflections and analysis of scholarship, leadership, practice, and project development. It ends with implications, applications, and directions for future research. This case study sought teachers' input regarding mathematics instruction and professional development. The outcome of the study was an MPDP, which attempts to address deficits in mathematics instruction by enabling teachers to learn constructively within peer communities. The project is included as Appendix A.

Project Strengths

This project has several significant strengths. These include that it was generated by teachers for teachers, is based on research, has a flexible format, was designed to be teacher friendly, is considerate of time, results in a tangible product, and requires little funding. These strengths resulted from careful consideration of many factors that arose from the context of data analysis. The project was tailored to meet the desires of teachers and targeted to address specific areas of need that emerged during the case study at ABC Elementary School.

The MPDP was created by a teacher and based on data gathered from teachers. Rather than relying on outside experts to impart wisdom, this project enables teachers to learn from within their peer groups and contribute to their own development as practitioners (American Federation of Teachers, 2002, p. 9). Engaging in professional collaboration centered on research-based principles is an appropriate way for teachers to become proficient in content areas and pedagogy (Greenberg & Walsh, 2008). This project is not a quick-fix program; it is a gradual introduction into current research and literature regarding effective mathematics instruction.

The flexible format of the MPDP allows teachers to learn from lesson study, discussion, teacher observation, exploration, and literature review. All activities were designed to take place in low risk environments and to give teachers knowledge they can immediately apply in their classrooms. It is teacher friendly and low maintenance. School leaders, including teachers, can modify the program to meet their specific needs.

Time was an important factor in this undertaking. LC sessions were planned to last approximately the same amount of time as teachers' planning periods to avoid requirements for teachers to stay after school in order to participate. Additionally, the program extends throughout 3 years. This gives teachers the ease of gaining knowledge slowly, and retaining it, as opposed to grasping ideas presented to them in an intense or fast paced program.

The cost of the program and the inclusion of a resource binder or electronic portfolio are also strengths of this project. The relatively low cost of the program, especially if the job of PF is performed by a faculty member rather than added as a new position, is important because funding is so frequently an issue in the field of education. ABC Elementary School leaders are always looking for ways to cut costs, and sometimes have to base important decisions on availability of funds. The inclusion of a resource binder or electronic portfolio is significant because it gives teachers a tangible product to consult, add to, and revise after the program has ended. The binder or portfolio will contain literature, discussion notes, example lesson plans, and personal reflections that teachers will find helpful in the time after they have completed the MPDP. This program has many strengths that make it a feasible choice for schools to adopt as part of their professional development plans.

Recommendations for Remediation of Limitations

There are limitations to the project that could be remediated, either through a replicated study or by integrating different ideas into the final MPDP. Limitations to the case study include that a limited number of participants were interviewed, the case study format did not include any quantitative data, and the potential for researcher bias existed.

Limitations to the project include that it is geared only toward elementary school mathematics teachers and it is aligned specifically to Georgia's state curriculum. All of these limitations could be addressed through different approaches to the study or project.

The limitations of the study could be remediated in order to provide a broader or different perspective. If someone wanted to replicate the study, for example, they might choose to interview a higher number of teachers from a wide range of locations. Because the participants in this study all worked in the same school, they likely did not provide a vast array of different ideas about mathematics instruction and professional development. By analyzing data from teachers throughout the state of Georgia, or even across the United States, one could conceive more comprehensive answers to the guiding questions.

Additionally, this study did not include any quantitative data. A needs assessment survey could be used in place of interviews or in addition to them. This would provide more objective answers to what teachers believe they need in order to increase student achievement in mathematics. A survey study would also be easier to expand across a larger pool of participants. Lastly, the potential for researcher bias existed in part because I, as a researcher, had previous relationships with all of the participants. I took special care to remain unbiased, but participants may have purposely or unconsciously skewed their answers during interviews because of their relationships with me. This risk could be reduced if a third party conducted data collection and analysis, although that would likely incur additional costs for the project.

The project design itself was also limited. The MPDP and the data it was based upon came from the Georgia state curriculum, and were geared toward mathematics teachers of Grades 1 through 5. Therefore, the project in its current form could not be utilized by teachers in other states, by middle or high school mathematics teachers, or by elementary teachers in other subject areas. However, the limitation of the Georgia curriculum is minor, as mathematics curricula across the United States are similar. Many are based on the NCTM (2001) standards, which are built into the format and content of the program. With just a few small changes, the program could be aligned to most state curricula.

Remediation of the grade level limitation would require much work in order to make the program applicable in middle or high school settings. Some concepts could remain, such as teacher collaboration, peer observation, and constructive learning, but some parts would not fit in an upper grade environment. For example, the sheets for teachers to find conceptual activities from the Van de Walle (2005) resource are aligned with standards and state units for Grades 1 through 5. In order to make them work for middle or high school teachers, one would have to insert new standards and align the charts with curriculum maps for the appropriate grade levels. If the MPDP were to be implemented in another state or among mathematics teachers in middle or high schools, these limitations would need to be remediated.

Scholarship

Through learning about learning, scholars discover processes of probing, trying new strategies, and sharing ideas (Hutchings & Huber, 2008). “As a form of practitioner research, the scholarship of teaching and learning is a practical enterprise, anchored in the concrete realities of teachers, students, and subject matter” (Hutchings & Huber, 2008, p. 229). This study allowed me to expand my own scholarship through my work within these realities: with teachers, as I interviewed them regarding instruction; for students, as

I investigated the problem of achievement; and with subject matter, as I created a program specifically targeting mathematics. Scholarship can be undertaken in many different ways, although all approaches entail the study of teaching and learning, to some degree (Delbecq, 2007, p. 390).

Bernander (2009, p. 37) found that sometimes teachers have to adjust to the idea of being students, or beginners, after having spent years as teachers, or experts. This represents a fundamental change in perspective and an important part of the scholarship process, allowing teachers to experience learning through different modes of instruction. When teachers then reflect on their experiential learning and engage in peer collaboration, they can reap important benefits such as understanding and refining their own instruction (Benander, 2009; Donnelly, 2009).

Scholars also lean on their own experiences to inform learning opportunities (Hutchings & Huber, 2008). Teachers carry with them years of working in classrooms. They know firsthand what educational problems need to be resolved, and they are able to anticipate barriers to solving those problems (Delbecq, 2007). Additionally, teachers engage in scholarly teaching by maintaining current professional standards and investigating student understanding (Kiener, 2009, p. 21).

Hutchings and Huber (2008) and Kiener (2009) agreed that the ultimate goal of scholarship is related to improvement of student learning. Considerations in accomplishing this goal are: effectiveness within classrooms, translation of teacher knowledge to student improvement, ability of work to affect a large audience, perspectives of the individuals and groups involved, and impact beyond the local environment (Hutchings & Huber, 2008). This case study sought to achieve all of these elements by resulting in a program to help teachers increase their effectiveness, relying upon teacher learning to translate to increased student achievement, having the ability to effect change by addressing an audience of educators, including teachers' perspectives during planning, and maintaining the potential to work in larger settings beyond the local community.

The purposes of scholarship can be approached in different ways. Delbecq (2007) recommended an approach to scholarship that includes focusing on problems about which one is passionate, working in enjoyable settings, partnering with experienced leaders, conducting pilot research, and applying knowledge in venues such as empirical research. I applied Delbecq's framework for scholarship by focusing on mathematics instruction (a personal topic of interest), working in a comfortable setting (the school in which I work), consulting with knowledgeable leaders (elementary school teachers and administrators), conducting a pilot study, and using the results of a case study to guide the development of a program. Throughout this doctoral study, I was able to greatly increase my knowledge about scholarship as both a teacher and a learner.

Project Development and Evaluation

This study provided a unique opportunity to learn about project development and evaluation. It resulted in a program designed to address the original problem. I not only learned about the planning and organization processes of program development, but also about effective forms of project evaluation.

Garvin (2008), Grady (1981), and Hahn (1999) identified the same basic elements involved in developing any project or program. These include (a) identifying the problem, (b) assessing needs, (c) choosing the location and participants, (d) planning for project evaluation, (e) developing the framework, (f) working out details, and (g) beginning implementation. Garvin found that two additional steps, conducting trials and making modifications, were crucial for success. Wildman et al. (2000) included promotion, in order to build enthusiasm at the beginning, and celebration, in order to acknowledge accomplishments at the conclusion.

Flexibility is a key, as sometimes programs need to be redesigned based on participant feedback (Hahn, 1999). Erbert, Mearns, and Dena (2005) found that issues such as "competence, support and recognition, collaboration (and cohesion), and commitment" (p. 49) contributed to participants' positive perceptions of organized team projects. Finally, effective project developers build in plans to disseminate results (Grady, 1981).

In this study, I implemented this research-based framework for project development and evaluation. I began by identifying societal problems to be addressed, which were elementary school mathematics instruction and a need for appropriate professional development. This problem was framed in the local setting but related to the much broader problem of mathematics achievement of students statewide and across the United States. I then collected data by conducting case study interviews and collecting documents from selected participants. By synthesizing teachers' perspectives, I was able to begin conceptualizing the project and organizing details. I ended by planning for project evaluation and implementation, with a structured plan to share outcomes of the study with others in the educational community.

Project evaluation for this study was an important consideration. Garvin (2008) and Grady (1981) both noted the importance of integrating evaluation activities from the beginning of a project. I integrated both formative and summative forms of evaluation into the project development plans. These evaluation methods were designed to occur iteratively throughout the implementation of the program as well as at the conclusion. Strategies include conducting participant interviews and surveys. Additionally, the project is flexible enough that modifications could be made to fit different evaluative situations. Project development and evaluation are integral features of this doctoral study.

Leadership and Change

School leadership must be functional in order to be effective, and openness to change is imperative. Donaldson (2001) explained that effective leadership "successfully promote[s] organizational improvement" and is "sustainable for the leaders themselves" (p. 3). These ideas envelope the concept of change; they represent a change in the view of leadership. Collaboration and collective accountability are parts of a model of school leadership that differs from the past view of top-down, authoritarian management (Challis, Holt, & Palmer, 2009; Spillane, 2009; Williams, 2009). New thoughts about leadership leave room for teachers to engage in self-inquiry and shared responsibility (Spillane, 2009). Other key factors in functional school leadership include reflection, management, teamwork, realistic goal-setting, and innovative practice (Challis et al., 2009; Spillane, 2009; Williams, 2009). As new views of school leadership emerged, the idea of teacher leadership also has evolved.

Teacher leaders in public schools have several responsibilities in addition to embracing change, teaching curricula, and developing professionalism (Phelps, 2006). Not only must a leader take a proactive stance to address current educational issues, he or she is also expected to balance the legitimate concerns of a constituency (Williams, 2009). In the field of education, that constituency refers to parents, teachers, administrators, and anyone else within the broader learning community. Teacher leaders hold the power to promote research-based educational ideas, make data-driven decisions, and collaborate with others to grow professionally.

School administrators can facilitate this perception of collaboration among faculty in order to accomplish the ultimate goal of increasing student achievement (Spillane, 2009; Williams, 2009). They can do this by encouraging teachers to engage in action research and disseminate results to a broader audience within the learning community (Williams, 2009). Effective leaders can use specific strategies, such as setting high standards and recognizing staff members who exhibit wanted behaviors, to increase motivation for leadership (Gortner, 2009).

Embracing leadership and change was a cornerstone of completing this doctoral study. I learned much about the three values of professionalism noted by Phelps (2006): taking risks, modeling integrity, and fulfilling duties. Leadership and change are much more than philosophies; they are realities. As Spillane (2009) noted, relationships and interactions among colleagues are often ignored as elements of leadership, but they play significant roles. I have developed strong relationships through my interactions with teachers, school administrators, and district officials as a result of my work. This doctoral study enabled me to increase my capacities as a leader and change-facilitator within my school and throughout my local learning community.

Analysis of Self as Scholar

As a scholar, this study led me to view myself as a novice in some areas and an expert in others. I have learned more than I ever thought was possible. By reviewing literature, conducting research, and developing an original program, I reached great depths of inquiry. My knowledge in the fields of mathematics instruction, professional development, data collection and analysis, project development, and evaluation was tested and improved as I was forced to embrace both my strengths and weaknesses as a learner and researcher.

Throughout this project study, I matured as a scholar, yet I understand that there is no definitive end to learning. At this point in my educational journey, I have accomplished an important goal but I know there are many ways I can continue to grow in my scholarly endeavors. I hope to expand my scholarship by applying what I have learned in my immediate setting. My first act will be to implement the program I designed within ABC Elementary School. After that, I would like to pursue further research in the field of mathematics education. I am also interested in writing for publication and marketing educational products that I have created for use in my classroom. The most meaningful part of analyzing myself as a scholar is realizing that prior to this doctoral study, my goals and priorities were so different. This experience changed my outlook as a teacher and as a learner. It taught me to value the processes and challenges associated with achievement, and I look forward to sharing what I have learned with my students and colleagues.

Analysis of Self as Practitioner

This doctoral study was an invaluable experience for my development as a practitioner. Although I have no measurable data to corroborate this statement, I am confident that my abilities as a mathematics teacher have evolved and improved during this process. Through my review of literature related to mathematics instruction, I internalized important concepts about relationships and connections that make mathematics logical. Through my review of learning theory, I realized that students learn best by constructing their own knowledge and testing ideas for themselves. I came to understand that learners benefit from discovering mathematical truths rather than having them handed down. As a practitioner who teaches mathematics to students in Grades K through 5, these discoveries have improved both my confidence and ability.

My doctoral study experience has resulted in positive effects within my classroom. By reviewing literature and research, I have increased my understanding of mathematical content and pedagogy, and this has enabled me to better meet the needs of my students. By hearing multiple perspectives during interviews, I have formed a broader perspective of mathematics instruction across grade levels at ABC Elementary School, and I work to connect concepts taught from one grade to the next. By studying all mathematics standards in Grades 1 through 5, I have familiarized myself with expectations and as a result I know how to help students prepare for standards-based assessments. Informally, I hear positive comments from teachers on a regular basis about how grateful they are for my help in teaching specific concepts. The transition from knowledge to application has been positive. In conclusion, my role as a teacher-practitioner has been greatly impacted through the doctoral study process.

Analysis of Self as Project Developer

Analyzing myself as a project developer requires me to examine my work as a reader, writer, researcher, planner, organizer, scholar, practitioner, and leader. As a teacher leader at a small rural elementary school, I became a project developer as I designed the MPDP based on findings from the case study. This included gathering data by interviewing teachers and analyzing documents, including lesson plans. I also worked to review and compile relevant, scholarly literature to enhance the study and project. In these ways, I enhanced my role as a scholar and practitioner.

As the study progressed and the project grew, I developed new skills in the areas of planning, organizing, and leading. I created a 3-year implementation plan with distinct phases, including time for teachers to collaborate, observe other teachers, share teaching strategies, explore mathematics manipulatives, model lessons, read current literature, investigate new types of technologies, research pedagogies and learning styles, and learn strategies for involving family members and other school stakeholders. The timeline provided a reasonable plan for meeting or exceeding all 12 NSDC standards for professional development. Orchestrating the activities and the timeline required careful planning, as well as consideration of many factors including case study findings and literary support. As a project developer, I developed my own leadership and promoted teacher leadership and social change through professional development at ABC Elementary School.

Discussion

The work that I completed during this doctoral study has been an invaluable experience to me as a professional. By reviewing literature about mathematics, I learned how students process concepts that lead to foundational understandings of numbers and operations. I improved my own instruction through applying new knowledge in my classroom. By reviewing literature about professional development, I learned about what teachers need in order to ascertain meaning and relevance as they collaborate. By conducting a case study, I gained perspective about teachers' ideas regarding mathematics instruction and professional development at ABC Elementary School. This enabled me to create a program suited to meet teachers' needs. I have evolved as a leader, practitioner, and scholar. Most of all, I feel that my work contributes to a need at the school in which I teach. I hope to facilitate positive change through implementing the MPDP in my local setting.

Implications, Applications, and Directions for Future Research

Implications of this study and the resulting project include increased understandings of mathematical concepts for students in elementary school. This could contribute to successes for students in high schools and colleges, and adults in the working world. Applications include implementing the MPDP immediately in the local setting, ABC Elementary School. Expanding the scope of the study or project could include teachers from additional districts, states, content areas, and grade levels. This study could be replicated or modified in other educational settings, and data collection and analysis procedures could be altered to investigate the same topic from different perspectives. Similarly, another study might yield different findings and therefore lead to alternative approaches to address the problem.

Directions for future research could include conducting a quantitative or mixed methods investigation either as the impetus for a similar project or as an evaluation of it, utilizing additional technologies as part of data collection or analysis, or exploring alternative solutions to the problem of ABC Elementary School students' mathematics achievement. A quantitative study could use statistical methods to assess needs related to mathematics instruction or professional development, or analyze the effectiveness of the MPDP based on student pre and posttest scores on a standardized instrument. Similarly, a mixed methods approach could be applied to result in numerical data that could be used to augment the ideas or themes identified here. The MPDP itself also could be implemented and evaluated using a mixed methods approach. This would be extremely beneficial in assessing the value of the MPDP for teachers as well as its effects on student achievement. As Skourdoumbis (2009) noted, studies that examine instructional practice in light of student performance should recognize contributing factors that are beyond teachers' control, such as school population and influence of peers.

Using technology and exploring alternative solutions are also important considerations for future research. One way technology could be integrated into a future study would be to set up online chats or blogs for participants. In this way, they could participate in modified focus group sessions to discuss specific topics. The archived posts could then be analyzed as data. Similarly, video observation could be added to the study to enhance the element of reflection, as was done in Stockero's (2008) study of prospective teachers. A possible final direction for future research is to explore different solutions to the problem of low student achievement in mathematics, besides professional development. Possibilities include implementing an intervention program for students, organizing parental involvement groups, creating educational resources (e.g. videos, handbooks, electronic portfolios) for use at home and school, or developing a mathematics mentoring program within the school. However, none of these alternatives get to the core of the issue, which is that teachers need support in order to meet instructional expectations associated with Georgia's new curriculum. Any future studies would need to be planned and conducted with teacher education as a priority.

Finally, future research could answer questions that still remain even after the completion of this study and creation of a program. For example, how can schools with unmotivated teachers implement a plan to improve mathematics instruction? How can teachers overcome their own fears and anxieties about mathematics? How can educators expect students to learn conceptually when they will be assessed with multiple-choice tests? How can leaders integrate data-driven decision making to increase student achievement in mathematics? Addressing these questions would be an excellent starting point for future research.

Conclusion

This study makes an important contribution to the fields of elementary mathematics instruction and professional development. I conducted a case study to investigate mathematics instruction and professional development at ABC Elementary School from the perspectives of a select group of teachers. As a result, I designed an original program that can be immediately applied in the local setting and modified to fit a number of educational situations. The final product, a Mathematics Professional Development Program, is an attempt to ameliorate the problem that prompted the study, which centered on how to improve student achievement in mathematics and address teacher concerns for appropriate training at ABC Elementary School.

The guiding questions framed the study and allowed for organization of themes within data, and the review of literature formed a structural foundation for scholarship. The first guiding question concerned mathematics instruction. I analyzed teachers' lesson plans and interview transcripts and used these results to determine the topics of study for the MPDP. The second guiding question concerned professional development. I used teachers' responses to these interview items to guide the format for the MPDP. The literature review in section 1 focused on mathematics instruction and concluded that a balanced approach is most effective in helping students understand foundational concepts. The literature review in section 3 focused on professional development and provided insight into elements that should be included in an effective teacher education program. Finally, this section included reflections and conclusions about the doctoral project study process as a whole. Scholarship and leadership were achieved through literature review and data analysis to answer guiding questions, and project development was achieved through creation of the MPDP.

Results from the case study indicated that content and pedagogy should be addressed through professional development in order to improve mathematics instruction. Areas of content included number sense, computation, problem solving, geometry, measurement, algebra, and data analysis. Areas of pedagogy included differentiation, remediation and enrichment, and teaching strategies. Additionally, I found that professional development should include observation, collaboration, engagement, literature and research, support, vertical alignment, and relevance. In conclusion, this study has the potential to effect positive change through improved practices in elementary mathematics instruction.

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Appendix A: Mathematics Professional Development Program

The CLOVERS Approach

by Carrie Scoggins, Ed.D.

A Mathematics Professional Development Program

For

Elementary School Teachers

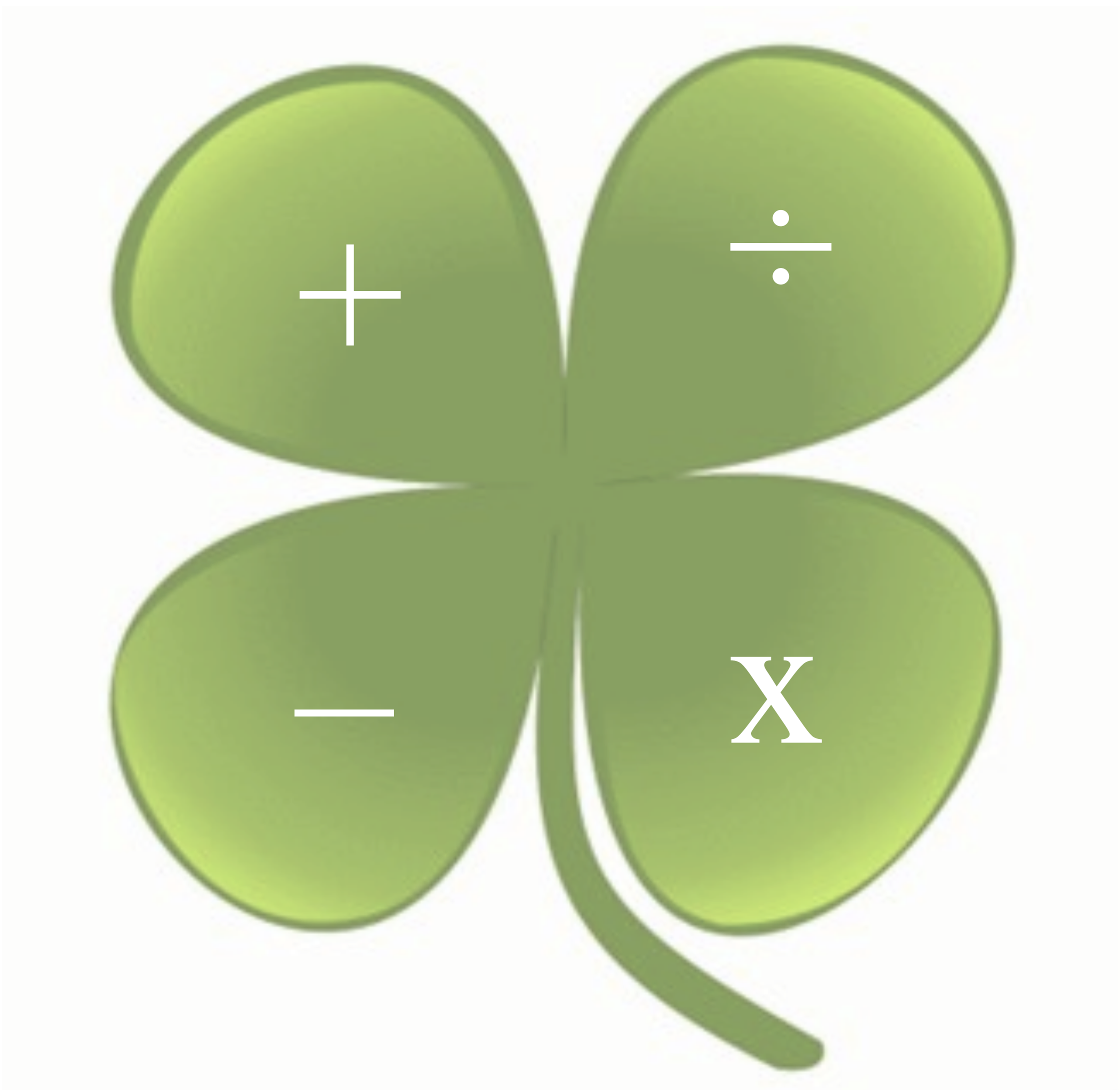


Table of Contents

C L O V E R S

An acronym that embodies the significant elements of professional development in mathematics, according to teachers' perceptions. This is a program FOR teachers, generated BY teachers.

Collaboration

Literature & Research

Observation

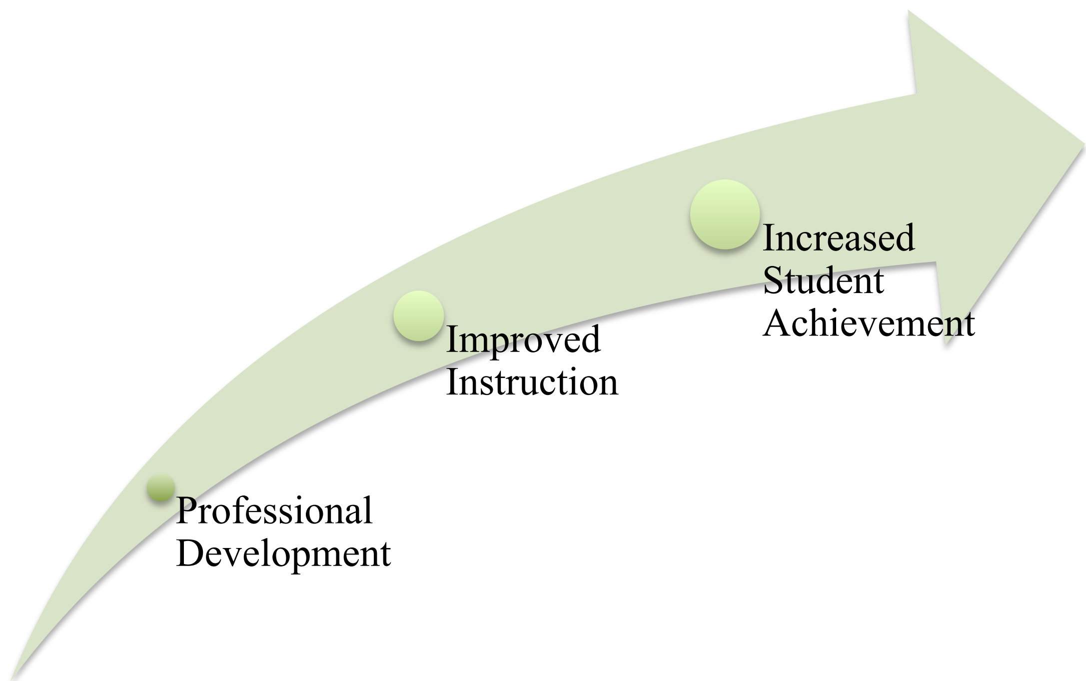
Vertical Alignment

Engagement

Relevance

Support

Goals of the Program

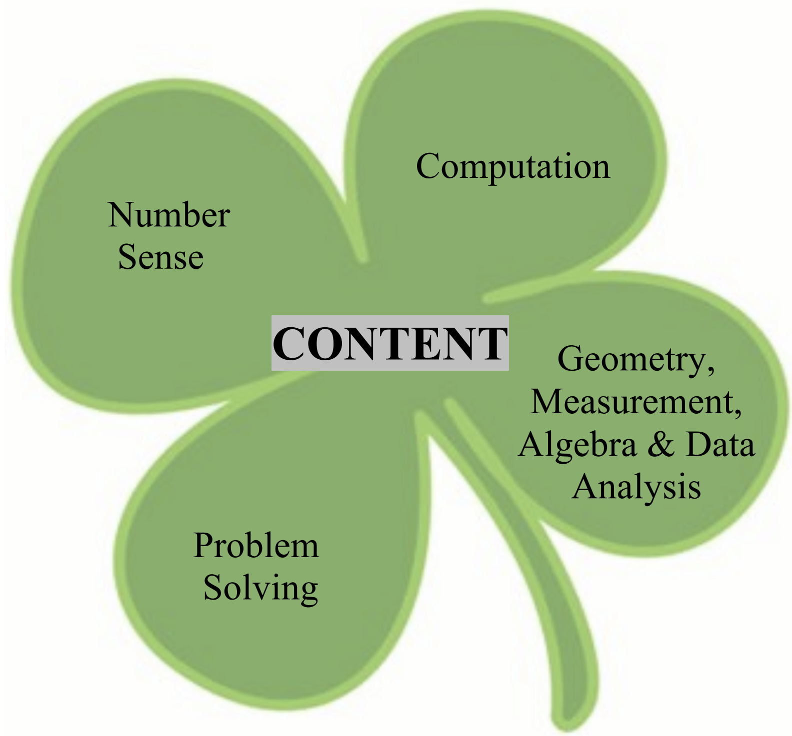


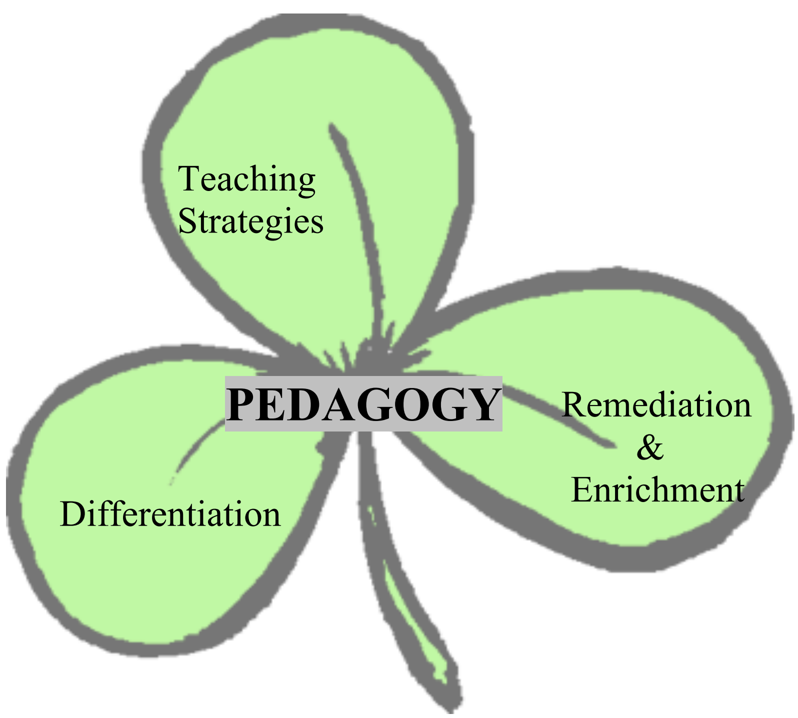
The purpose of this Mathematics Professional Development Program is to increase student achievement in mathematics through improved instruction. The program is designed to improve instruction through in-depth, ongoing, standards-based, collaborative professional development for mathematics teachers in Grades 1-5.

Overview of the Program

Content and pedagogy are the wheels that drive this professional development program for teachers. The areas of content, pedagogy, and professional development are broken down further to provide specific topics and formats of study.

Overview of Content and Pedagogy Topics



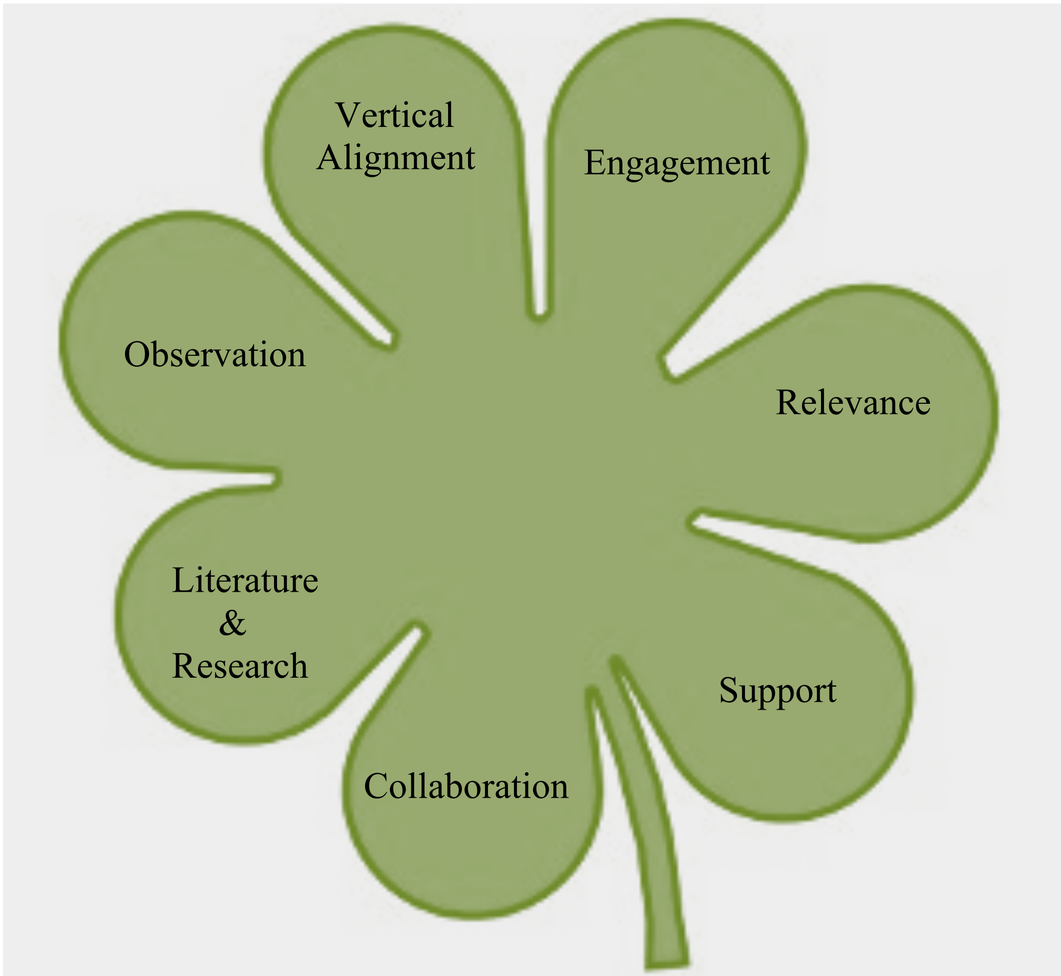


Overview of Module Organization

This program includes seven topics of study, organized as separate modules. Four modules are based on content, and three modules are based on pedagogy. All modules include suggested tasks, discussion questions, homework assignments, literature and research, and online resources. The flexible format allows teachers to progress through the modules as they are currently organized (focusing on one topic at a time), or blend elements from different modules for a more integrated approach.

Content	
Module 1	Number Sense
Module 2	Computation
Module 3	Problem Solving
Module 4	Geometry, Measurement, Algebra, and Data Analysis
Pedagogy	
Module 5	Differentiation
Module 6	Remediation and Enrichment
Module 7	Teaching Strategies

Overview of Professional Development Components

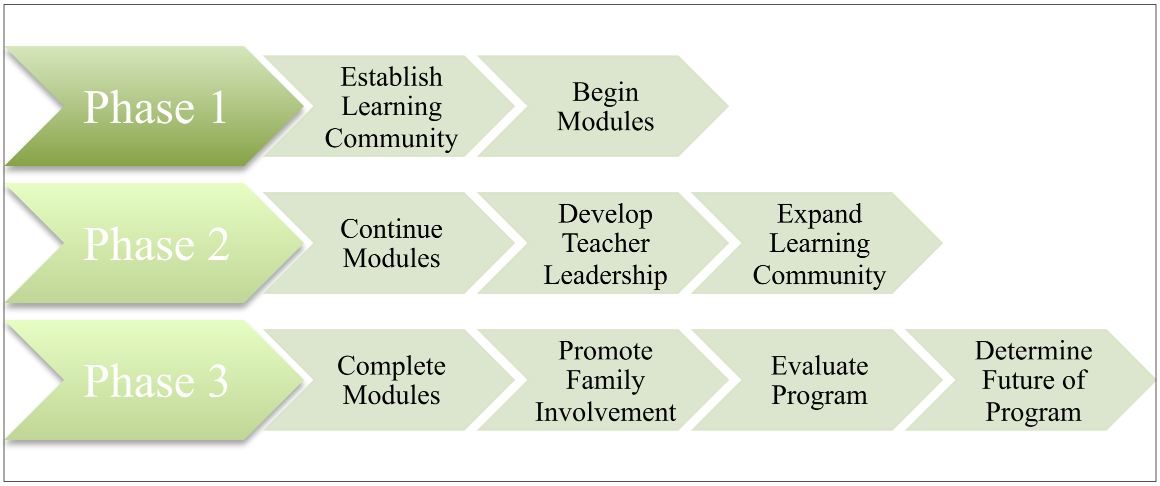


The components of professional development are built in to the design of the program. Within the program, learning community members will *collaborate* regularly about a multitude of topics, study *literature and research*, *observe* instruction, work to achieve *vertical alignment* of standards and instruction, *engage* in mathematical tasks, find *relevance* for knowledge by applying it in their classrooms, and enlist both administrative and parental *support*.

Alignment of Program Components

	Learning Community (LC) Tasks	Homework Assignments	Discussion Opportunities
Collaboration	*Work as a team within LC group *Work with other grade level teachers outside of LC	*Consult other teachers for input on various homework assignments	*Actively participate in discussions as a member of LC
Literature & Research	*Complete tasks found in chapters during book study *Read and reflect upon research and literature *Explore resources for each module	*Complete book study *Read assigned literature *Explore assigned websites	*Actively participate in discussions of literature and research *Share resources such as books, articles, websites
Observation	*Observe lessons during LC sessions	*Observe lessons at the grade levels above and below your own *Observe at another school or district	*Give and receive feedback regarding observations
Vertical Alignment	*Align standards in Grades 1-5 *Read literature appropriate to Grades 1-5 *Complete tasks for Grades 1-5	*Complete book study covering concepts in Grades 1-5 *Read literature appropriate to Grades 1-5	*Participate in discussions about how standards or concepts span Grades 1-5
Engagement	*Complete mathematical tasks (tutorials, online games, lessons) *Put yourself in place of the student	*Complete various homework assignments (explore websites, complete tasks as part of book study)	*Actively participate in discussions of tasks as a member of LC
Relevance	*Model lessons during LC sessions *Share how you applied knowledge in classroom	*Create lessons that apply concepts learned in LC	*Discuss how you could or did apply knowledge in classroom *Communicate with other grade level teachers about what you need
Support	*Give and receive professional support by completing program *Ask administrators to attend LC sessions	*Enlist parental support through newsletters, websites, blogs *Plan and host Parent Involvement Night	*Generate list of support needed from administrators

Suggested Progression of Program



Phase 1 / Year 1 is an introduction to the program. The scope and sequence is presented in a semistructured format that allows for flexibility. During this phase, teachers will familiarize themselves with the learning community model of professional development. They may make modifications as they see fit, in either the content or format of learning. They will begin by working through one or more of the mathematics content or pedagogy modules. This phase will end with teachers evaluating the success of the program and determining the structure of modules to complete during the next year.

Phase 2 / Year 2 is a continuation and expansion of the first phase. Teachers will take on more responsibility for their own learning in this phase, including designing the pace, makeup, and direction of the modules they complete. They will also expand the reach of the learning community to include teachers from other schools within the district, and possibly parents from the school community.

Phase 3 / Year 3 is a year in which teachers will complete the learning modules presented in this program. They should also promote family involvement during this phase by organizing ways to familiarize parents with mathematical expectations and instructional methods. This could include hosting one or more family involvement fun nights at school, conducting parent education courses, or creating a resource for families to use at home, such as a DVD or handbook. The phase will end with teachers completing a survey to measure the perceived effectiveness or success of the program. At this point, they can determine how or if the program will continue.

Frequently Asked Questions

1. Where did the discussion questions (DQ) come from?

The DQ are based on views expressed by teachers. They vary depending on the topic of discussion. DQ focus mainly on expanding content and pedagogical understanding across multiple grade levels (vertical alignment). DQ also push teachers to talk about how they can apply knowledge in their daily instruction (relevance).

2. Why is there a distinction between Grades 1-2 and Grades 3-5 in some of the DQ and tasks?

There are two reasons for this. The school for whom this project was originally designed, ABC Elementary School, includes grades K-5. When distinguishing the lower grades from the upper grades, there is a natural division of K-2 and 3-5. The Georgia Performance Standards similarly divide mathematics into two parts: K-2 and 3-5, with the lower grades focusing on building conceptual foundations and the upper grades focusing on extending mathematical reasoning and application.

3. Why is such strong emphasis placed on connecting Grades 1-2 with Grades 3-5?

Beginning in 3rd grade, mathematics standards in Georgia become more complex. Students are expected to compute and function efficiently with fractions and decimals in addition to whole numbers. In order for students to be successful in the upper grades, they need a firm conceptual grasp of the number system and other basic concepts when they leave 2nd grade. Connections are emphasized so that teachers in lower grades can foster specific ideas to assist students as they progress through upper grades.

4. What literature or research supports the MPDP activities?

Before designing this program, Dr. Scoggins spent years reviewing literature and readings studies associated with mathematics instruction and professional development. That work is presented in a separate doctoral study and supports the context, process, and content of the MPDP activities. Additionally, Dr. Scoggins conducted a case study to determine what type of program teachers wanted. The MPDP is Dr. Scoggins's synthesis of the literature and research she explored/conducted in her study of elementary mathematics instruction and professional development.

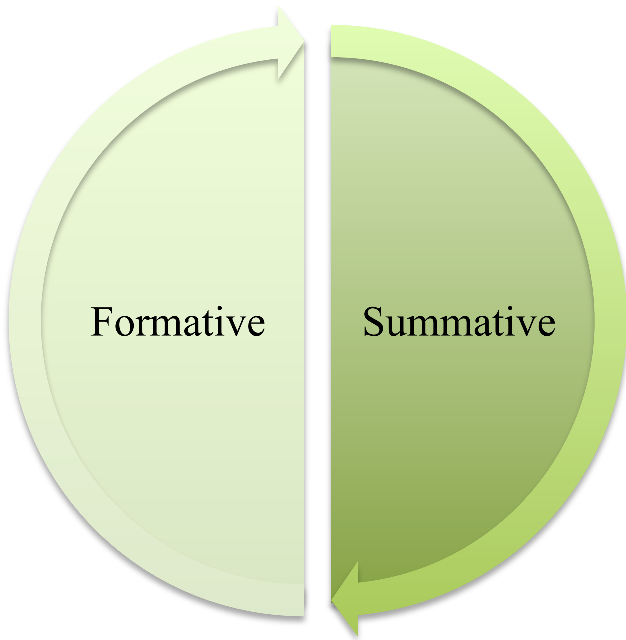
5. Why can't I access the Learning Village tutorials? What are they?

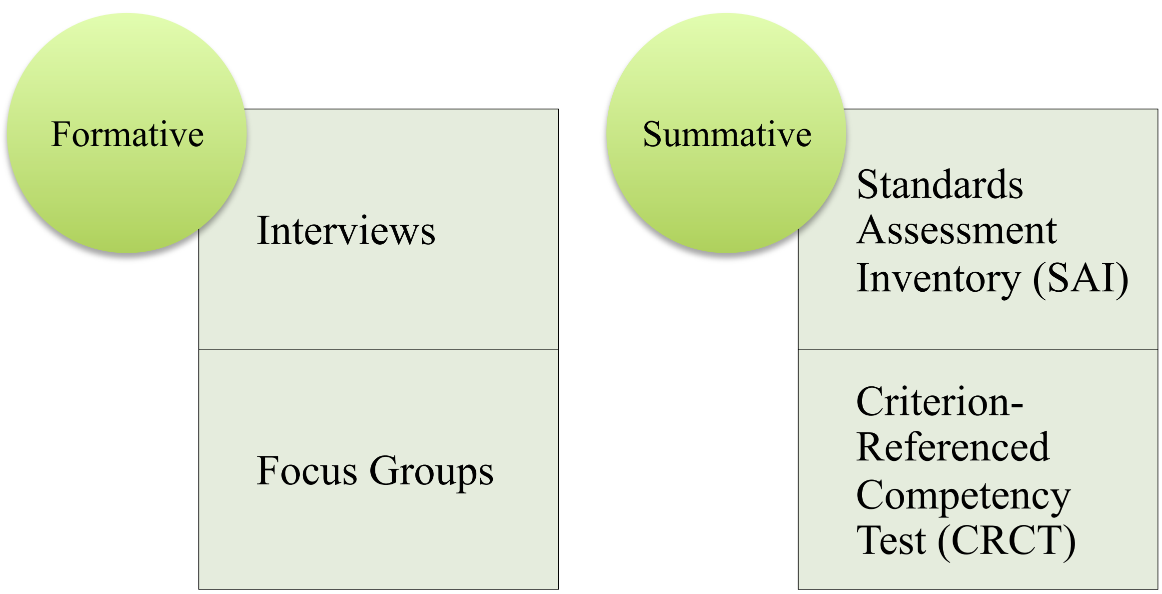
The Learning Village tutorials are not available to the general public. They are located on the Georgia Department of Education's website, www.georgiastandards.org, but they are password-protected. Any teacher or administrator in Georgia can apply for a password in order to access these tutorials. Dr. Scoggins has personally completed every one of them and believes they are excellent resources. The tutorials present both conceptual and traditional approaches in an interactive format, and they are correlated with the state standards.

6. How do the activity sheets fit in with the different modules, and who is supposed to complete them?

Each of the content modules includes activity sheets with the standards for the specific domain, such as number sense. The activity sheets include chapter and volume numbers (at the top) that correspond with a book used in the MPDP, *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005). There are blank spaces labeled “Activity Description” and “pg. #” for LC members to complete. The activity sheets address many of the elements of CLOVERS: collaboration (if done with a partner or group), literature and research, vertical alignment (when activities are shared during sessions), and relevance. These assignments provide opportunities for teachers to acquire new teaching strategies, which they requested. Also, they can use the activity sheets to help them plan future lessons. Directions within the list of tasks is linked to the activity sheets with an asterisk*.

Program Evaluation Plan





Interview & Focus Group Questions

(These can be modified depending on the needs of the LC)

- What is the most meaningful part of the MPDP?
- What is the least meaningful part of the MPDP?
- What changes would you like to make regarding format, pacing, or content of the MPDP?
- How could we improve the LC sessions?

Standards Assessment Inventory (SAI)

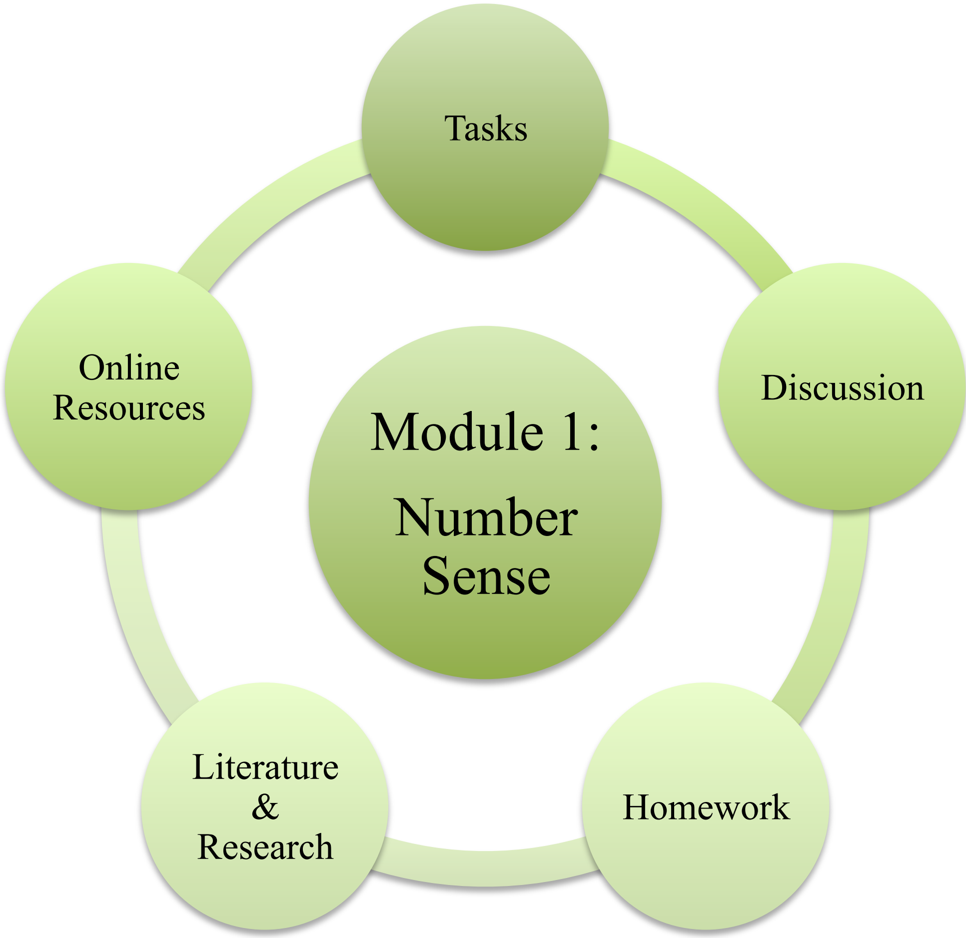
http://www.nsdc.org/standards/sai.cfm

To be completed by MPDP participants

Criterion-Referenced Competency Test (CRCT)

http://www.doe.k12.ga.us/ci_testing.aspx?PageReq=CI_TESTING_CRCT

To be completed by students



Module 1: Number Sense is made up of tasks, discussions, homework assignments, literature, research, and online resources. In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. In this module, ten learning community sessions have been planned in a structured sequence. In other modules, activities are listed but program participants should determine the process for accomplishing them. This module could serve as a guide for planning other modules, or teachers could generate their own ideas for how to continue the program.

Content: Number Sense
Learning Community Session 1

1.) Task: Work as a team to put all Numbers & Operations standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

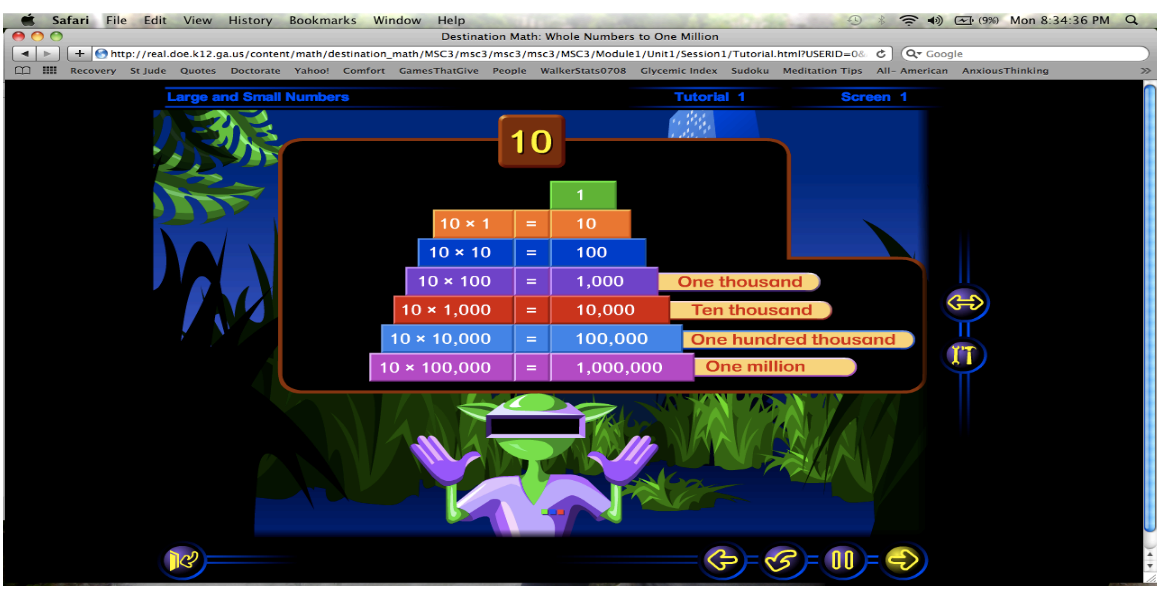
2.) Discussion:

-How do number sense standards in Grades 1 and 2 relate to number sense standards in Grades 3, 4, and 5?

-What are the gaps within the curriculum that could inhibit the flow of number sense from Grade 1 to Grade 5?

-How can we address those gaps?

3.) Task: Complete Learning Village Destination Math Tutorial: Course III Numbers and Number Sense: Whole Numbers to One Million @ http://real.doe.k12.ga.us/content /math /destination_math/MSC3/msc3/msc3 /msc3/Menu.html (PASSWORD PROTECTED)



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4.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding number sense?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

Homework:

5.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Two - Developing Early Number Concepts and Number Sense (Van de Walle & Lovin, 2005).

6.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Two - Number and Operation Sense (Van de Walle & Lovin, 2005).

7.) Prepare an activity from these chapters to present at next session.

8.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

Content: Number Sense
Learning Community Session 2

1.) Homework Discussion:

-What parts of the *Teaching Student-Centered Mathematics* chapters did you find most interesting / surprising?

-How can you apply the concepts in Chapter 2 to your classroom?

-What insights did you gain from exploring the Literature & Research?

2.) Task: Demonstrate one instructional activity (prepared as homework) that fosters number sense.

3.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

4.) Use *Teaching Student-Centered Mathematics* Chapter 2 (Van de Walle & Lovin, 2005) to find and correlate number sense activities with the standards at your grade level. (Complete Number Sense Activities sheets attached*).

Homework:

5.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Five – Base-Ten Concepts and Place Value (Van de Walle & Lovin, 2005).

6.) Observe a teacher facilitating a Number Sense lesson. Meet with the teacher afterward to provide feedback. Discuss how the number sense concept(s) you observe relate to number sense development in other grade levels.

7.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

***First Grade Number Sense Activities**
Volume 1 Chapter 2 – Developing Early Number Concepts and Number Sense
Volume 1 Chapter 5 – Base-Ten Concepts and Place Value
Unit 2 – Understanding Operations, Unit 5 – Place Value & Money

Standard	Activity Description	Pg. #
M1N1. Students will estimate, model, compare, order, and represent whole numbers up to 100. a. Represent numbers up to 100 using a variety of models, diagrams, and number sentences. Represent numbers larger than 10 in terms of tens and ones using manipulatives and pictures. b. Correctly count and represent the number of objects in a set using numerals. c. Compare small sets using the terms greater than, less than, and equal to. d. Understand the magnitude and order of numbers up to 100 by making ordered sequences and representing them on a number line. e. Exchange equivalent quantities of coins by making fair trades involving combinations of pennies, nickels, dimes, and quarters up to one dollar, and count out a combination needed to purchase items up to one dollar.		

f. Identify bills ($1, $5, $10, $20) by name and value and exchange equivalent quantities by making fair trades involving combinations of bills and count out a combination of bills needed to purchase items that total up to twenty dollars.		
M1N2. Students will understand place value notation for the numbers 1 to 99. (Discussions may allude to 3-digit numbers to assist in understanding place value.)		
a. Determine to which ten a given number is closest using tools such as a sequential number line or chart. b. Represent collections of less than 30 objects with 2-digit numbers and understand the meaning of place value. c. Decompose numbers from 10 to 99 as the appropriate number of ones.		

Second Grade Number Sense Activities
Volume 1 Chapter 2 – Developing Early Number Concepts and Number Sense
Volume 1 Chapter 5 – Base-Ten Concepts and Place Value
Unit 2 – Place Value, Money, and Estimation

Standard	Activity Description	Pg. #
M2N1. Students will use multiple representations of numbers to connect symbols to quantities. a. Represent numbers using a variety of models, diagrams, and number sentences (e.g. 4703 represented as 4,000 + 700 + 3, and units, 47 hundreds + 3, or 4,500 + 203). b. Understand the relative magnitudes of numbers using 10 as a unit, 100 as a unit, or 1000 as a unit. Represent 2-digit numbers with drawings of tens and ones and 3-digit numbers with drawings of hundreds, tens, and ones. c. Use money as a medium of exchange. Make change and use decimal notation and the dollar and cent symbols to represent the collection of coins and currency.		

Third Grade Number Sense Activities
Volume 1 Chapter 2 – Developing Early Number Concepts and Number Sense
Volume 1 Chapter 5 – Base-Ten Concepts and Place Value
Volume 2 Chapter 2 – Number and Operation Sense
Units 1-2 (Embedded) Whole Numbers

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="3">M3N1. Students will further develop their understanding of whole numbers and decimals and ways of representing them.

a. Identify place values from tenths through ten thousands.

b. Understand the relative sizes of digits in place value notation (10 times, 100 times, 1/10 of a single digit whole number) and ways to represent them including word name, standard form, and expanded form.</td><td></td><td></td></tr>
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Fourth Grade Number Sense Activities
Volume 2 Chapter 2 – Number and Operation Sense
Unit 1 – Whole Numbers, Place Value, and Rounding

Standard	Activity Description	Pg. #
M4N1. Students will further develop their understanding of how whole numbers are represented in the base-ten numeration system. a. Identify place value names and places from hundredths through one million.		
b. Equate a number's word name, its standard form, and its expanded form.		
M4N2. Students will understand and apply the concept of rounding numbers. a. Round numbers to the nearest ten, hundred, or thousand.		
b. Describe situations in which rounding numbers would be appropriate and determine whether to round to the nearest ten, hundred, or thousand.		

Fifth Grade Number Sense Activities
Volume 2 Chapter 2 – Number and Operation Sense
Units 2-3 (Embedded) Fractional & Decimal Understanding

Standard	Activity Description	Pg. #
M5N1. Students will further develop their understanding of whole numbers. a. Classify the set of counting numbers into subsets with distinguishing characteristics (odd/even, prime/composite).		
b. Find multiples and factors.		
c. Analyze and use divisibility rules. **M5N2. Students will further develop their understanding of decimals as part of the base-ten number system.** a. Understand place value. b. Analyze the effect on the product when a number is multiplied by 10, 100, 1000, 0.1, and 0.01. c. Compare decimals and justify the comparison.		

Content: Number Sense
Learning Community Session 3

1.) Reading Homework Discussion:

-What parts of the *Teaching Student-Centered Mathematics* chapter did you find most interesting / surprising?

-How can you apply the concepts in Chapter 5 to your classroom?

-What insights did you gain by exploring Literature & Research?

2.) Observation Homework Discussion: Members share perspectives of their observation experiences. Was it beneficial? If not, how can we make observation experiences more beneficial in the future?

-Describe the actual work that students engaged in while you were observing.

-Describe the teacher's role in the lesson you observed.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

-What additional teaching strategies could be used to enhance a similar lesson?

3.) Task: Complete Learning Village Destination Math Tutorial: Course II Number Sense: Numbers to 9,999. Place Value: Thousands, Hundreds, Tens, and Ones @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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4.) Discussion:

-What concepts within this tutorial prepare students to engage in higher-level thinking processes?

-How can we apply what we've learned into our daily instruction?

5.) Explore the Mathematics Navigator *Beginning Place Value* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

Homework:

6.) Use *Teaching Student-Centered Mathematics* Chapter 5 (Van de Walle & Lovin, 2005) to find and correlate number sense and place value activities with the standards at your grade level. (Add to Number Sense Activities sheets*).

7.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Nine – Early Fraction Concepts (Van de Walle & Lovin, 2005).

8.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Five – Developing Fraction Concepts (Van de Walle & Lovin, 2005).

9.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

Content: Number Sense
Learning Community Session 4

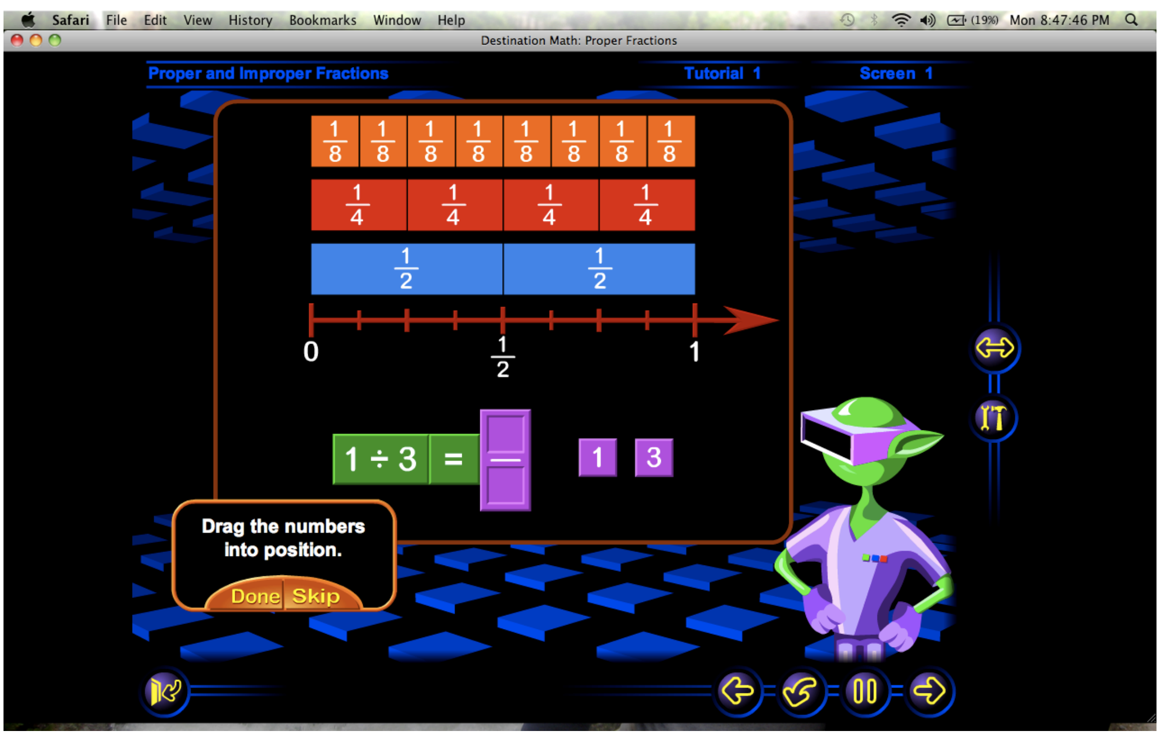
1.) Homework Discussion:

-What parts of the *Teaching Student-Centered Mathematics* chapters did you find most interesting / surprising?

-How can you apply the concepts about Fractions to your classroom?

-What insights did you gain by exploring Literature & Research?

2.) Task: Complete Learning Village Destination Math Tutorial: Course III Fractions: Proper Fractions @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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3.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding fractions?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

4.) Use *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) chapters to find and correlate Fraction activities with the standards at your grade level. (Complete Fractions Activities sheets attached*).

Homework:

5.) Observe a teacher facilitating a Fractions lesson. Meet with the teacher afterward to provide feedback. Discuss how the concept(s) you observe relate to fraction development in other grade levels.

6.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

***First Grade Fractions Activities**
Volume 1 Chapter 9 – Early Fraction Concepts
Unit 3 – Shapes and Fractions

Standard	Activity Description	Pg. #
M1N4. Students will count collections of up to 100 objects by dividing them into equal parts and represent the results using words, pictures, or diagrams.		
a. Use informal strategies to share objects equally between two to five people.		
b. Build number patterns, including concepts of even and odd, using various concrete representations. (Examples of concrete representations include a hundreds chart, ten grid frame, place value chart, number line, counters, or other objects.) c. Identify, label, and relate fractions (halves, fourths) as equal parts of a whole using pictures and models. d. Understand halves and fourths as representations of equal parts of a whole.		

Second Grade Fractions Activities
Volume 1 Chapter 9 – Early Fraction Concepts
Unit 5 – Parts of a Whole

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="3">M2N4. Students will understand and compare fractions.

a. Model, label, identify, and compare fractions (thirds, sixths, eighths, tenths) as a representation of equal parts of a whole or of a set.

b. Know that when all fractional parts are included, such as three thirds, the result is equal to the whole.</td><td></td><td></td></tr>
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Third Grade Fractions Activities
Volume 1 Chapter 9 – Early Fraction Concepts
Volume 2 Chapter 5 – Developing Fraction Concepts
Unit 4 - Fractions and Decimals

Standard	Activity Description	Pg. #
M3N5.Students will understand the meaning of decimal fractions and common fractions in simple cases and apply them in problem-solving situations.		
a. Identify fractions that are decimal fractions and/or common fractions. b. Understand a decimal fraction (i.e., 3/10) can be written as a decimal (i.e. 0.3).		
c. Understand the fraction *a/b* represents *a* equal sized parts of a whole that is divided into *b* equal sized parts. d. Know and use decimal		

fractions and common fractions to represent the size of parts created by equal divisions of a whole. e. Understand the concept of addition and subtraction of decimal fractions and common fractions with like denominators.		
f. Model addition and subtraction of decimal fractions and common fractions with like denominators. g. Use mental math and estimation strategies to add and subtract decimal fractions and common fractions with like denominators.		
h. Solve problems involving decimal fractions and common fractions with like denominators.		

Fourth Grade Fractions Activities
Volume 2 Chapter 5 – Developing Fraction Concepts
Volume 2 Chapter 6 – Fraction Computation
Unit 5 – Fractions and Decimals

Standard	Activity Description	Pg. #
M4N6. Students will further develop their understanding of the meaning of decimal fractions and common fractions and use them in computations. a. Understand representations of equivalent common fractions and/or decimal fractions.		
b. Add and subtract fractions and mixed numbers with common denominators. (Denominators should not exceed twelve.)		
c. Use mixed numbers and improper fractions interchangeably.		

Fifth Grade Fractions Activities
Volume 2 Chapter 5 – Developing Fraction Concepts
Volume 2 Chapter 6 – Fraction Computation
Unit 3 – Fractional Understanding and Operations

Standard	Activity Description	Pg. #
M5N4. Students will continue to develop their understanding of the meaning of common fractions and will compute with them.		
a. Understand division of whole numbers can be represented as a fraction ($a/b = a \div b$).		
b. Understand the value of a fraction is not changed when both its numerator and denominator are multiplied or divided by the same number because it is the same as multiplying or dividing by one.		
c. Find equivalent fractions and simplify fractions.		
d. Model the multiplication and division of common fractions.		
e. Explore finding common denominators using concrete, pictorial, and computational models.		

<table>
<tr><td rowspan="3">f. Use <, >, or = to compare fractions and justify the comparison.

g. Add and subtract common fractions and mixed numbers with unlike denominators.

h. Use fractions (proper and improper) and decimals interchangeably.

i. Estimate products and quotients.</td><td></td><td rowspan="3"></td></tr>
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Content: Number Sense
Learning Community Session 5

1.) Homework Discussion: Members share perspectives of their observation experiences.

-Describe the actual work that students engaged in while you were observing.

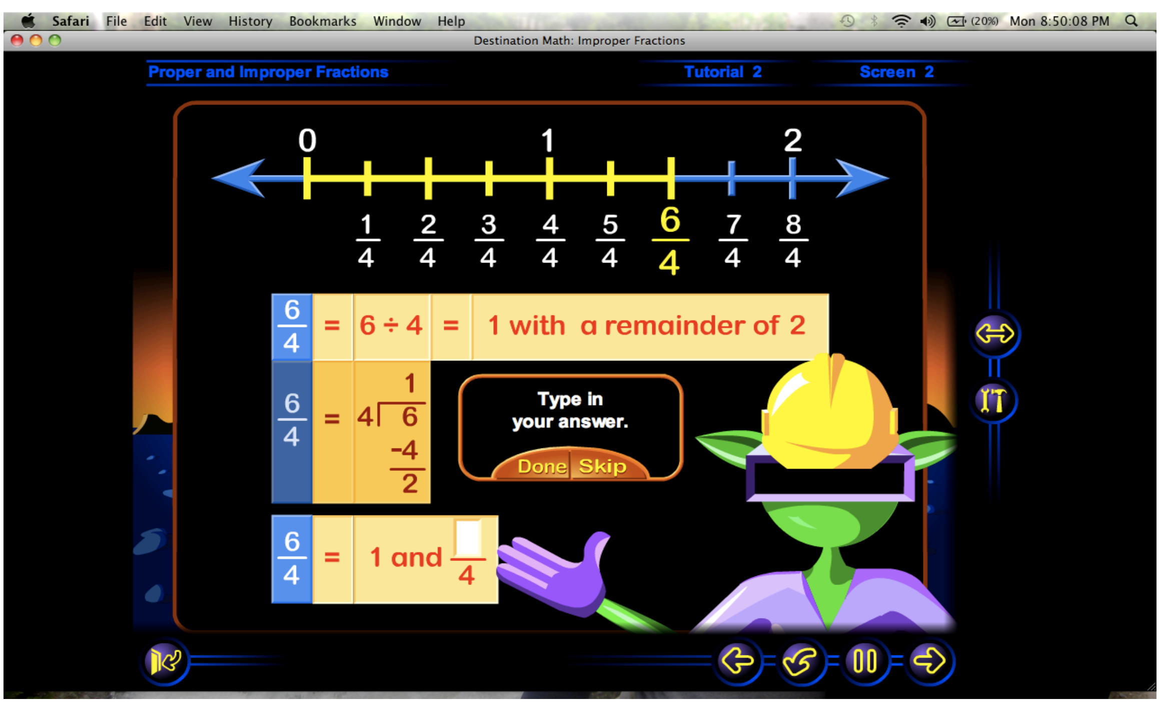
-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

2.) Complete Learning Village Destination Math Tutorial: Course III Fractions: Improper Fractions @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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3.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

4.) Explore the Mathematics Navigator *Knowing Fractions* and *Understanding Fractions* Teacher's Editions and Student Workbooks (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

Homework:

5.) Explore the National Library of Virtual Manipulatives (NLVM) http://nlvm.usu.edu/

6.) Write down several ideas for how you could utilize this website as part of your mathematics instruction. Focus on Fractions.

7.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Six – Fraction Computation (Van de Walle & Lovin, 2005).

Content: Number Sense
Learning Community Session 6

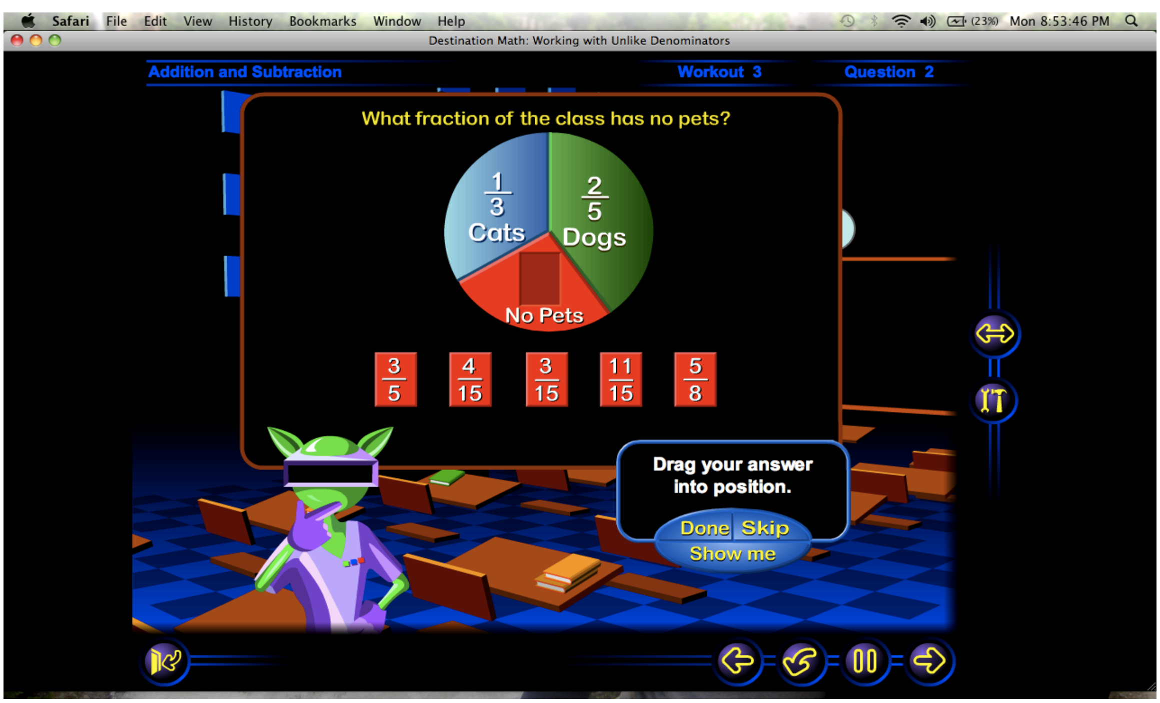
1.) Homework Discussion:

-What did you find on the NLVM website?

-How could you use this website to teach fractions?

-Share something you learned from *Teaching Student-Centered Mathematics* Volume 2: Chapter Six - Fraction Computation. Give examples of how you might apply concepts in your classroom.

2.) Task: Complete Learning Village Destination Math Tutorial: Course III Fractions: Working with Unlike Denominators @ [http://real.doe.k12.ga.us/content/math/destination_ math/](http://real.doe.k12.ga.us/content/math/destination_math/)MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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3.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What common errors or misconceptions do you see when students add or subtract fractions?

-How can we address those misconceptions?

4.) Use *Teaching Student-Centered Mathematics* Volume 2: Chapter Six – Fraction Computation to find and correlate Fraction activities with the standards at your grade level. (Add to Fractions Activities sheets*).

Homework:

5.) Complete Learning Village Destination Math Tutorial: Course III Fractions: Multiplication and Division @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)

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6.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

Content: Number Sense
Learning Community Session 7

1.) Homework Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What common errors or misconceptions do you see when students multiply or divide fractions?

-How can we address those misconceptions?

-What insights did you gain by exploring Literature & Research?

2.) Task: Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

3.) Discussion:

-Share ideas about how you can improve your instruction regarding development of number sense, specifically with fractions.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about fractions when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of fraction concepts and computation.

Homework:

5.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Seven – Decimal and Percent Concepts and Decimal Computation (Van de Walle & Lovin, 2005).

6.) Prepare an activity from this chapter to present at next session.

7.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

Content: Number Sense
Learning Community Session 8

1.) Homework Discussion:

-What parts of the *Teaching Student-Centered Mathematics* chapter did you find most interesting / surprising?

-How can you apply the concepts about Decimals to your classroom?

-What insights did you gain by exploring Literature & Research?

2.) Task: Demonstrate one instructional activity that fosters developing number sense of decimals.

3.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

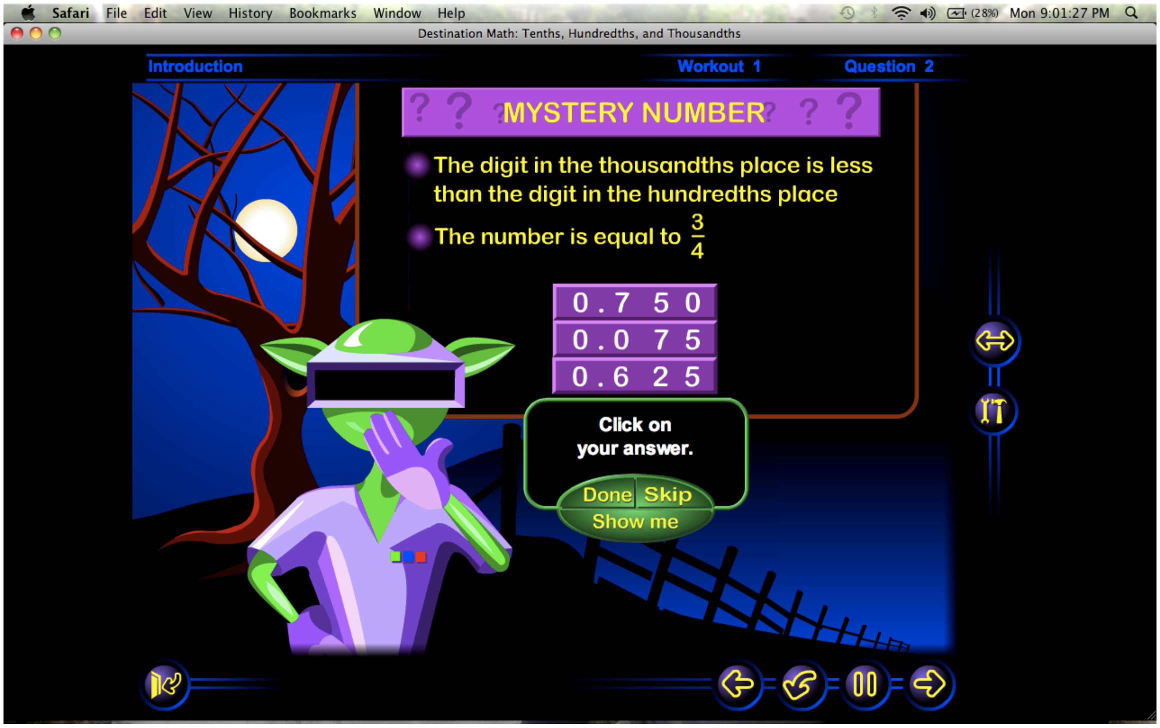
-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

4.) Explore the Mathematics Navigator *Place Value: From Decimals to Billions* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

5.) Complete Learning Village Destination Math Tutorial: Course III Decimals: Introduction @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/ msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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6.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

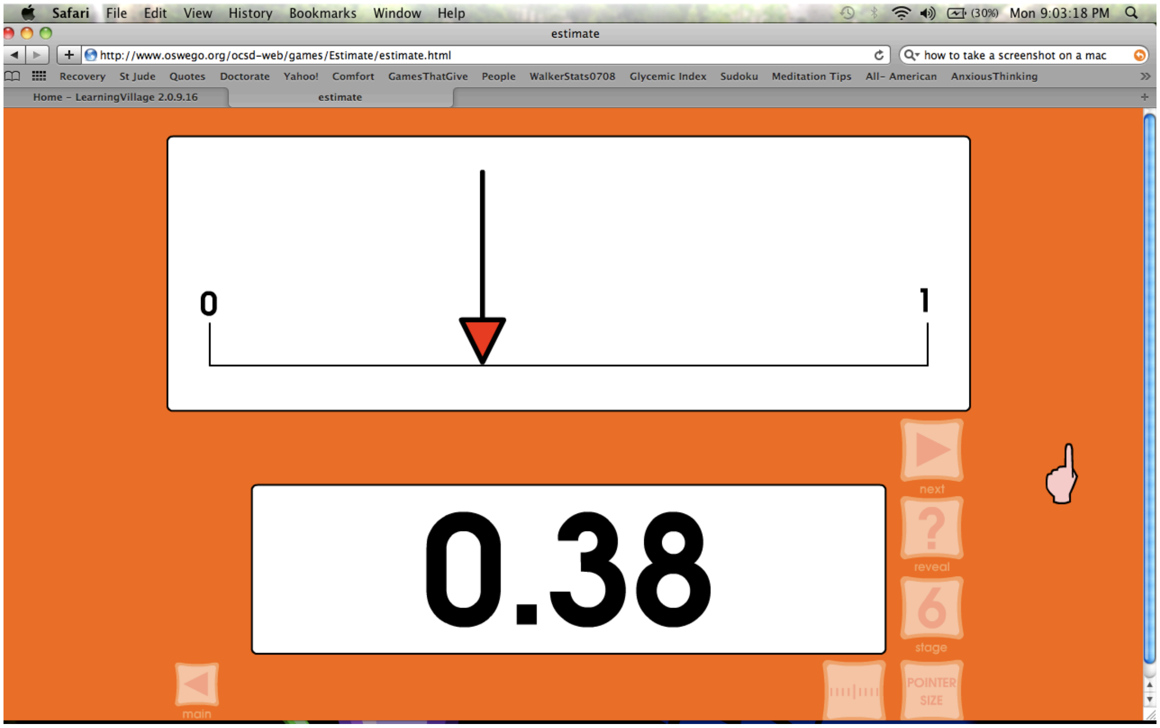
-What are the most common errors or misconceptions you see regarding decimals?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

Homework:

7.) Teachers of Grades 1 and 2 – Visit http://www.oswego.org/ocsd-web/games/Estimate/estimate.html and write down several ideas about how you could use this tool in your classroom.



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8.) Teachers of Grades 3, 4, and 5 – Use *Teaching Student-Centered Mathematics* Volume 2 Chapter Seven (Van de Walle & Lovin, 2005) to find and correlate Decimals activities with the standards at your grade level. (Complete Decimals Activities sheets attached*).

***Third Grade Decimals Activities**

Volume 2 Chapter 7 – Decimal and Percent Concepts and Decimal Computation

Unit 4 – Fractions and Decimals

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="3">M3N5.Students will understand the meaning of decimal fractions and common fractions in simple cases and apply them in problem-solving situations.

a. Identify fractions that are decimal fractions and/or common fractions.

b. Understand a decimal fraction (i.e., 3/10) can be written as a decimal (i.e. 0.3).

c. Understand the fraction a/b represents a equal sized parts of a whole that is divided into b equal sized parts.

d. Know and use decimal fractions and common fractions</td><td></td><td></td></tr>
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to represent the size of parts created by equal divisions of a whole. e. Understand the concept of addition and subtraction of decimal fractions and common fractions with like denominators. f. Model addition and subtraction of decimal fractions and common fractions with like denominators. g. Use mental math and estimation strategies to add and subtract decimal fractions and common fractions with like denominators. h. Solve problems involving decimal fractions and common fractions with like denominators.		

Fourth Grade Decimals Activities
Volume 2 Chapter 7 – Decimal and Percent Concepts and Decimal Computation
Unit 5 – Fractions and Decimals

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="3">M4N2. Students will understand and apply the concept of rounding numbers.

c. Determine to which whole number or tenth a given decimal is closest using tools such as a number line, and/or charts.

d. Round a decimal to the nearest whole number or tenth.

M4N5. Students will further develop their understanding of the meaning of decimal fractions and use them in computations.

a. Understand decimal fractions are a part of the base-ten system.

b. Understand the relative size of numbers and order two digit decimal fractions.</td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

c. Add and subtract both one and two digit decimal fractions. d. Model multiplication and division of decimals by whole numbers.		
e. Multiply and divide both one and two digit decimal fractions by whole numbers **M4N6. Students will further develop their understanding of the meaning of decimal fractions and common fractions and use them in computations.** a. Understand representations of equivalent common fractions and/or decimal fractions.		

Fifth Grade Decimals Activities
Volume 2 Chapter 7 – Decimal and Percent Concepts and Decimal Computation
Unit 2 – Decimal Understanding and Operations

Standard	Activity Description	Pg. #
M5N3. Students will further develop their understanding of the meaning of multiplication and division with decimal fractions and use them. a. Model multiplication and division of decimals.		
b. Explain the process of multiplication and division, including situations in which the multiplier and divisor are both whole numbers and decimals.		
c. Multiply and divide with decimals including decimals less than one and greater than one. d. Understand that the relationships and rules for multiplication and division of whole numbers also apply to decimals.		

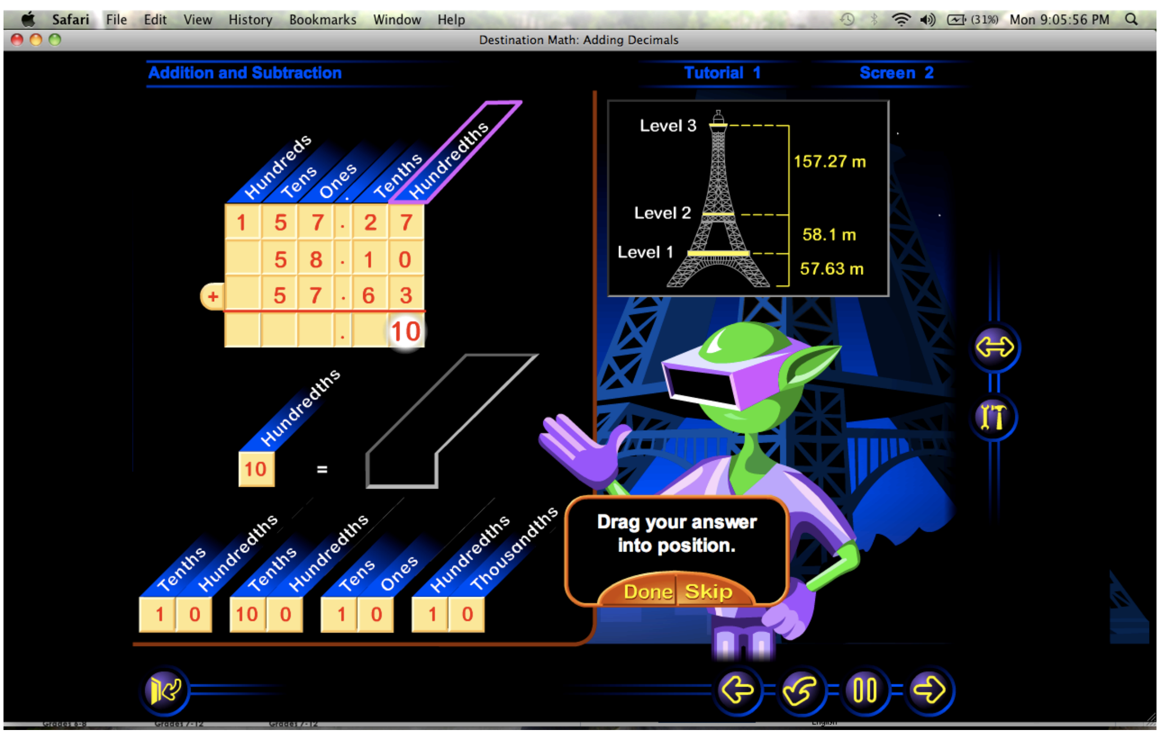
Content: Number Sense
Learning Community Session 9

1.) Homework Discussion:

-Discuss website and ideas for using it for instruction. Explore website on interactive whiteboard.

-Discuss the role of estimation in working with decimals.

2.) Task: Complete Learning Village Destination Math Tutorial: Course III Decimals: Addition and Subtraction @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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3.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What common errors or misconceptions do you see when students add or subtract decimals?

-How can we address those misconceptions?

Homework:

4.) Complete Learning Village Destination Math Tutorial: Course III Decimals: Multiplication and Division @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)

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5.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain.

Content: Number Sense
Learning Community Session 9

1.) Homework Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What common errors or misconceptions do you see when students multiply or divide decimals?

-How can we address those misconceptions?

-What insights did you gain by exploring Literature & Research?

2.) Task: Visit http://my.hrw.com/math06_07/nsmedia/tools/Decimal_Fractions/Decimal_Fractions.html and explore ways of modeling decimal computation.

3.) Discussion:

-How can we apply our knowledge of decimal concepts in our classrooms?

4.) Task: Field Trip! Go to the Computer Lab and explore online resources (attached) for decimals. Write down ideas for applying what you find in your classroom.

5.) Discussion:

-Share ideas about how you can improve your instruction regarding development of number sense, specifically with decimals.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about decimals when they come to you.

Above: Ask what you could do to better prepare students to meet expectations in the area of decimal concepts and computation.

Homework:

6.) Review Resources:

-*Teaching Student-Centered Mathematics* Volume 1: Chapters 2, 5, and 9 (Van de Walle & Lovin, 2005)

-*Teaching Student-Centered Mathematics* Volume 2: Chapters 2, 5, 6, and 7 (Van de Walle & Lovin, 2005)

7.) Explore Literature & Research (attached) and continue to apply knowledge and concepts in your daily mathematics instruction.

Evaluation & Future Planning
Learning Community Session 10

1.) Task: Evaluate the professional development program in order to guide the direction of the future modules. Items to consider:

-Is the learning community model working for us or do we want to modify it?

-Are the tasks that we complete beneficial to us as teachers? Do we want to change the types or number of tasks we complete during learning community sessions?

-How meaningful are homework assignments? Do we want more homework? Less?

-Have the lesson observations been productive? What changes could we make to boost the usefulness of observations?

-Is the review of literature and research a practice we want to continue? How can we make it more practical and relevant?

2.) Task: Work together to plan future modules. Use suggested tasks, discussion questions, and homework assignments. Supplement or modify as needed. Items to consider:

-Do we want to complete modules as organized (by topic) or do we want to blend content with pedagogy?

-At what pace do we want to proceed?

-Are there areas we want to explore that are not included within the program?

-Do we want to expand our learning community outreach to include teachers from within the district?

-How can we involve parents in our learning process?

-Do we want to outline several sessions in advance or plan each session as we go?

-What support do we need in order to continue the program? How can we gain that support?

Literature & Research: Number Sense

Books and Articles

Bobis, J. (1991). The effect of instruction on the development of computation estimation strategies. *Mathematics Education Research Journal*, 3, 7-29.

Bobis, J. (1996). *Visualisation and the development of number sense with kindergarten children*. In Mulligan, J. & Mitchelmore, M. (Eds.) Children's Number Learning: A Research Monograph of the Mathematics Education Group of Australasia and the Australian Association of Mathematics Teachers. Adelaide: AAMT

Case, R. & Sowder, J. (1990). The development of computational estimation: A neo-Piagetian analysis. *Cognition and Instruction, 7*, 79-104.

Fischer, F. (1990). A part-part-whole curriculum for teaching number to kindergarten. *Journal for Research in Mathematics Education , 21*, 207-215.

Gelman, R. & Gallistel, C. (1978). *The child's understanding of number.* Cambridge, MA: Harvard University Press.

Hope, J. & Sherril, J. (1987). Characteristics of unskilled and skilled mental calculators. *Journal for Research in Mathematics Education*, *18*, 98-111.

Mokashi, N. (2009). Math Fair: Focus on Fractions. *Teaching Children Mathematics, 15*(9), 542-551.

Mortiboys, A. (1984). *Numeracy: Linking skills to application*. London: Adult Literacy and Basic Skills Unit.

Mtetwa, D., & Garofalo, J. (1989). Beliefs about mathematics: An overlooked aspect of student difficulties. *Academic Therapy, 24*, 611.

Panaoura, A., Gagatsis, A., Deliyianni, E., & Elia, I. (2009). The structure of students' beliefs about the use of representations and their performance on the learning of fractions. *Educational Psychology, 29*(6), 713-728.

Ross, S. (1989). Parts, wholes, and place value: A developmental view. *Arithmetic Teacher*, *36*, 47-51.

Sarama, J., & Clements, D. H. (2006). Teaching mathematics: A place to start. *EarlyChildhood Today, 20*(4), 15.

Sowder, J. (1988). Mental computation and number comparison: Their roles in the development of number sense and computational estimation. In Heibert & Behr (Eds.). *Research Agenda for Mathematics Education: Number Concepts and Operations in the Middle Grades* (pp. 192-197). Hillsdale, NJ: Lawrence, Erlbaum & Reston.

Trafton, P. (1992). Using number sense to develop mental computation and computational estimation. In C. Irons (Ed.) *Challenging children to think when they compute*. (pp. 78-92). Brisbane: Centre for Mathematics and Science Education, Queensland University of Technology.

Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*. New York, NY: Allyn & Bacon.

Van Kraayenoord, C. E., & Elkins, J. (2004). Learning difficulties in numeracy in Australia. *Journal of Learning Disabilities, 37*(1), 32-41.

Online References

http://nrich.maths.org/public/viewer.php?obj_id=2479&part=

http://www.ldonline.org/article/Developing_Early_Number_Sense_for_Students_with_Disabilities

http://www.highbeam.com/doc/1G1-141167413.html

http://www.psy.jhu.edu/~labforchilddevelopment/pdf_files/US%20IN%20THE%20NEWS%20PDF'S/Headlines@Hopkins_%20Johns%20Hopkins%20University%20News%20Releases.pdf

http://www.psy.jhu.edu/~labforchilddevelopment/pdf_files/US%20IN%20THE%20NEWS%20PDF'S/Take%20a%20stab_%20Estimating%20math%20skills%20by%20observing%20estimation%20-%20Ars%20Technica.pdf

http://www.iso.gmu.edu/~mmankus/PBlocks/pbact/other.htm

Online Instructional Resources

Number Sense Development (Grades K-2)

http://www.ictgames.com/football2.html

http://www.ictgames.com/octopus.html

http://www.oswego.org/ocsd-web/games/DogBone/gamebone.html

http://www.ictgames.com/sharknumbers.html

http://illuminations.nctm.org/ActivityDetail.aspx?ID=74

http://illuminations.nctm.org/ActivityDetail.aspx?ID=75

http://www.abcya.com/connect_the_dots_butterfly.htm

http://www.abcya.com/connect_the_dots_bear.htm

http://www.abcya.com/connect_the_dots_donkey.htm

http://www.ictgames.com/fishy2s.html

http://www.ictgames.com/fairyfog10s_v2.html

http://www.curriculumbits.com/prodimages/details/maths/dicemenu.swf

http://www.ictgames.com/dinoplacevalue.html

http://www.oswego.org/ocsd-web/games/Estimate/estimate.html

http://www.oswego.org/ocsd-web/games/Ghostblasterseven/ghosteven.html

http://funschool.kaboose.com/preschool/games/game_monster_numbers.html

http://www.akgupta.com/Java/alphabet.htm

http://www.toonuniversity.com/flash.asp?err=496&engine=5

http://www.bbc.co.uk/wales/snapdragon/yesflash/how-many-1.htm

http://www.primaryresources.co.uk/online/numbersquare.swf

http://www.crickweb.co.uk/assets/resources/flash.php?&file=Toolkit index2a

http://www.crickweb.co.uk/assets/resources/flash.php?&file=count-with-lecky7b

http://www.ictgames.com/newduckshoot.html

http://www.ictgames.com/newduckshoot10s.html

http://www.aaamath.com/cmpk1a-morefewer.html - section3

http://www.ictgames.com/mucky.html

http://www.haelmedia.com/html/og_m1_001.html

http://www.ictgames.com/beaver.html

http://www.primaryresources.co.uk/online/numberboard.swf

http://www.bbc.co.uk/schools/ks1bitesize/numeracy/units/index.shtml

http://www.apples4theteacher.com/math/games/100-number-chart-one.html

http://www.mathsonline.co.uk/freesite_tour/resource/whiteboard/decimals/dec_notes.htm
l

http://www.ictgames.com/fairyfog.html

http://pbskids.org/cyberchase/games/algebra/

http://www.oswego.org/ocsd-web/games/GhostblastersOdd/ghostodd.html

http://www.bbc.co.uk/schools/ks1bitesize/numeracy/ordering/index.shtml

http://www.ictgames.com/caterpillar_slider.html

http://www.ictgames.com/sharkNumbers_v2.html

http://www.funbrain.com/cgi-bin/tens.cgi?A1=s&A2=6

http://www.bbc.co.uk/education/mathsfile/shockwave/games/roundoff.html http://www.aplusmath.com/Flashcards/rounding.html

http://www.aaamath.com/est32-round100.html#section2

http://www.dositey.com/addsub/Mystery10.htm - s

http://www.crickweb.co.uk/assets/resources/flash.php?&file=Toolkit%20index2a

Number Sense Development (Grades 3-5)

http://www.bbc.co.uk/schools/ks1bitesize/numeracy/units/index.shtml

http://illuminations.nctm.org/ActivityDetail.aspx?ID=3

http://www.apples4theteacher.com/math/games/100-number-chart-one.html

http://www.mathsonline.co.uk/freesite_tour/resource/whiteboard/decimals/dec_notes.htm
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http://www.aplusmath.com/Flashcards/rounding.html

http://www.quia.com/rr/32598.html?AP_rand=659227961&playHTML=1

http://www.bbc.co.uk/education/mathsfile/shockwave/games/roundoff.html

http://www.ictgames.com/caterpillar_slider.html

http://www.primaryresources.co.uk/online/numberboard.swf

http://www.mathplayground.com/mathgames/MathMillionaire_new.swf

http://www.crickweb.co.uk/assets/resources/flash.php?&file=Toolkit index2a

http://www.toonuniversity.com/flash.asp?err=496&engine=5

http://www.oswego.org/ocsd-web/games/Estimate/estimate.html

http://www.freemathtest.com/Elementary_Math/Comparisons/Test.aspx?min=100&max=
999&qty=

http://www.crickweb.co.uk/assets/resources/flash.php?&file=Toolkit%20index2a

Fractions

http://www.bbc.co.uk/skillswise/numbers/fractiondecimalpercentage/fractions/comparingfractions/quiz.shtml

http://www.dositey.com/2008/math/mistery2.html

http://www.beaconlearningcenter.com/WebLessons/FloweringFractions/default.htm

http://www.sheppardsoftware.com/mathgames/fractions/memory_equivalent1.htm

http://www.arcytech.org/java/fractions/fractions.html

http://illuminations.nctm.org/ActivityDetail.aspx?ID=11

http://www.harcourtschool.com/activity/con_math/g03c21.html

http://www.sums.co.uk/playground/n6a/playground.htm

http://visualfractions.com/EnterCircle.html

http://www.beaconlearningcenter.com/WebLessons/IWantMyHalf/default.htm

http://www.sheppardsoftware.com/mathgames/fractions/memory_fractions4.htm

http://www.thatquiz.org/tq/practice.html?idfraction

http://www.sheppardsoftware.com/mathgames/fractions/Balloons_fractions3.htm

http://www.oswego.org/ocsd-web/games/PercentPaint/ppaint.html

http://www.rickyspears.com/rulergame/

http://www.sheppardsoftware.com/mathgames/fractions/memory_fractions1.htm

Decimals

http://www.bbc.co.uk/education/mathsfile/shockwave/games/roundoff.html

http://www.mrnussbaum.com/placevaluepirates1.htm

http://www.mathslice.com/placevalue.php

http://www.oswego.org/ocsd-web/games/PercentPaint/ppaint.html

http://www.mathsonline.co.uk/freesite_tour/resource/whiteboard/decimals/dec_notes.htm
l

http://www.sheppardsoftware.com/mathgames/placevalue/value.htm

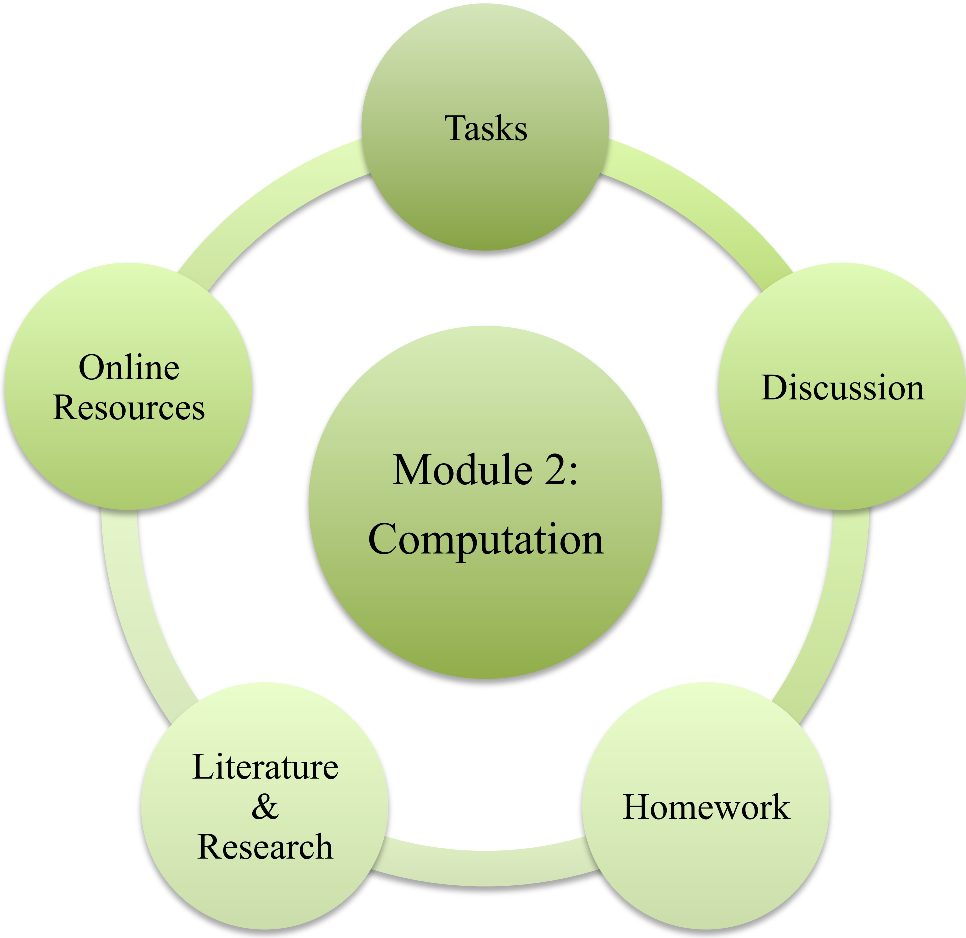
http://www.sheppardsoftware.com/mathgames/placevalue/scooterQuest.htm

http://my.hrw.com/math06_07/nsmedia/tools/Decimal_Fractions/Decimal_Fractions.html

http://www.freemathtest.com/Elementary_Math/Comparisons/Test.aspx?min=100&max=
999&qty=

http://mrsbogucki.com/cgi-bin/quiz.pl

http://pbskids.org/cyberchase/games/decimals/index.html



Module 2: Computation is made up of tasks, discussions, homework assignments, literature, and online resources. In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Computation

1.) Work as a team to put all Computation (addition, subtraction, multiplication, division) standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

2.) Discussion:

-How do computation standards in grades 1 and 2 relate to computation standards in grades 3, 4, and 5?

-What computation skills in the lower grades would help students meet expectations in the upper grades?

-What are the gaps within the curriculum that could inhibit the flow of computation from Grade1 to Grade 5?

-How can we address those gaps?

3.) Complete Learning Village Destination Math Tutorial: Course II Addition and Subtraction: Estimating and Finding Sums Less Than 1,000 @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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4.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding addition to 1,000?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

-What role does estimation play in addition?

5.) Complete Learning Village Destination Math Tutorial: Course II Addition and Subtraction: Estimating and Finding Differences Less Than 1,000

@ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu .html (PASSWORD PROTECTED)

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6.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding subtraction to 1,000?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

-What role does estimation play in subtraction?

7.) Demonstrate one instructional activity (prepared as homework) that fosters computation at your grade level.

8.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

9.) Use *Teaching Student-Centered Mathematics* Volume 1: Chapters Four and Six, and Volume 2: Chapters Three and Four (Van de Walle & Lovin, 2005) to find and correlate computation activities with the standards at your grade level. (Complete Computation Activities sheets attached*).

10.) Field Trip! Go to the Computer Lab and explore online resources for Computation (attached). Write down ideas for applying what you find in your classroom.

11.) Discussion:

-Share ideas about how you can improve your instruction regarding development of computation, especially regarding estimation.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about numbers and operations when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of computation, including whole numbers, fractions, and decimals.

12.) Complete Learning Village Destination Math Tutorial: Course II Multiplication: Repeated Addition and Arrays @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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13.) Discussion:

-What concepts are presented in this tutorial that will be expanded in the upper grades?

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding multiplication?

-How can we address those misunderstandings?

-How can we apply what we’ve learned into our daily instruction?

-What role do estimation and number sense play in multiplication?

14.) Complete Learning Village Destination Math Tutorial: Course II Multiplication: Finding Products Less Than 100 @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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15.) Discussion:

-What concepts or properties of multiplication are presented through this tutorial?

-How can these concepts provide a foundation for higher level multiplication tasks?

16.) Complete Learning Village Destination Math Tutorial: Course II Division: Dividing By a 1-Digit Number @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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17.) Discussion:

-How does this tutorial blend concepts of division with the traditional algorithm?

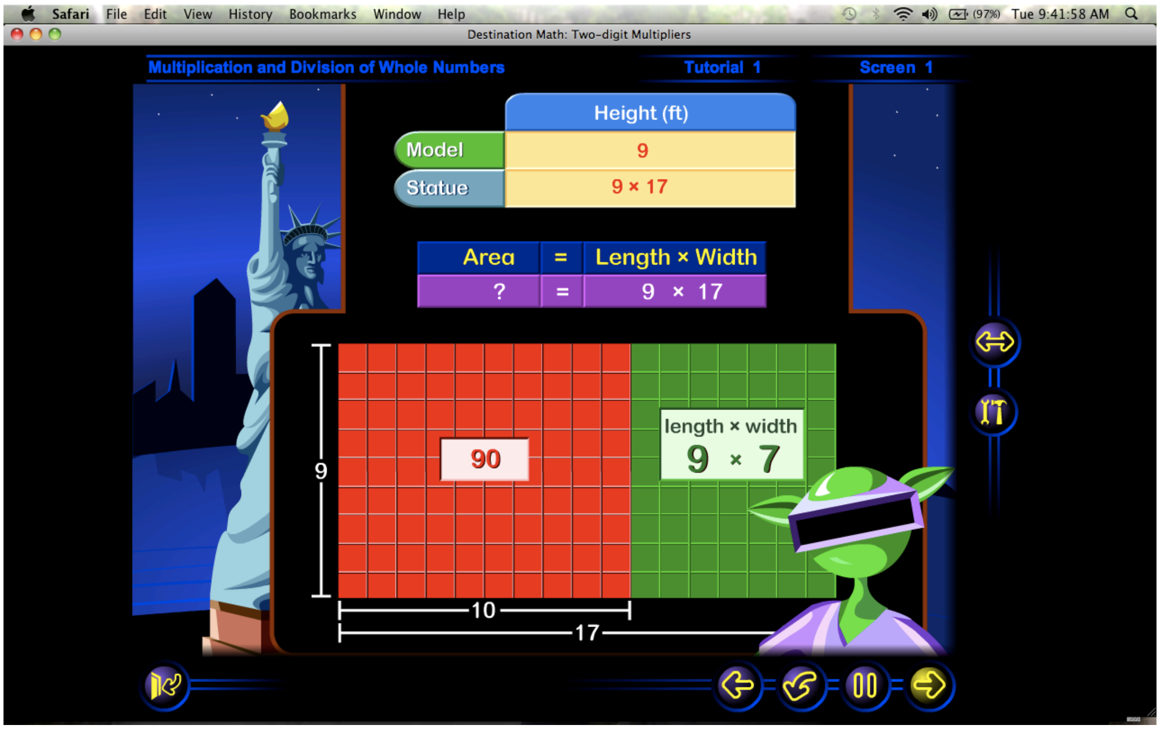
-How can you apply this strategy within your classroom?

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding division?

-What is the role of estimation in division?

18.) Complete Learning Village Destination Math Tutorial: Course III Operations with Whole Numbers – Two-Digit Multipliers @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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19.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

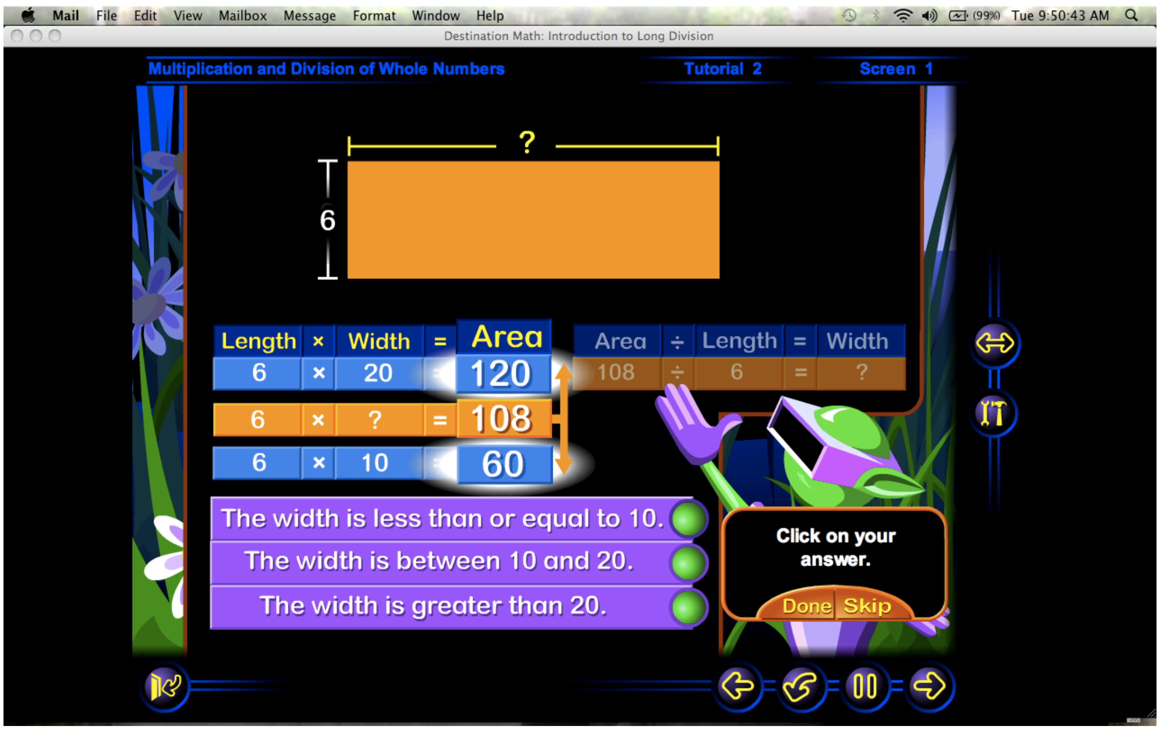
-What are the most common errors or misconceptions you see regarding two-digit multipliers?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

-What role does estimation play in multiplying with two-digit multipliers?

20.) Complete Learning Village Destination Math Tutorial: Course III Operations with Whole Numbers – Introduction to Long Division @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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21.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding long division?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

-What role does estimation play in long division?

-How does the inverse operation play a role in long division?

22.) Take turns making suggestions about what teachers can do to increase student achievement in computation.

23.) Watch videos of Computation lessons and provide constructive feedback to learning community members.

24.) Take a given problem, such as 342 x 56, and solve it as many different ways as possible. Pay special attention to the use of estimation.

25.) Take a given problem, such as 8,791 ÷ 34, and solve it as many different ways as possible. Pay special attention to the use of estimation.

26.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

27.) Brainstorm about ways to get parents and administrators involved in increasing the computational proficiency of students.

28.) Discuss ways in which we can use homework to reinforce automaticity of basic facts.

29.) Explore America's Choice *Addition*, *Subtraction*, *Multiplication* and *Division* Teacher's Manuals. Discuss how you could use these resources to enhance your instruction on computation.

30.) Model a lesson that includes several of the strategies or resources we have explored during this module.

31.) Explore the Mathematics Navigator *Knowing Addition and Subtraction Facts* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

32.) Explore the Mathematics Navigator *Understanding Addition and Subtraction* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

33.) Explore the Mathematics Navigator *Knowing Multiplication and Division Facts* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

34.) Explore the Mathematics Navigator *Understanding Multiplication* Teacher's Edition and Student Workbook. Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

35.) Explore the Mathematics Navigator *Understanding Division* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

36.) Explore the Mathematics Navigator *Multiplying Multidigit Whole Numbers* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

***First Grade Computation Activities**

Volume 1 Chapter 4 – Helping Children Master the Basic Facts

Volume 1 Chapter 6 – Strategies for Whole-Number Computation

Unit 2 – Understanding Operations, Unit 6 – Revisiting Operations

Standard	Activity Description	Pg. #
M1N3. Students will add and subtract numbers less than 100 as well as understand and use the inverse relationship between addition and subtraction. a. Identify one more than, one less than, 10 more than, and 10 less than a given number.		
b. Skip-count by 2's, 5's, and 10's forward and backwards – to and from numbers up to 100.		
c. Compose/decompose numbers up to 10 --"break numbers apart", e.g., 8 is represented as 4 + 4, 3 + 5, 5 + 2 + 1, and 10-2). d. Understand a variety of situations to which subtraction may apply: taking away from a set, comparing two sets, and determining how many more or how many less.		
e. Understand addition and subtraction number combinations using strategies such as counting on, counting back, doubles and making tens. f. Know the single-digit addition		

facts to 18 and corresponding subtraction facts with understanding and fluency. (Use strategies such as relating to facts already known, applying the commutative property, and grouping facts into families.)		
g. Apply addition and subtraction to 2 digit numbers without regrouping (e.g. 15 + 4, 80-60, 56 + 10, 100-30, 52 + 5).		
h. Solve and create word problems involving addition and subtraction to 100 without regrouping. Use words, pictures, and concrete models to interpret story problems and reflect the combining of sets as addition and taking away or comparing elements of sets as subtraction.		
M1N4. Students will count collections of up to 100 objects by dividing them into equal parts and represent the results using words, pictures, or diagrams. a. Use informal strategies to share objects equally between two to five people.		

Second Grade Computation Activities
Volume 1 Chapter 4 – Helping Children Master the Basic Facts
Volume 1 Chapter 6 – Strategies for Whole-Number Computation
Unit 6 – Addition and Subtraction

Standard	Activity Description	Pg. #
M2N2. Students will build fluency with multi-digit addition and subtraction. a. Correctly add and subtract two whole numbers up to three digits each with regrouping.		
b. Understand and use the inverse relation between addition and subtraction to solve problems and check solutions.		
c. Use mental math strategies such as benchmark numbers to solve problems. d. Use basic properties of addition (commutative, associative, and identity) to simplify problems (e.g. 98 + 17 by taking two from 17 and adding it to the 98 to make 100 and replacing the original problem by the sum 100 + 15). e. Estimate to determine if solutions are reasonable for addition and subtraction.		

Second Grade Computation Activities
Volume 1 Chapter 4 – Helping Children Master the Basic Facts
Volume 1 Chapter 6 – Strategies for Whole-Number Computation
Unit 7 – Multiplication and Division

Standard	Activity Description	Pg. #
M2N3. Students will understand multiplication, multiply numbers, and verify results. a. Understand multiplication as repeated addition.		
b. Use repeated addition, arrays, and counting by multiples (skip counting) to correctly multiply 1-digit numbers and construct the multiplication table.		
c. Use the multiplication table (grid) to determine a product of two numbers. d. Use repeated subtraction, equal sharing, and forming equal groups to divide large collections of objects and determine factors for multiplication.		

Third Grade Computation Activities
Volume 1 Chapter 4 – Helping Children Master the Basic Facts
Volume 1 Chapter 6 – Strategies for Whole-Number Computation
Volume 2 Chapter 3 – Helping Children Master the Basic Facts
Volume 2 Chapter 4 – Strategies for Whole-Number Computation
Unit 1 – Addition and Subtraction of Whole Numbers
Unit 2 – Multiplication and Division of Whole Numbers

Standard	Activity Description	Pg. #
M3N2. Students will further develop their skills of addition and subtraction and apply them in problem solving. a. Use the properties of addition and subtraction to compute and verify the results of computation. b. Use mental math and estimation strategies to add and subtract. c. Solve problems requiring addition and subtraction. d. Model addition and subtraction by counting back change using the fewest number of coins.		

M3N3. Students will further develop their understanding of multiplication of whole numbers and develop the ability to apply it in problem solving. a. Describe the relationship between addition and multiplication, i.e., multiplication is defined as repeated addition. b. Know the multiplication facts with understanding and fluency to 10 x 10. c. Use arrays and area models to develop understanding of the distributive property and to determine partial products for multiplication of 2- or 3-digit numbers by a 1- digit number. d. Understand the effect on the product when multiplying by multiples of 10. e. Apply the identity, commutative and associative properties of multiplication and verify the results.		

f. Use mental math and estimation strategies to multiply. g. Solve problems requiring multiplication.		
M3N4. Students will understand the meaning of division and develop the ability to apply it in problem solving.		
a. Understand the relationship between division and multiplication and between division and subtraction.		
b. Recognize that division may be two situations: the first is determining how many equal parts of a given size or amount may be taken away from the whole as in repeated subtraction, and the second is determining the size of the parts when the whole is separated into a given number of equal parts as in a sharing model.		

c. Recognize problem-solving situations in which division may be applied and write corresponding mathematical expressions. d. Explain the meaning of a remainder in division in different circumstances. e. Divide a 2 and 3-digit number by a 1-digit divisor. f. Solve problems requiring division.		
M3N5.Students will understand the meaning of decimal fractions and common fractions in simple cases and apply them in problem-solving situations. e. Understand the concept of addition and subtraction of decimal fractions and common fractions with like denominators. f. Model addition and subtraction of		

decimal fractions and common fractions. g. Use mental math and estimation strategies to add and subtract decimal fractions and common fractions with like denominators.		

Fourth Grade Computation Activities
Volume 2 Chapter 3 – Helping Children Master the Basic Facts
Volume 2 Chapter 4 – Strategies for Whole-Number Computation
Unit 2 – Multiplication and Division of Whole Numbers

Standard	Activity Description	Pg. #
M4N3. Students will solve problems involving multiplication of 2-3 digit numbers by 1 or 2 digit numbers.		
M4N4. Students will further develop their understanding of division of whole umbers and divide in problem solving situations without calculators. a. Know the division facts with understanding and fluency.		
b. Solve problems involving division by 1 or 2-digit numbers (including those that generate a remainder). c. Understand the relationship between dividend, divisor, quotient, and remainder.		
d. Understand and explain the effect on the quotient of multiplying or dividing both the divisor and dividend by the same number. (2050 ÷ 50 yields the same answer as 205 ÷ 5).		

M4N5. Students will further develop their understanding of the meaning of decimal fractions and use them in computations. c. Add and subtract both one and two digit decimal fractions. d. Model multiplication and division of decimal fractions by whole numbers. e. Multiply and divide both one and two digit decimal fractions by whole numbers		
M4N6. Students will further develop their understanding of the meaning of decimal fractions and common fractions and use them in computations.		
b. Add and subtract fractions and mixed numbers with common denominators. (Denominators should not exceed twelve.) **M4N7. Students will explain and use properties of the four arithmetic operations to solve and check problems.** a. Describe situations in which the four operations may be used and the relationships among them. b. Compute using the order of operations, including parentheses.		

c. Compute using the commutative, associative, and distributive properties. d. Use mental math and estimation strategies to compute.		

Fifth Grade Computation Activities
Volume 2 Chapter 4 – Strategies for Whole-Number Computation
Volume 2 Chapter 6 – Fraction Computation
Volume 2 Chapter 7 – Decimal Computation
Unit 2 – Decimal Understanding and Operations
Unit 3 – Fractional Understanding and Operations

Standard	Activity Description	Pg. #
M5N3. Students will further develop their understanding of the meaning of multiplication and division with decimals and use them. a. Model multiplication and division of decimals.		
b. Explain the process of multiplication and division, including situations in which the multiplier and divisor are both whole numbers and decimals.		
c. Multiply and divide with decimals including decimals less than one and greater than one. d. Understand that the relationships and rules for multiplication and division of whole numbers also apply to decimals.		
M5N4. Students will continue to develop their understanding of the meaning of common fractions and will compute with them. a. Understand division of whole		

numbers can be represented as a fraction ($a/b = a \div b$). b. Understand the value of a fraction is not changed when both its numerator and denominator are multiplied or divided by the same number because it is the same as multiplying or dividing by one. c. Find equivalent fractions and simplify fractions. d. Model the multiplication and division of common fractions. e. Explore finding common denominators using concrete, pictorial, and computational models. f. Use <, >, or = to compare fractions and justify the comparison. g. Add and subtract common fractions and mixed numbers with unlike denominators. h. Use fractions (proper and improper) and decimals interchangeably. i. Estimate products and quotients.		

Homework Assignments: Computation

1.) Read *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 1: Chapter Four – Helping Children Master the Basic Facts and Chapter Six – Strategies for Whole-Number Computation.

2.) Read *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 2: Chapter Three – Helping Children Master the Basic Facts and Chapter Four – Strategies for Whole-Number Computation.

3.) Prepare an activity from these chapters to present at Learning Community session.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments, could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a teacher facilitating a Computation lesson. Meet with the teacher afterward to provide feedback. Discuss how the computation concept(s) you observe relate to computation development in other grade levels.

6.) Videotape yourself teaching a Computation lesson. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs or concerns (support) for parents or administrators.

9.) Create a list of websites students can use at home to increase computation skills.

Literature & Research: Computation

Books and Articles

Burns, M. (1998, April). Can I balance arithmetic instruction with real-life mathematics? *Instructor,* 55-58.

Caron, T. A. (2007). Learning multiplication the easy way. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 80*(6), 278-282.

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Naidoo, N., & Naidoo, R. (2007). Collaborative computing as a means of overcoming mathematics phobia in primary school learners: Case study in calculating simple perimeters. *The International Journal of Learning, 14*(2), 181-193.

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Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*. New York, NY: Allyn & Bacon.

Westwood, P. (2003). Drilling basic number facts: Should we or should we not? *Journal of Learning Disabilities, 8*(4), 12-18.

Online References

http://math.about.com/od/reference/a/Errors.htm

http://www.rhlschool.com/computation/

http://www.ehow.com/how_4556836_improve-math-fact-computation.html

http://everydaymath.uchicago.edu/educators/computation/

http://www.educationworld.com/math/

http://www.awesomelibrary.org/Classroom/Mathematics/Elementary_School_Math/Elementary_School_Math.html

Online Instructional Resources

Addition and Subtraction

http://www.mathfactcafe.com/

http://www.sheppardsoftware.com/mathgames/quickmath/quickmath.htm

http://www.interventioncentral.org/htmdocs/tools/mathprobe/addsing.php

http://www.ictgames.com/funkymum.html

http://www.ictgames.com/frog.html

http://nlvm.usu.edu/en/nav/frames_asid_156_g_1_t_1.html?open=activities

http://www.sheppardsoftware.com/mathgames/earlymath/subHarvest.htm

http://www.ictgames.com/robindoubles.html

http://www.ictgames.com/rhoodbeyond10.html

http://www.aplusmath.com/Games/index.html

http://www.ictgames.com/spacejumps.html

http://www.ictgames.com/soccer_subtraction.html

http://www.cut-the-knot.org/Games/WolfRabbit.shtml

http://www.bbc.co.uk/schools/ks1bitesize/numeracy/numbers/index.shtml

http://www.ictgames.com/fairy2.html

http://www.ictgames.com/5andabit.html

http://funschool.kaboose.com/formula-fusion/carnival/games/game_math_popper.html

http://www.crickweb.co.uk/assets/resources/flash.php?&file=digitmenu

Multiplication and Division

http://nlvm.usu.edu/en/nav/frames_asid_192_g_2_t_1.html

http://www.ictgames.com/arrayDisplay.html

http://www.prongo.com/math/multiplication.html

http://nlvm.usu.edu/en/nav/frames_asid_202_g_3_t_1.html

http://www.netrover.com/~kingskid/MulTab/Applet.html

http://www.haelmedia.com/OnlineActivities_txh/mc_txh3_002.html

http://www.sheppardsoftware.com/mathgames/multiple/multiple_frenzy.htm

http://www.sums.co.uk/playground/c4a/playground.htm

http://www.multiplication.com/interactive_games.htm

http://www.multiplication.com/flashgames/Moles.htm

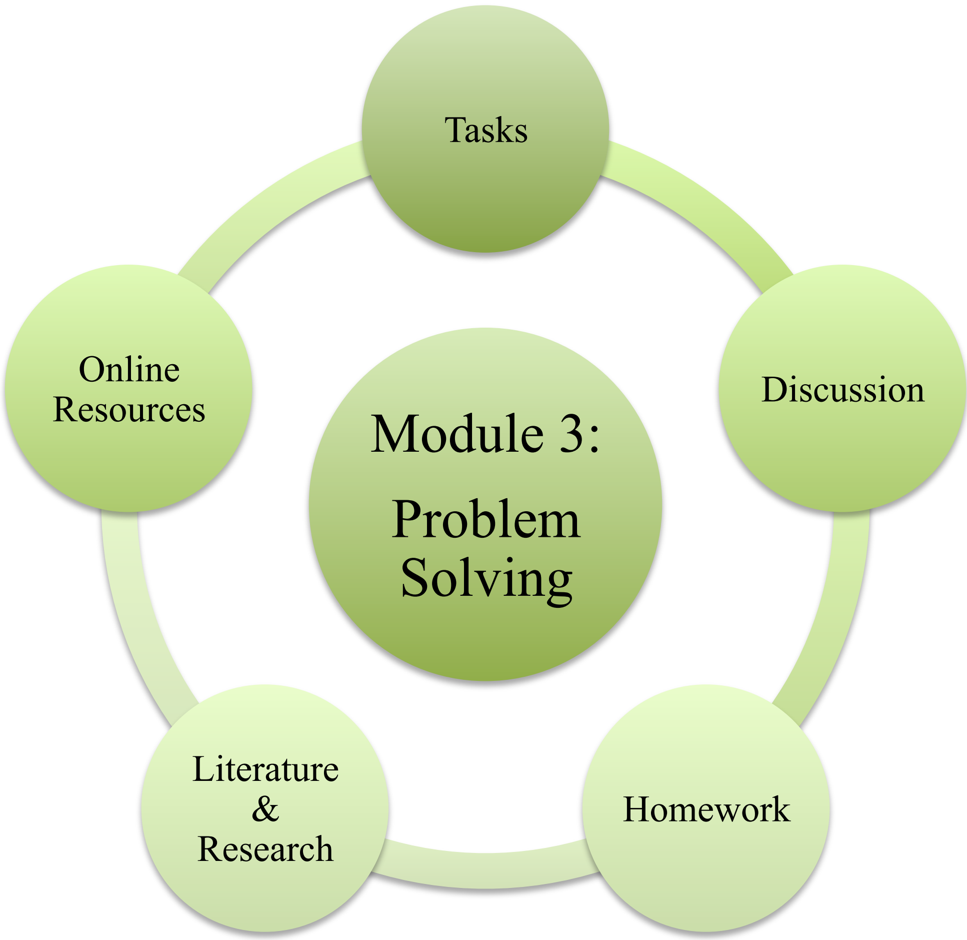
http://www.mathslice.com/oljpdy.php

http://www.cut-the-knot.org/Games/WolfRabbit.shtml

http://www.sheppardsoftware.com/mathgames/quickmath/quickmath.htm

http://nlvm.usu.edu/en/nav/frames_asid_156_g_1_t_1.html?open=activities

http://www.crickweb.co.uk/assets/resources/flash.php?&file=Toolkit%20index2a



Module 3: Problem Solving is made up of tasks, discussions, homework assignments, literature, research, and online resources. In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Problem Solving

1.) Read http://www.nctm.org/uploadedFiles/Math_Standards/12752_exec_pssm.pdf and discuss the role of problem solving in math, according to the National Council of Teachers of Mathematics (NCTM).

2.) Use http://www.berghuis.co.nz/abiator/maths/sa/saindex.html to find a variety of math problems. On several occasions, take turns solving these problems in as many different ways as possible. Alternate between working independently and working with a partner or group. Discuss the advantages and disadvantages of each situation.

3.) Discussion:

-How should we approach problem solving in our instruction?

-Should problem solving be a separate unit or should it be embedded within other units?

-Should we teach students a direct instruction approach (step-by-step method) for solving math problems or allow them to devise their own approaches?

4.) Discussion:

-What are the most common misconceptions associated with problem solving?

-How can we address those misconceptions?

5.) Explore the Mathematics Navigator *Understanding and Reading Word Problems* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

6.) Read http://math.about.com/library/weekly/aa123001a.htm and discuss how math journals can be used to promote problem solving.

7.) Read http://www.mathgoodies.com/articles/problem_solving.html and discuss how we can teach math via problem solving, rather than teaching problem solving as a part of math instruction.

8.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

9.) Discussion:

-How can looking for "clue words" in story problems be misleading? Write some story problems that contain a misleading clue word.

- Why do students struggle with multistep word problems? What can we do to help students be better problem solvers?

10.) Generate several real-life situations in which math problem solving is necessary. Discuss how you could incorporate these relevant uses for math into your instruction.

11.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

12.) Discussion:

-Share ideas about how you can improve your instruction regarding development of problem solving skills.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about problem solving when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of problem solving.

13.) Demonstrate one instructional activity (prepared as homework) that fosters problem solving.

14.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

15.) Complete Problem Solving sheets (attached*) by correlating activities or concepts from *Teaching Student-Centered Mathematics* Volume 1: Chapter Three – Developing Meaning for the Operations and Solving Story Problems (Van de Walle & Lovin, 2005).

***Problem Solving Activities**
Volume 1 Chapter 3 – Developing Meaning for the Operations and Solving Story Problems
All Units (Embedded)

Standard (Same standards for all grade levels)	**Activity Description**	**Pg. #**
M3P1. Students will solve problems (using appropriate technology). a. Build new mathematical knowledge through problem solving.		
b. Solve problems that arise in mathematics and in other contexts. c. Apply and adapt a variety of appropriate strategies to solve problems.		
d. Monitor and reflect on the process of mathematical problem solving. **M3P2. Students will reason and evaluate mathematical arguments.** a. Recognize reasoning and proof as		

fundamental aspects of mathematics. b. Make and investigate mathematical conjectures. c. Develop and evaluate mathematical arguments and proofs. d. Select and use various types of reasoning and methods of proof.		
M3P3. Students will communicate mathematically. a. Organize and consolidate their mathematical thinking through communication. b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.		
c. Analyze and evaluate the mathematical thinking and strategies of others. d. Use the language of mathematics to express mathematical ideas precisely. **M3P4. Students will make connections among mathematical ideas and to other disciplines.**		

a. Recognize and use connections among mathematical ideas. b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. c. Recognize and apply mathematics in contexts outside of mathematics.		

M3P5. Students will represent mathematics in multiple ways. a. Create and use representations to organize, record, and communicate mathematical ideas. b. Select, apply, and translate among mathematical representations to solve problems. c. Use representations to model and interpret physical, social, and mathematical phenomena.		

Homework Assignments: Problem Solving

1.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments, could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

2.) Observe a teacher facilitating a lesson that includes Problem Solving. Meet with the teacher afterward to provide feedback. Discuss how the problem solving concept(s) you observe relate to problem solving development in other grade levels.

3.) Videotape yourself teaching a lesson that includes problem solving. Ask teachers to provide feedback about your instruction and the activity itself.

4.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

5.) Generate a list of needs (support) for parents or administrators.

6.) Create a list of websites students can use at home to increase problem solving skills.

7.) Invite administrators or parents to a Learning Community session. Ask for their perspectives on the issue of math problem solving.

8.) Assign students to generate several real-life situations in which math problem solving is necessary (they can enlist help from their parents). Report the results of this assignment at a Learning Community session. Discuss how you could incorporate this relevant use for math into your instruction.

Literature & Research: Problem Solving

Books and Articles

Bottge, B. A. (2001). Reconceptualizing mathematics problem solving for low-achieving students. *Remedial & Special Education, 22*(2), 102-104.

Bracey, G. W. (2000). Trying to understand teaching math for understanding. *Phi Delta Kappan, 81*(6), 473-474.

Burke, D., & Dunn, R. (2002). Teaching mathematics effectively to elementary students. *Academic Exchange*, 91-95.

Burns, M. (1998, April). Can I balance arithmetic instruction with real-life mathematics? *Instructor,* 55-58.

Ciancone, T., & Tout, D. (2001). Learning outcomes: Skills or function? In *The International Conference of Adults Learning Mathematics.* Boston, MA.

Cobb, P., Wood, T., Yackel, E., Nicholls, J., Wheatley, G., Trigatti, B., & Perlwitz, M. (1991). Assessment of a problem-centred second-grade mathematics project. *Journal for Research in Mathematics Education* , 22, 3-29.

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Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*. New York, NY: Allyn & Bacon.

Online References

http://library.thinkquest.org/25459/learning/problem/

http://nrich.maths.org/public/

http://math.about.com/library/weekly/aa123001a.htm

http://www.mathgoodies.com/articles/problem_solving.html

Online Instructional Resources

http://www.rblewis.net/technology/EDU506/WebQuests/wordprob/wordprob.html

http://www.angelfire.com/home/chas/WQ.html

http://www.vcsc.k12.in.us/staff/hackneyl/mkwebquest/#Introduction

http://projects.edtech.sandi.net/grant/aquarium/index.html

http://www.rhlschool.com/math.htm

http://www.homeschoolmath.net/online/problem_solving.php

http://www.haelmedia.com/html/mc_m1_001.html

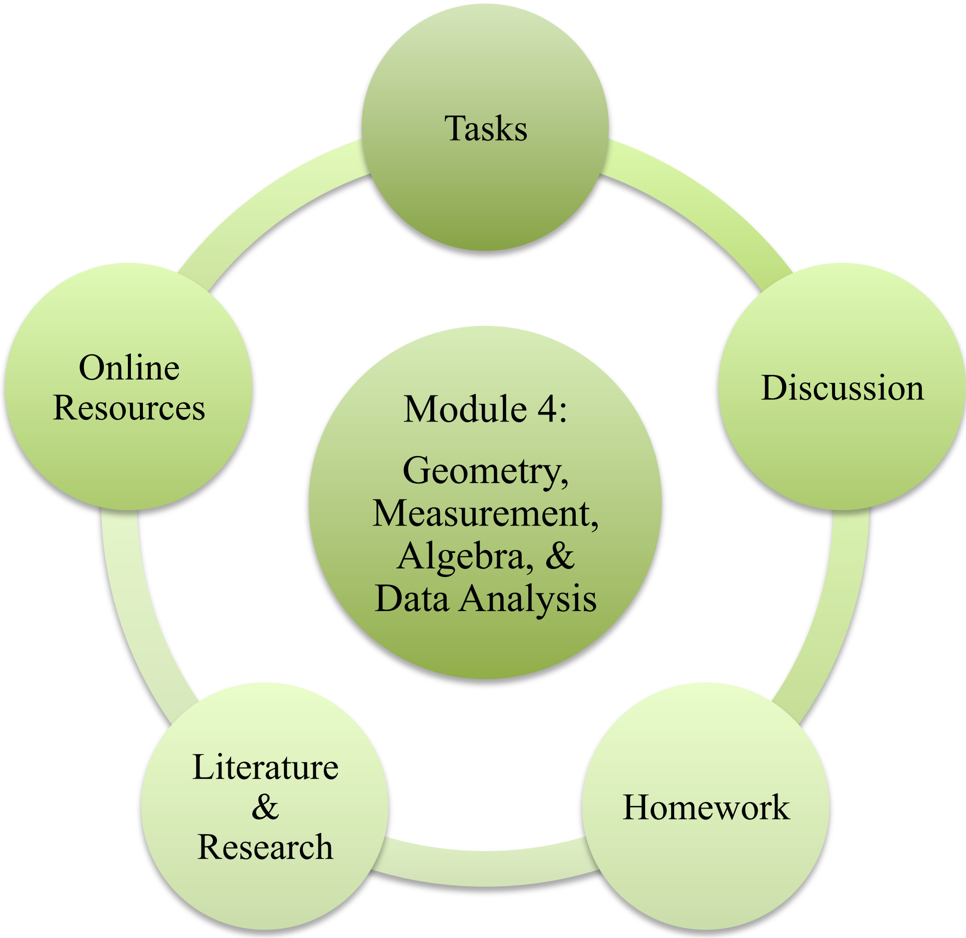
http://www.berghuis.co.nz/abiator/maths/sa/saindex.html

http://www.haelmedia.com/html/mc_m1_001.html

http://www.haelmedia.com/html/mc_m1_001.html

http://www.mathfactcafe.com/

http://mathforum.org/library/topics/problem_solving/



Module 4: Geometry, Measurement, Algebra, and Data Analysis is made up of tasks, discussions, homework assignments, literature, research, and online resources. In order to reap the full benefits of this module, all parts should be completed.

However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Geometry

1.) Work as a team to put all Geometry standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

2.) Discussion:

-How do geometry standards in grades 1 and 2 relate to geometry standards in grades 3, 4, and 5?

-What are the gaps within the curriculum that could inhibit the flow of geometry from Grade1 to Grade 5?

-How can we address those gaps?

3.) Complete Learning Village Destination Math Tutorial: Course II Geometry – Area @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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4.) Discussion:

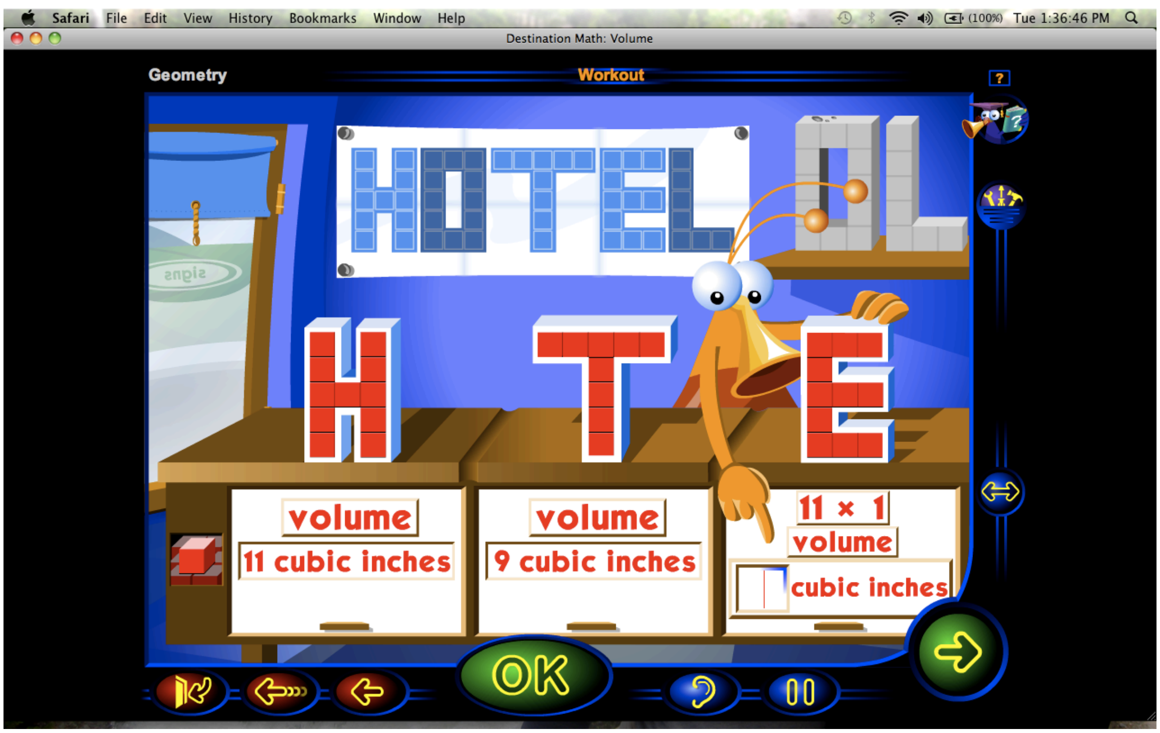
-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding area, especially area of a triangle?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

5.) Complete Learning Village Destination Math Tutorial: Course II Geometry – Volume @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)



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6.) Discussion:

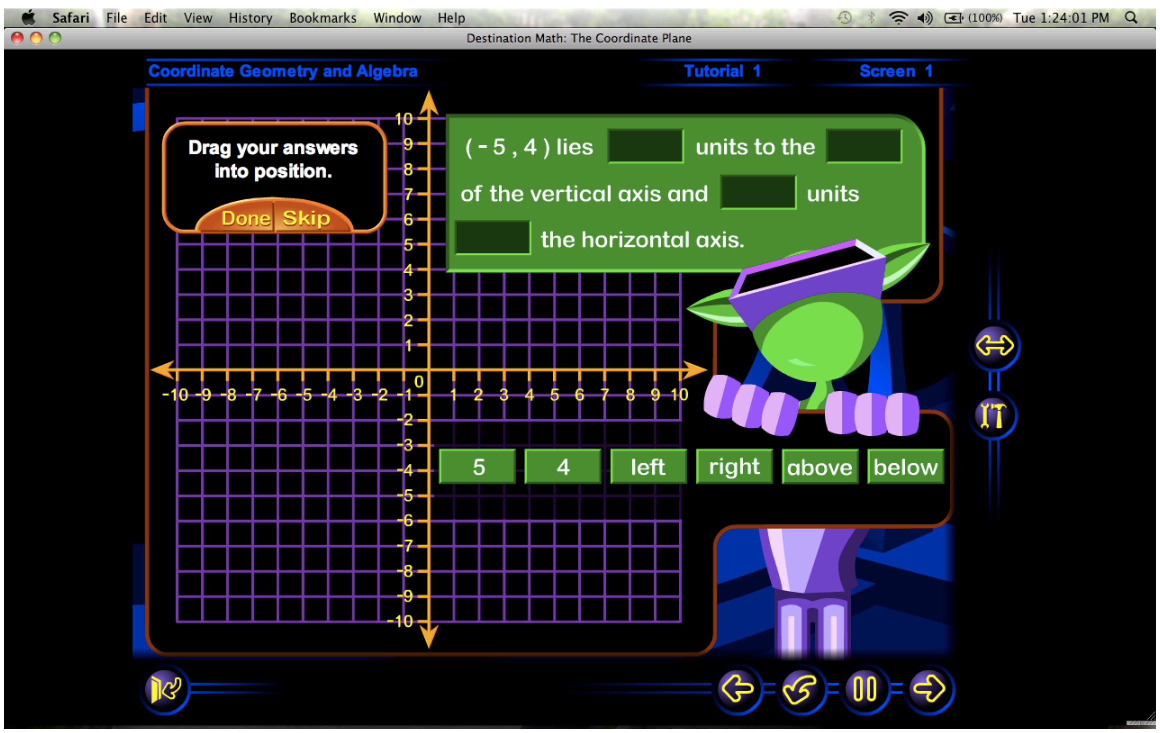
-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding volume?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

7.) Complete Learning Village Destination Math Tutorial: Course III Geometry – Coordinate Geometry and Algebra @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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8.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding geometry?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

9.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

10.) Complete interactive presentation at http://www.beaconlearningcenter.com/WebLessons/SolidPatterns/default.htm and discuss how you could use this in your classroom.

11.) Explore virtual geoboard at http://www.crickweb.co.uk/assets/resources/flash.php?&file=vpinboard4 and discuss how you could use this as part of your instruction.

12.) Explore the Mathematics Navigator *Geometry* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

13.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

14.) Discussion:

-Share ideas about how you can improve your instruction regarding geometry.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about geometry when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of geometry.

15.) Use *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 1: Chapter Seven – Geometric Thinking and Geometric Concepts, and Volume 2: Chapter Eight – Geometric Thinking and Geometric Concepts to find and correlate Geometry activities with the standards at your grade level. (Complete Geometry Activities sheets attached*).

16.) Model a geometry lesson and incorporate feedback from the learning community.

17.) Demonstrate one instructional activity (prepared as homework) that involves geometry.

18.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

***First Grade Geometry Activities**
Volume 1 Chapter 7 – Geometric Thinking and Geometric Concepts
Unit 3 – Shapes and Fractions

Standard	Activity Description	Pg. #
M1G1. Students will study and create various two and three-dimensional figures and identify basic figures (squares, circles, triangles, and rectangles) within them.		
a. Build, draw, name, and describe triangles, rectangles, pentagons, and hexagons.		
b. Build, represent, name, and describe cylinders, cones, and rectangular prisms. c. Create pictures and designs using shapes, including overlapping shapes.		
M1G2. Students will compare, contrast, and/or classify geometric shapes by the common attributes of position, shape, size, number of sides, and number of corners.		
M1G3. Students will arrange and describe objects in space by proximity, position, and direction (near, far, below, above, up, down, behind, in front of, next to, and left or right of).		

Second Grade Geometry Activities
Volume 1 Chapter 7 – Geometric Thinking and Geometric Concepts
Unit 4 – Plane and Solid Figures

Standard	Activity Description	Pg. #
M2G1. Students will describe and classify plane figures (triangles, square, rectangle, trapezoid, quadrilateral, pentagon, hexagon, and irregular polygonal shapes) according to the number of edges and vertices and the sizes of angles (right angle, obtuse, acute). **M2G2. Students will describe and classify solid geometric figures (prisms, cylinders, cones, and spheres) according to such things as the number of edges and vertices and the number and shape of faces and angles.** a. Recognize the (plane) shapes of the faces of a geometric solid and count the number of faces of each type. b. Recognize the shape of an angle as a right angle, an obtuse or acute angle. **M2G3. Students will describe the change in attributes as two and three-dimensional shapes are cut and rearranged.**		

Third Grade Geometry Activities
Volume 1 Chapter 7 – Geometric Thinking and Geometric Concepts
Volume 2 Chapter 8 – Geometric Thinking and Geometric Concepts
Unit 3 – Geometry and Measurement

Standard	Activity Description	Pg. #
M3G1. Students will further develop their understanding of geometric figures by drawing them. They will also state and explain their properties. a. Draw and classify previously learned fundamental geometric figures as well as scalene, isosceles, and equilateral triangles. b. Identify and explain the properties of fundamental geometric figures. c. Examine and compare angles of fundamental geometric figures. d. Identify the center, diameter, and radius of a circle.		

Fourth Grade Geometry Activities
Volume 2 Chapter 8 – Geometric Thinking and Geometric Concepts
Unit 4 – Geometric Figures, Plane Coordinates, and Data

Standard	Activity Description	Pg. #
M4G1. Students will define and identify the characteristics of geometric figures through examination and construction. a. Examine and compare angles in order to classify and identify triangles by their angles.		
b. Describe parallel and perpendicular lines in plane geometric figures.		
c. Examine and classify quadrilaterals (including parallelograms, squares, rectangles, trapezoids, and rhombi). d. Compare and contrast the relationships among quadrilaterals.		
M4G2. Students will understand fundamental solid figures. a. Compare and contrast a cube and a rectangle prism in terms of the number and shape of their faces, edges, and vertices.		
b. Describe parallel and perpendicular lines and planes in connection with the rectangular prism.		

c. Build/ collect models for solid geometric figures (cubes, prisms, cylinders, pyramids, spheres, and cones) using nets and other representations.		
M4G3. Students will use the coordinate system. a. Understand and apply ordered pairs in the first quadrant of the coordinate system. b. Locate a point in the first quadrant in the coordinate plane and name the ordered pair.		
c. Graph ordered pairs in the first quadrant.		

Fifth Grade Geometry Activities
Volume 2 Chapter 8 – Geometric Thinking and Geometric Concepts
Unit 4 – Geometry and Measurement (Plane Figures)
Unit 5 Geometry and Measurement (Solid Figures)

Standard	Activity Description	Pg. #
M5M1. Students will extend their understanding of area of fundamental geometric plane figures. a. Estimate the area of fundamental geometric plane figures.		
b. Derive the formula for the area of a parallelogram.		
c. Derive the formula for the area of a triangle. d. Find the areas of triangles and parallelograms using formulae. e. Estimate the area of a circle through partitioning and tiling.		
f. Find the area of a polygon (regular and irregular) by dividing it into squares, rectangles, and/or triangles and finding the sum of the areas of those shapes.		

g. Derive the formula for the area of a circle. h. Find the area of a circle using the formula a pi = 3.14.		
M5G1. Students will understand congruence of geometric figures and the correspondence of their vertices, sides, and angles.		
M5G2. Students will understand the relationship of the circumference of a circle to its diameter is pi (∏≈3.14).		

Homework Assignments: Geometry

1.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Seven – Geometric Thinking and Geometric Concepts (Van de Walle & Lovin, 2005).

2.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Eight – Geometric Thinking and Geometric Concepts (Van de Walle & Lovin, 2005).

3.) Prepare an activity from these chapters to present at next session.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a teacher facilitating a Geometry lesson. Meet with the teacher afterward to provide feedback. Discuss how the geometry concept(s) you observe relate to geometry development in other grade levels.

6.) Videotape yourself teaching a geometry lesson. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs (support) for parents or administrators.

9.) Create a list of websites students can use at home to increase problem solving skills.

Literature & Research: Geometry

Books and Articles

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http://www.instructorweb.com/lesson/geometryshapes.asp

http://mathforum.org/geometry/geom.units.html

http://www.apples4theteacher.com/math.html

http://math.about.com/od/geometry/a/perareavolume.htm

Online Instructional Resources

http://www.bcps.org/offices/lis/curric/elem/elemgeo.html

http://edweb.tusd.k12.az.us/ekowalcz/math/elementary_web_sites.htm#Geometry%20an
d%20Measurement

http://www.coolmath.com/reference/geometry-trigonometry-reference.html

http://www.homeschoolmath.net/online/geometry.php

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http://resources.oswego.org/games/BillyBug/bugcoord.html

http://www.crickweb.co.uk/assets/resources/flash.php?&file=vpinboard4

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http://www.amblesideprimary.com/ambleweb/mentalmaths/protractor.html

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Tasks and Discussions: Measurement

1.) Task: Work as a team to put all Measurement standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

2.) Discussion:

-How do measurement standards in grades 1 and 2 relate to measurement standards in grades 3, 4, and 5?

-What are the gaps within the curriculum that could inhibit the flow of measurement from Grade1 to Grade 5?

-How can we address those gaps?

3.) Complete Learning Village Destination Math Tutorial: Course II Geometry – Volume @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/msc2/menu.html (PASSWORD PROTECTED)

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4.) Discussion:

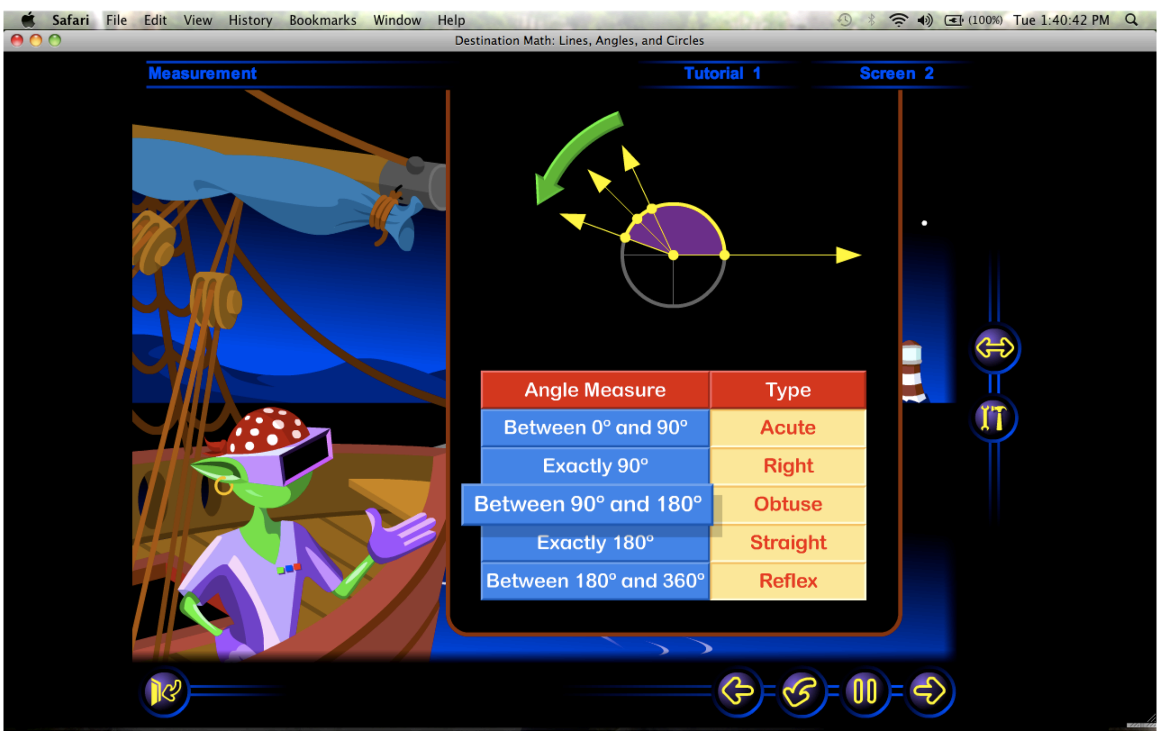
-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding measurement, especially volume?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

5.) Complete Learning Village Destination Math Tutorial: Course III Measurement – Lines, Angles, and Circles @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)



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6.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding angle measurement?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

7.) Complete Learning Village Destination Math Tutorial: Course III Measurement – Triangles @ http://real.doe.k12.ga.us/content/math/destination_math/MSC3/ msc3/msc3/msc3/Menu.html (PASSWORD PROTECTED)

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8.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding measurement of triangles?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

9.) Complete Learning Village Destination Math Tutorial: Course II Measurement – Time @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/msc2/ msc2/menu.html (PASSWORD PROTECTED)

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10.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding measurement of time? What about elapsed time?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

11.) Complete Learning Village Destination Math Tutorial: Course II Measurement – Money @ http://real.doe.k12.ga.us/content/math/destination_math/MSC2/msc2/ msc2/msc2/menu.html (PASSWORD PROTECTED)

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12.) Discussion:

-What tasks or assignments in the lower grades could prepare students to engage in thinking processes like those presented in this tutorial?

-What are the most common errors or misconceptions you see regarding money? How about making change?

-How can we address those misunderstandings?

-How can we apply what we've learned into our daily instruction?

13.) Explore Touch Money materials. Discuss how using Touch Money can help struggling students. Visit www.touchmath.com.

14.) View http://www.linkslearning.org/Kids/1_Math/2_Illustrated_Lessons/6_Weight_and_Capacity/index.html and discuss how you could use this video on Weight and Capacity in your classroom instruction.

15.) Explore the Mathematics Navigator *Measurement* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

16.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

17.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

18.) Discussion:

-Share ideas about how you can improve your instruction regarding measurement.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about measurement when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of measurement.

19.) Use *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 1: Chapter Eight – Developing Measurement Concepts, and Volume 2: Chapter Nine – Developing Measurement Concepts to find and correlate Measurement activities with the standards at your grade level. (Complete Measurement Activities sheets attached*).

20.) Demonstrate one instructional activity (prepared as homework) that involves measurement.

21.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

***First Grade Measurement Activities**
Volume 1 Chapter 8 – Developing Measurement Concepts
Unit 4 – Measurement

Standard	Activity Description	Pg. #
M1M1. Students will compare and/or order the length, weight, or capacity of two or more objects by using direct comparison or a nonstandard unit.		
a. Directly compare length, weight, and capacity of concrete objects.		
b. Estimate and measure using a non-standard unit that is smaller than the object to be measured.		
c. Measure with a tool by creating a "ruled" stick, tape, or container by marking off ten segments of the repeated single unit.		
M1M2. Students will develop an understanding of the measurement of time.		
a. Tell time to the nearest hour and half hour and understand the movement of the minute hand and how it relates to the hour hand.		
b. Begin to understand the relationship of calendar time by knowing the number of days in a week and months in a year.		
c. Compare and/or order the		

sequence or duration of events (e.g., shorter/longer and before/after).		

Second Grade Measurement Activities
Volume 1 Chapter 8 – Developing Measurement Concepts
Unit 3 – Length, Temperature, and Time

Standard	Activity Description	Pg. #
M2M1. Students will know the standard units of inch, foot, yard, and metric units of centimeter and meter and measure length to the nearest inch or centimeter. a. Compare the relationship of one unit to another by measuring objects twice using different units each time. b. Estimate lengths, and then measure to determine if estimations were reasonable. c. Determine an appropriate tool and unit for measuring.		
M2M2. Students will tell time to the nearest five minutes and know relationships of time such as the number of minutes in an hour and hours in a day. **M2M3. Students will explore temperature.** a. Determine a reasonable temperature for a given situation. b. Read a thermometer.		

Third Grade Measurement Activities
Volume 1 Chapter 8 – Developing Measurement Concepts
Volume 2 Chapter 9 Developing Measurement Concepts
Unit 3 – Geometry and Measurement

Standard	Activity Description	Pg. #
M3M1. Students will further develop their understanding of the concept of time by determining elapsed time of a full, half, and quarter-hour.		
M3M2. Students will measure length choosing appropriate units and tools. a. Use the units kilometer (km) and mile (mi.) to discuss the measure of long distances.		
b. Measure to the nearest 1/4 inch, 1/2 inch, and millimeter (mm) in addition to the previously learned inch, foot, yard, centimeter, and meter c. Estimate length and represent it using appropriate units.		
d. Compare one unit to another within a single system of measurement. **M3M3. Students will understand and measure the perimeter of simple geometric figures (squares and rectangles).** a. Understand the meaning of the linear unit in measuring perimeter.		

b. Understand the concept of perimeter as being the boundary of a simple geometric figure. c. Determine the perimeter of a simple geometric figure by measuring and summing the lengths of the sides. **M3M4. Students will understand and measure the area of simple geometric figures (squares and rectangles).** a. Understand the meaning of the square unit in measuring area. b. Model (by tiling) the area of a simple geometric figure using square units (square inch, square foot, etc.). c. Determine the area of squares and rectangles by counting, adding, and multiplying with models.		

Fourth Grade Measurement Activities
Volume 2 Chapter 9 Developing Measurement Concepts
Unit 3 – Measurement: Weight and Angles

Standard	Activity Description	Pg. #
M4M1. Students will understand the concept of weight and how to measure weight. a. Use standard and metric units to measure the weight of objects.		
b. Know units used to measure weight (gram, kilogram, ounces, pounds, and tons).		
c. Compare one unit to another within a single system of measurement.		
M4M2. Students will understand the concept of angles and how to measure them. a. Use tools, such as a protractor or angle ruler, and other methods such as paper folding, drawing a diagonal in a square, to measure angles.		
b. Understand the meaning and measure of a half rotation (180°) and a full rotation (360°). c. Determine the sum of the three angles of a triangle is always 180°.		

Fifth Grade Measurement Activities
Volume 2 Chapter 9 Developing Measurement Concepts
Unit 4 – Geometry and Measurement (Plane Figures)
Unit 5 Geometry and Measurement (Solid Figures)

Standard	Activity Description	Pg. #
M5M1. Students will extend their understanding of area of fundamental geometric plane figures. a. Estimate the area of fundamental geometric plane figures.		
b. Derive the formula for the area of a parallelogram (e.g., cut the parallelogram apart and rearrange it into a rectangle of the same area).		
c. Derive the formula for the area of a triangle (e.g. demonstrate and explain its relationship to the area of a rectangle with the same base and height). d. Find the areas of triangles and parallelograms using formulae. e. Estimate the area of a circle through partitioning and tiling and then find the area of a circle with formula (let pi = 3.14). f. Find the area of a polygon (regular and irregular) by dividing it into squares, rectangles, and/or triangles and finding the sum of the areas of those shapes.		

M5M3. Students will measure capacity with appropriately chosen units and tools. a. Use milliliters, liters, fluid ounces, cups, pints, quarts, and gallons to measure capacity. b. Compare one unit to another within a single system of measurement (e.g., 1 quart = 2 pints).		
M5M4. Students will understand and compute the volume of a simple geometric solid. a. Understand a cubic unit (u3) is represented by a cube in which each edge has the length of 1 unit. b. Identify the units used in computing volume as cubic centimeters (cm3), cubic meters (m3), cubic inches (in3), cubic feet (ft3), and cubic yards (yd3). c. Derive the formula for finding the volume of a cube and a rectangular prism using manipulatives. d. Compute the volume of a cube and a rectangular prism using formulae. e. Estimate the volume of a simple		

geometric solid. f. Understand the similarities and differences between volume and capacity.		

Homework Assignments: Measurement

1.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Eight - Developing Measurement Concepts (Van de Walle & Lovin, 2005).

2.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Nine – Developing Measurement Concepts (Van de Walle & Lovin, 2005).

3.) Prepare an activity from these chapters to present at next session.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Visit

http://www.touchmath.com/index.cfm?fuseaction=WYT.welcome&page=FreeSaleItems

and order free samples. Use these with your students and report back to the Learning Community about your experience.

6.) Observe a teacher facilitating a Measurement lesson. Meet with the teacher afterward to provide feedback. Discuss how the concept(s) you observe relate to measurement understanding in other grade levels.

7.) Videotape yourself teaching a Computation lesson. Ask teachers to provide feedback about your instruction and the activity itself.

8.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

9.) Generate a list of needs or concerns (support) for parents or administrators.

10.) Create a list of websites students can use at home to increase computation skills.

Literature & Research: Measurement

Books and Articles

Blanchard, R., Epps, C., Greene, C., Backes, M., & Griggs, J. (2007). MATH MAILBAG. *Mailbox: The Intermediate Edition, 29*(2), 30-32.

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http://illuminations.nctm.org/WebResourceList.aspx?Ref=2&Std=3&Grd=0

http://www.instructorweb.com/basicskills/measurement.asp

http://www.mathinvestigations.com/MeasurementWorksheets.html

http://www.slideshare.net/whitmo2/teaching-measurement

http://www.moneyinstructor.com/lesson/liquidcapacity.asp

http://www.kindergarten-lessons.com/teaching-measurement.html

Online Instructional Resources

http://www.mathplayground.com/alienangles.html

http://www.amblesideprimary.com/ambleweb/mentalmaths/protractor.html

http://www.apples4theteacher.com/clocks.html

http://www.tvokids.com/framesets/bby.html?game=119&

http://www.harcourtschool.com/activity/elab2002/grade_3/018.html

http://resources.oswego.org/games/bananahunt/bhunt.html

http://www.rickyspears.com/rulergame/

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http://www.bbc.co.uk/schools/ks1bitesize/numeracy/time/index.shtml

http://resources.oswego.org/games/StopTheClock/sthec3.html

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http://resources.oswego.org/games/StopTheClock/sthecR.html

http://resources.oswego.org/games/StopTheClock/sthec4.html

http://www.beaconlearningcenter.com/WebLessons/ItsADate/default.htm

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y/index.html

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting&cdn=parenting&tm=10&f=20&tt=14&bt=0&bts=1&zu=http%3A//www.funbrain.com/cashreg/index.html

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http://www.haelmedia.com/html/mc_mk_003.html

http://www.english-zone.com/grammar/money1.html

http://www.sheppardsoftware.com/mathgames/matching/memoryMath_coins_level1.htm

http://primarygames.com/Spending%20Spree/start.htm

Tasks and Discussions: Algebra

1.) Task: Work as a team to put all Algebra standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

2.) Discussion:

-How do algebra standards in grades 1 and 2 relate to algebra standards in grades 3, 4, and 5?

-What are the gaps within the curriculum that could inhibit the flow of algebra from Grade1 to Grade 5?

-How can we address those gaps?

3.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

4.) Discussion:

-Share ideas about how you can improve your instruction regarding development of algebraic concepts.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about algebra when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of algebra.

5.) Use *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 1: Chapter Ten – Algebraic Reasoning, and Volume 2: Chapter Ten – Algebraic

Reasoning to find and correlate Algebra activities with the standards at your grade level. (Complete Algebra Activities sheets attached*).

6.) Demonstrate one instructional activity (prepared as homework) that involves algebra.

7.) Discussion: Members provide constructive feedback about the activities presented.

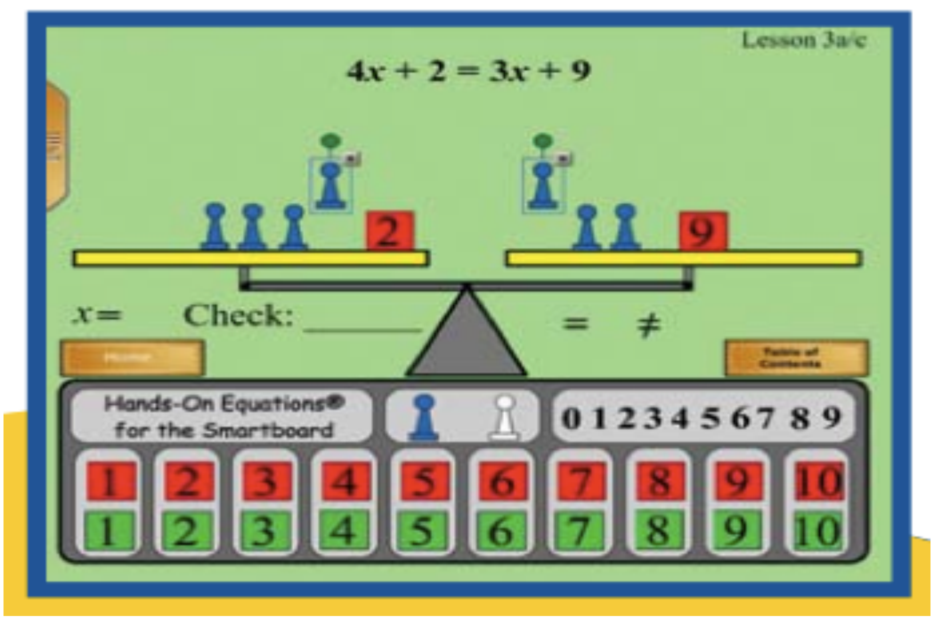
-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

8.) Explore *Hands-On Equations* kit. Discuss experience using it and use the kit to engage in some practice problems.



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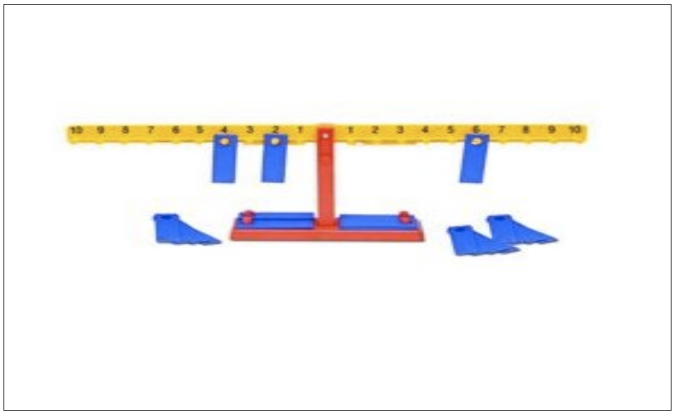
9.) Practice using a number balance to model equations with missing addends, inequalities, etc. How else could this tool be used?



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10.) Visit http://www.crickweb.co.uk/assets/resources/flash.php?&file=nbKS1 and discuss how it could be used to introduce basic algebraic concepts.

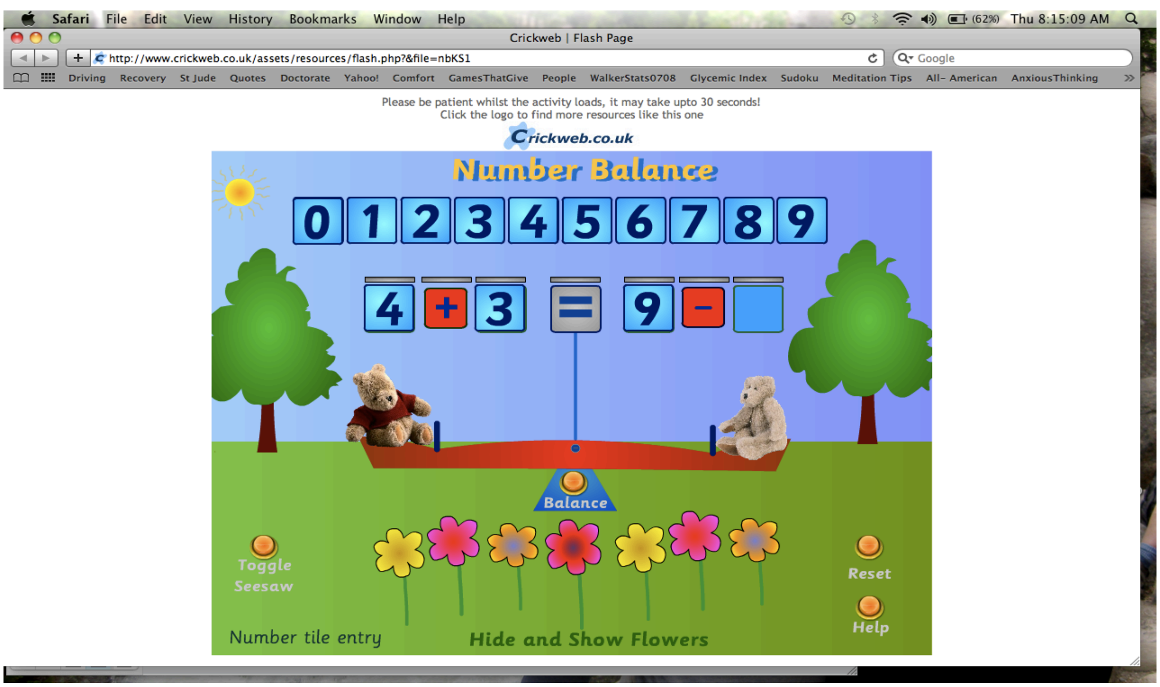


Image copyrighted by Crickweb, used with permission

11.) Explore http://illuminations.nctm.org/ActivityDetail.aspx?id=26 and discuss how this website could be used to facilitate algebraic understanding from Grades 1-5.

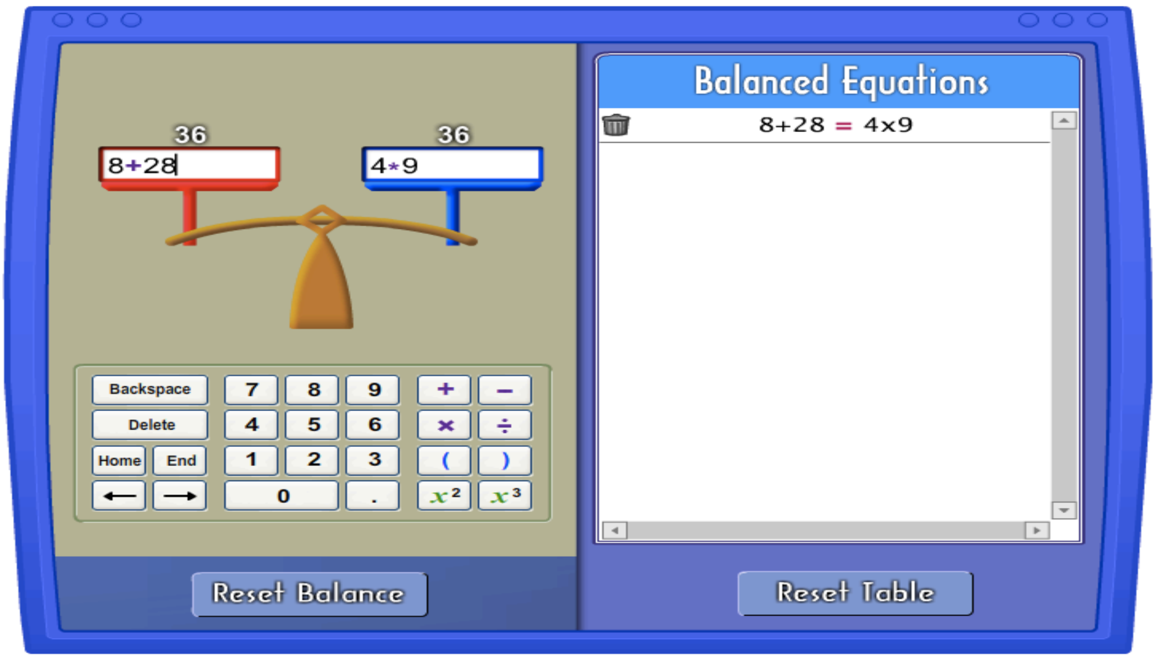


Image copyrighted by National Council of Teachers of Mathematics, used with permission

12.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

13.) Generate several real-life situations in which algebra is necessary. Discuss how you could incorporate these relevant uses for math into your instruction.

***Third Grade Algebra Activities**
Volume 1 Chapter 10 – Algebraic Reasoning
Volume 2 Chapter 10 – Algebraic Reasoning
Unit 6 – Algebra

Standard	Activity Description	Pg. #
M3A1. Students will use mathematical expressions to represent relationships between quantities and interpret given expressions. a. Describe and extend numeric and geometric patterns.		
b. Describe and explain a quantitative relationship represented by a formula (such as the perimeter of a geometric figure).		
c. Use a symbol, such as □ and Δ, to represent an unknown and find the value of the unknown in a number sentence.		

Fourth Grade Algebra Activities
Volume 2 Chapter 10 – Algebraic Reasoning
Unit 6 – Algebra

Standard	Activity Description	Pg. #
M4A1. Students will represent and interpret mathematical relationships in quantitative expressions.		
a. Understand and apply patterns and rules to describe relationships and solve problems.		
b. Represent unknowns using symbols, such as □ and Δ.		
c. Write and evaluate mathematical expressions using symbols and different values.		

Fifth Grade Algebra Activities
Volume 2 Chapter 10 – Algebraic Reasoning
Unit 6 – Algebra

Standard	Activity Description	Pg. #
M5A1. Students will represent and interpret the relationships between quantities algebraically. a. Use variables, such as n or x, for unknown quantities in algebraic expressions.		
b. Investigate simple algebraic expressions by substituting numbers for the unknown.		
c. Determine that a formula will be reliable regardless of the type of number (whole numbers or decimal fractions) substituted for the variable.		

Homework Assignments: Algebra

1.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Ten – Algebraic Reasoning (Van de Walle & Lovin, 2005).

2.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Ten – Algebraic Reasoning (Van de Walle & Lovin, 2005).

3.) Prepare an activity from these chapters to present at next session.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a teacher facilitating an Algebra lesson. Meet with the teacher afterward to provide feedback. Discuss how the concept(s) you observe relate to algebraic understanding in other grade levels.

6.) Videotape yourself teaching an Algebra lesson. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs or concerns (support) for parents or administrators.

9.) Create a list of websites students can use at home to increase algebra skills.

Literature & Research: Algebra

Books and Articles

Bay-Willams, J. (2001). What is algebra in elementary school? (Cover story). *Teaching Children Mathematics, 8*(4), 196.

Caison, B., North Carolina State Dept. of Public Instruction, R., & And, O. (1997). Resources for Algebra.

Earnest, D., & Balti, A. (2008). Instructional strategies for teaching algebra in elementary school: Findings from a research-practice collaboration. *Teaching Children Mathematics, 14*(9), 518-522.

Foster, C. (2007). Solving the X factor. *Times Educational Supplement*, (4763), 48-49.

Kalman, R. (2006). Building algebra readiness in the lower grades. *New York State Mathematics Teachers' Journal, 56*(1), 14-18.

Kalman, R. (2008). Teaching algebra without algebra. *Mathematics Teaching in the Middle School, 13*(6), 334-339.

Moritz, J. (2003). Constructing coordinate graphs: Representing corresponding ordered values with variation in two-dimensional space. *Mathematics Education Research Journal, 15*(3), 226-251.

Parmar, R., & Signer, B. (2005). Sources of error in constructing and interpreting graphs: A study of fourth- and fifth- grade students with LD. *Journal of Learning Disabilities, 38*(3), 250-261.

Porteous, K. (2008, May). How to not teach algebra e.g simplify 2a + 3a. *Mathematics in School*, 9-13.

Pullano, F., Garofalo, J., & Bell, R. (2005). Using Probeware to improve students' graph interpretation abilities. *School Science & Mathematics, 105*(7), 373-376.

Sakshaug, L., & Wohlhuter, K. (2001). Responses to the Which Graph Is Which? problem. *Teaching Children Mathematics, 7*(6), 350-53.

Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*. New York, NY: Allyn & Bacon.

Online References

http://www.gameclassroom.com/skill/3440/beginning-algebra

http://www.onlinemathlearning.com/basic-algebra.html

http://www.coolmath.com/prealgebra/index.html

http://www.algebra.com/

http://www.homeschoolmath.net/online/algebra.php

http://www.gamequarium.com/algebra.htm

http://www.crickweb.co.uk/assets/resources/flash.php?&file=fmach

http://www.crickweb.co.uk/assets/resources/flash.php?&file=nbKS1

Online Instructional Resources

http://www.onlinemathlearning.com/algebra-math-games.html

http://www.coolmath.com/crunchers/algebra-problems-solving-equations-1.htm

http://www.coolmath.com/crunchers/algebra-problems-solving-equations-2.htm

http://www.coolmath.com/crunchers/algebra-problems-solving-equations-3.htm

http://www.coolmath.com/crunchers/algebra-problems-solving-equations-5.htm

http://funbasedlearning.com/algebra/graphing/lines/default.htm

http://www.learnalberta.ca/content/mejhm/index.html?ID1=AB.MATH.JR.NUMB&ID2=AB.MATH.JR.NUMB.INTE&lesson=html/object_interactives/order_of_operations/use_it.html

http://www.fi.uu.nl/toepassingen/00008/toepassing_wisweb.en.html

http://www.dositey.com/2008/math/mistery2.html

Tasks and Discussions: Data Analysis

1.) Work as a team to put all Data Analysis standards in order from 1st grade to 5th grade with no labels or guidance. Check answers.

2.) Discussion:

-How do data analysis standards in grades 1 and 2 relate to data analysis standards in grades 3, 4, and 5?

-What are the gaps within the curriculum that could inhibit the flow of data analysis understanding from Grade1 to Grade 5?

-How can we address those gaps?

3.) Use *Teaching Student-Centered Mathematics* (Van de Walle & Lovin, 2005) Volume 1: Chapter Eleven – Helping Children Use Data, and Volume 2: Chapter Eleven – Exploring Data Analysis to find and correlate Data Analysis activities with the standards at your grade level. (Complete Data Analysis Activities sheets attached*).

4.) Demonstrate one instructional activity (prepared as homework) that involves data analysis.

5.) Discussion: Members provide constructive feedback about the activities presented.

-How could we extend the activity to a deeper cognitive level?

-How could we expand it to include more complex standards / numbers?

-How could we modify it to reach different learning styles?

-What would remediation and enrichment look like?

6.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

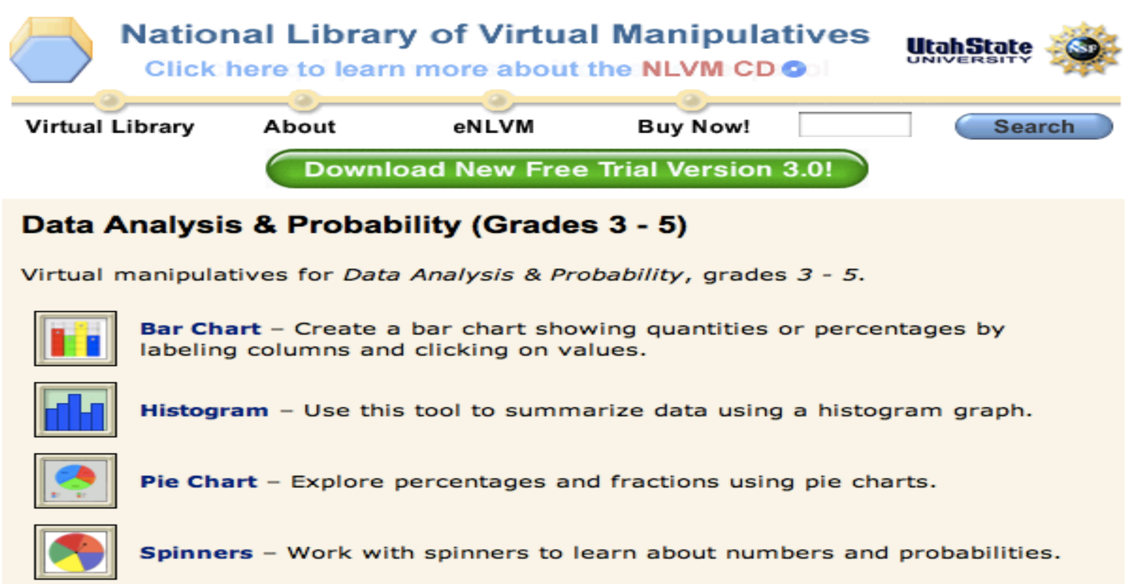
7.) Discussion:

-Share ideas about how you can improve your instruction regarding data analysis.

-Meet with the teachers at the grade levels directly below and above you. Below: Share what you would like students to understand about data analysis when they come to you. Above: Ask what you could do to better prepare students to meet expectations in the area of data analysis.

8.) Explore the Mathematics Navigator *Tables, Charts, and Graphs* Teacher's Edition and Student Workbook (America's Choice, 2006). Focus on the section entitled "Common Misconceptions" and discuss how we can address those misconceptions.

9.) Visit http://nlvm.usu.edu/en/nav/category_g_2_t_5.html and practice using data analysis tools. Discuss how you could use these in your classroom.



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10.) Bring in student work samples and analyze errors. Discuss ways of addressing these errors. In the lower grades, discuss strategies that could prevent errors or misconceptions.

***First Grade Data Analysis Activities**

Volume 1 Chapter 11 – Helping Children Use Data

Unit 1 – Routines and Data

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="2">M1D1. Students will create simple tables and graphs and interpret them.

a. Interpret tally marks, picture graphs, and bar graphs.

b. Pose questions, collect, sort, organize, and record data using objects, pictures, tally marks, picture graphs, and bar graphs.</td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Second Grade Data Analysis Activities
Volume 1 Chapter 11 – Helping Children Use Data
Unit 1 – Venn Diagrams, Charts, and Graphs

Standard	Activity Description	Pg. #
M2D1. Students will create simple tables and graphs and interpret their meaning. a. Create, organize, and display data using pictographs, Venn diagrams, bar graphs, picture graphs, simple charts, and tables to record results with scales of 1, 2, and 5. b. Know how to interpret picture graphs, Venn diagrams, and bar graphs.		

Third Grade Data Analysis Activities
Volume 1 Chapter 11 – Helping Children Use Data
Volume 2 Chapter 11 – Exploring Data Analysis
Unit 5 – Data Analysis

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="2">M3D1. Students will create and interpret simple tables and graphs.

a. Solve problems by organizing and displaying data in charts, tables, and graphs.

b. Construct and interpret line plot graphs, pictographs, Venn diagrams, and bar graphs using scale increments of 1, 2, 5, and 10.</td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Fourth Grade Data Analysis Activities
Volume 2 Chapter 11 – Exploring Data Analysis
Unit 4 – Geometric Figures, Plane Coordinates, and Data

Standard	Activity Description	Pg. #
M4D1. Students will gather, organize, and display data according to the situation and compare related features. a. Contstruct and interpret line graphs, line plot graphs, pictographs, Venn diagrams, and bar graphs. b. Investigate the features and tendencies of graphs. c. Compare various graphical representations for a given set of data. d. Identify missing information and duplications in data. e. Determine and justify the range, mode, and median of a set of data.		

Fifth Grade Data Analysis Activities
Volume 2 Chapter 11 – Exploring Data Analysis
Unit 1 – Data Analysis and Graphing

<table>
<tr><th>Standard</th><th>Activity Description</th><th>Pg. #</th></tr>
<tr><td rowspan="3">M5D1. Students will analyze graphs.

a. Analyze data presented in a graph.

b. Compare and contrast multiple graphic representations (circle graphs, line graphs, line plot graphs, pictographs, Venn diagrams, and bar graphs) for a single set of data and discus the advantages / disadvantages of each.

c. Determine and justify the mean, range, mode, and median of a set of data.

M5D2. Students will collect, organize, and display data using the most appropriate graph.</td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Homework Assignments: Data Analysis

1.) Read *Teaching Student-Centered Mathematics* Volume 1: Chapter Eleven – Helping Children Use Data (Van de Walle & Lovin, 2005).

2.) Read *Teaching Student-Centered Mathematics* Volume 2: Chapter Eleven – Exploring Data Analysis (Van de Walle & Lovin, 2005).

3.) Prepare an activity from these chapters to present at next session.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a Data Analysis lesson. Provide feedback to the teacher regarding the lesson and how concepts would apply in different grade levels.

6.) Videotape yourself teaching a Data Analysis lesson. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs or concerns (support) for parents or administrators.

9.) Create a list of websites students can use at home to increase data analysis skills.

Literature & Research: Data Analysis

Books and Articles

Cook, C. (2008). I Scream, You Scream: Data Analysis with Kindergartners. *Teaching Children Mathematics, 14*(9), 538-540.

Hudson, P., Shupe, M., Vasquez, E., & Miller, S. (2008). Teaching Data Analysis to Elementary Students with Mild Disabilities. *Teaching Exceptional Children Plus, 4*(3), 1-14.

McMillen, S., & McMillen, B. (2010). My Bar Graph Tells a Story. *Teaching Children Mathematics, 16*(7), 430-436.

Niman, J. (1975). Graph Theory in the Elementary School. Educational Studies in Mathematics.

Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*.New York, NY: Allyn & Bacon.

Online References

http://www.teach-nology.com/themes/math/graphing/

http://homeschooling.about.com/gi/o.htm?zi=1/XJ/Ya&zTi=1&sdn=homeschooling&cdn=education&tm=5&f=20&tt=14&bt=0&bts=1&zu=http%3A//teacher.scholastic.com/max/hairy/index.htm

http://homeschooling.about.com/gi/o.htm?zi=1/XJ/Ya&zTi=1&sdn=homeschooling&cdn=education&tm=27&f=20&tt=14&bt=0&bts=1&zu=http%3A//www.eduplace.com/activity/capsule.html

http://homeschooling.about.com/od/mathchartgraphs4/Charts_and_Graphs_Grades_46.htm

http://preschool.suite101.com/article.cfm/teaching-preschool-math-skills-using-graphs

http://www.superteacherworksheets.com/graphing.html

http://www.powertolearn.com/articles/teaching_with_technology/how_to_make_graphs_with_excel.shtml

http://curricula-by-grade.suite101.com/article.cfm/elementary_recipe_math_lesson_plan

Online Instructional Resources

http://www.sfsocialstudies.com/g1/u6/index.html

http://www.beaconlearningcenter.com/WebLessons/IAmSpecial/default.htm

http://ksnn.larc.nasa.gov/k2/m_whatGraph_v.html

http://www.ixl.com/math/practice/grade-3-pictographs

http://illuminations.nctm.org/ActivityDetail.aspx?ID=63

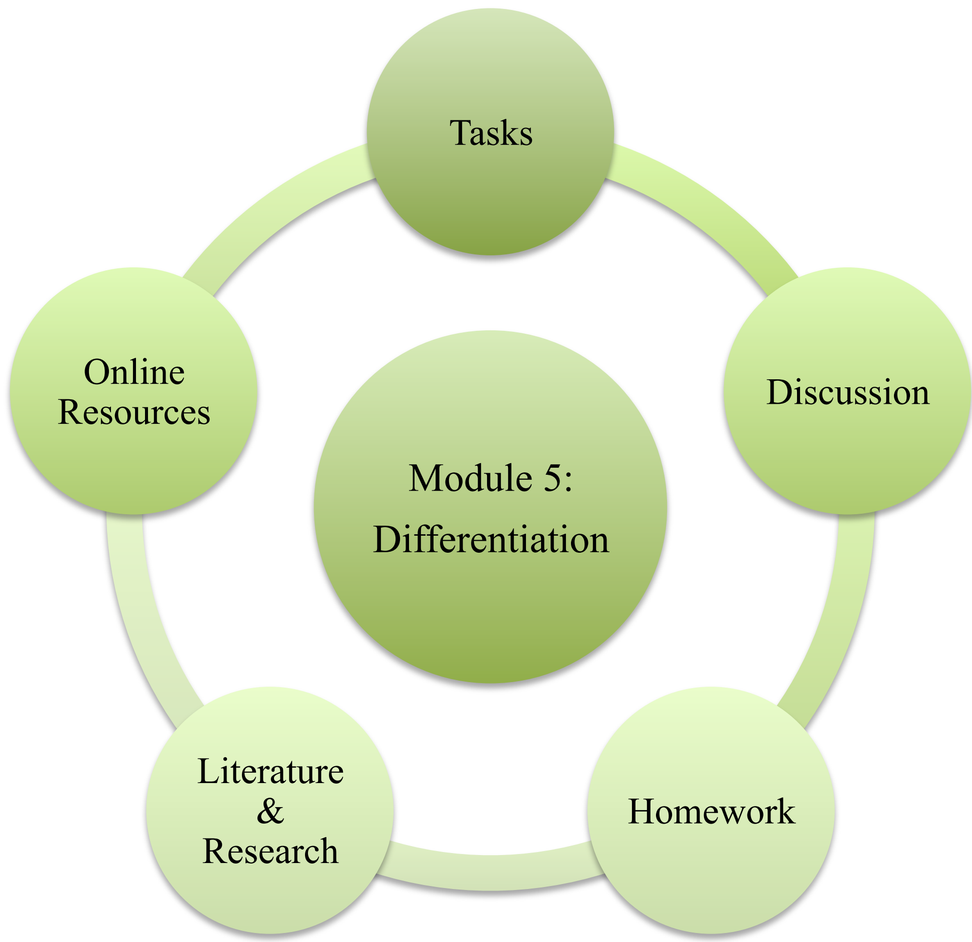
http://www.bbc.co.uk/schools/ks1bitesize/numeracy/data/index.shtml

http://nces.ed.gov/nceskids/createagraph/

http://www.oswego.org/ocsd-web/quiz/mquiz.asp?filename=ccarrollgraph

http://www.beaconlearningcenter.com/WebLessons/PlayBall/default.htm

http://www.bbc.co.uk/schools/ks2bitesize/maths/data/interpreting_data/play.shtml



Module 5: Differentiation is made up of tasks, discussions, homework assignments, literature, research, and online resources. In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Differentiation

1.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

2.) Discussion:

-Share ideas about how you can improve your instruction regarding differentiation.

-Share experiences about how you differentiate instruction in math. What has worked well? What would you like to learn more about?

3.) Take turns bringing in lesson plans. Members of the learning community can view the lesson plan and brainstorm about ways to differentiate the particular lesson.

4.) Visit http://www.ldpride.net/learningstyles.MI.htm and refresh your knowledge about learning styles. Discuss ideas about how to reach different styles of learners in math.

5.) Visit http://www.ldrc.ca/projects/miinventory/miinventory.php to take the Multiple Intelligence Inventory. This will result in a personalized profile that may give you insight into how you teach.

6.) Visit http://www.ldpride.net/learning-style-test.html to find out what your learning style is.

7.) Use the chart on http://www.chaminade.org/INSPIRE/learnstl.htm to characterize some of your students. Brainstorm math activities that correspond the visual, auditory, and kinesthetic learners. Try taking one standard and writing three different ways to teach it, according to this chart. Repeat with other standards.

Learning Styles

This chart helps you determine your learning style; read the word in the left column and then answer the questions in the successive three columns to see how you respond to each situation. Your answers may fall into all three columns, but one column will likely contain the most answers. The dominant column indicates your primary learning style.

When you..	Visual	Auditory	Kinesthetic & Tactile
Spell	Do you try to see the word?	Do you sound out the word or use a phonetic approach?	Do you write the word down to find if it feels right?
Talk	Do you sparingly but dislike listening for too long? Do you favor words such as *see*, *picture*, and *imagine*?	Do you enjoy listening but are impatient to talk? Do you use words such as *hear*, *tune*, and *think*?	Do you gesture and use expressive movements? Do you use words such as *feel*, *touch*, and *hold*?
Concentrate	Do you become distracted by untidiness or movement?	Do you become distracted by sounds or noises?	Do you become distracted by activity around you?
Meet someone again	Do you forget names but remember faces or remember where you met?	Do you forget faces but remember names or remember what you talked about?	Do you remember best what you did together?
Contact people on business	Do you prefer direct, face-to-face, personal meetings?	Do you prefer the telephone?	Do you talk with them while walking or participating in an activity?
Read	Do you like descriptive scenes or pause to imagine the actions?	Do you enjoy dialog and conversation or hear the characters talk?	Do you prefer action stories or are not a keen reader?
Do something new at work	Do you like to see demonstrations, diagrams, slides, or posters?	Do you prefer verbal instructions or talking about it with someone else?	Do you prefer to jump right in and try it?
Put something together	Do you look at the directions and the picture?		Do you ignore the directions and figure it out as you go along?
Need help with a computer application	Do you seek out pictures or diagrams?	Do you call the help desk, ask a neighbor, or growl at the computer?	Do you keep trying to do it or try it on another computer?

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8.) Visit http://www.vark-learn.com/english/index.asp for another perspective on learning styles and a 16-item questionnaire to determine yours.

9.) Read and discuss the article *Learning Styles in Mathematics Classrooms* at http://math.unipa.it/~grim/EKeast6.PDF. Discuss how to apply this information within your classroom instruction.

10.) Facilitate a mock math lesson that includes small group differentiated instruction. Take turns playing the roles of teacher and students.

11.) Create math activities that include elements of multiple intelligences or different learning styles.

12.) Supplement math frameworks with differentiated activities.

13.) Report and discuss findings from observations, including both elementary lessons and college courses.

Homework Assignments: Differentiation

1.) Bring in any resources you have on differentiation, learning styles, multiple intelligences, etc., to share with the learning community.

2.) Interview another teacher about ways in which he or she applies differentiated instruction. Report what you find out at a learning community session.

3.) Prepare an activity that includes differentiation. Present at learning community session. Ask teachers for feedback.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a differentiated math lesson. Provide feedback to the teacher regarding the lesson and how concepts would apply in different grade levels or with different mathematical concepts.

6.) Videotape yourself teaching a lesson that includes differentiation. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs or concerns (support) for parents or administrators to assist in differentiation.

9.) Arrange to observe a local college course on differentiation. Possibilities include Dalton State College, Northwestern Technical College, Covenant College, or University of Tennessee at Chattanooga. Report your findings to the learning community.

Literature & Research: Differentiation

Books and Articles

Beecher, M., & Sweeny, S. (2008). Closing the Achievement Gap With Curriculum Enrichment and Differentiation: One School's Story. *Journal of Advanced Academics, 19*(3), 502-530.

Bray, W. (2009). The Power of Choice. *Teaching Children Mathematics, 16*(3), 178-183.

Burns, M. (2007). Nine Ways to Catch Kids up. *Educational Leadership, 65*(3), 16-21.

Chen, J., & Weiland, L. (2007). Helping young children learn mathematics: Strategies for meeting the needs of diverse learners. *Exchange, 174*, 46-51.

Ellis, D., Ellis, K., Huemann, L., & Stolarik, E. (2007, June 1). *Improving mathematics skills using differentiated instruction with primary and high school students*.

Forsten, C., Grant, J., & Hollas, B. (2002). *Differentiated Instruction: Different Strategies for Different Learners*. Peterborough, NH: Crystal Springs Books.

Gregory, G. H., & Chapman, C. (2002). *Differentiated instructional strategies: One size doesn't fit all.* Thousand Oaks, CA: Corwin Press.

Heacox, D. (2002). *Differentiating instruction in the regular classroom.* Minneapolis, MN: Free Spirit.

Grimes, K., & Stevens, D. (2009). Glass, bug, mud. *Phi Delta Kappan, 90*(9), 677-680.

Hamm, M., & Adams, D. (2008). *Differentiated instruction for K-8 math and science: Activities and lesson plans*. Eye on Education.

Hoeflinger, M. (1998). Developing Mathematically Promising Students. *Roeper Review, 20*(4), 244-47.

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

Taylor-Cox, J. (2009). *Math intervention: Building number power with formative assessments, differentiation, and games, Grades 3-5*. Eye on Education.

Tomlinson, C. A. (1999). *The differentiated classroom: Responding to the needs of all learners.* Alexandria, VA: Association for Supervision and Curriculum Development.

Online Resources

http://instructionalcenter.org/files/Summary%20of%209%20studies%20on%20RTI%20math%20and%20struggling%20math%20students.pdf

http://www.k8accesscenter.org/training_resources/mathdifferentiation.asp

http://www.glencoe.com/sec/teachingtoday/subject/dimath.phtml

http://www.prufrock.com/client/client_pages/GCT_Readers/Math/Ch._4/Tiered_Lessons_for_Gifted_Children.cfm

http://www.ltps.org/webpages/jpolakowski/files/Differentiated%20Instruction%20for%20Math.pdf

http://www.montgomeryschoolsmd.org/departments/development/resources/math_lab/index.shtm

http://www.ericdigests.org/2001-2/elementary.html http://www.teach-nology.com/tutorials/teaching/differentiate/print.htm

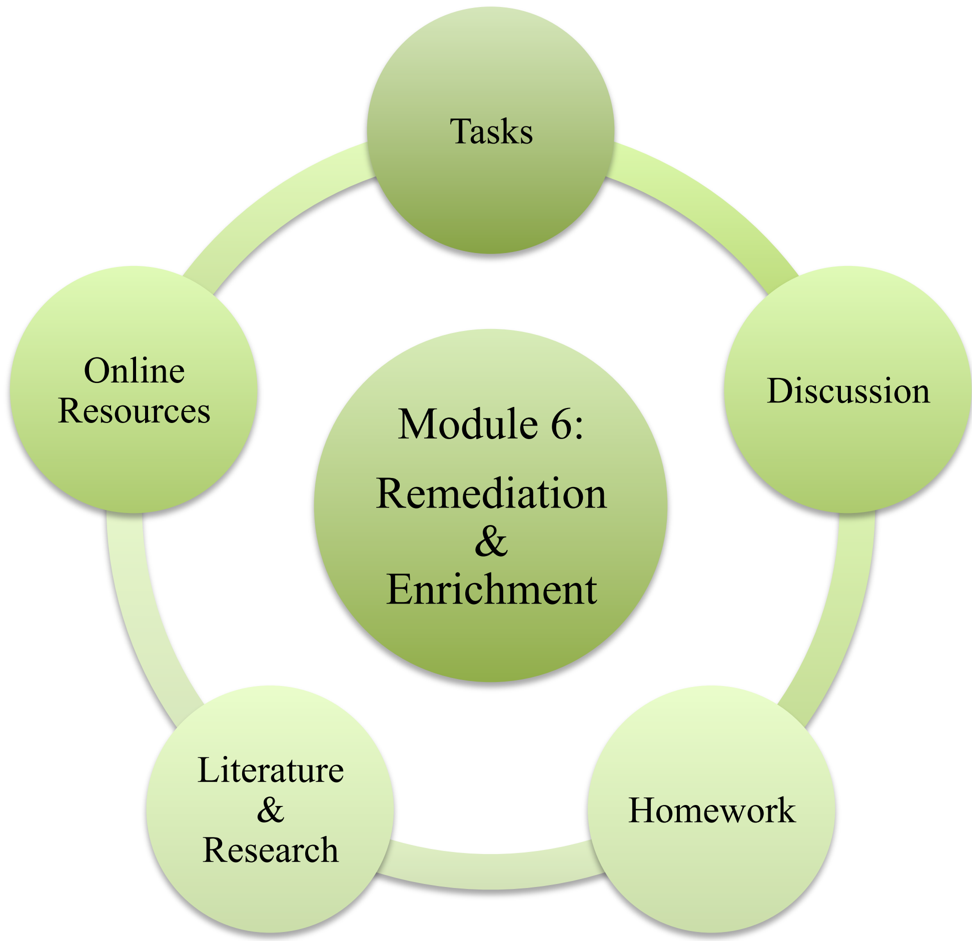
http://www.activemath.com/pdf/differentiated_sample.pdf

http://my-ecoach.com/online/webresourcelist.php?rlid=1591

http://www.ldpride.net/learningstyles.MI.htm

http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm

http://www.maa.org/devlin/devlin_1_00.html



Module 6: Remediation and Enrichment is made up of tasks, discussions, homework assignments, literature, research, and online resources.

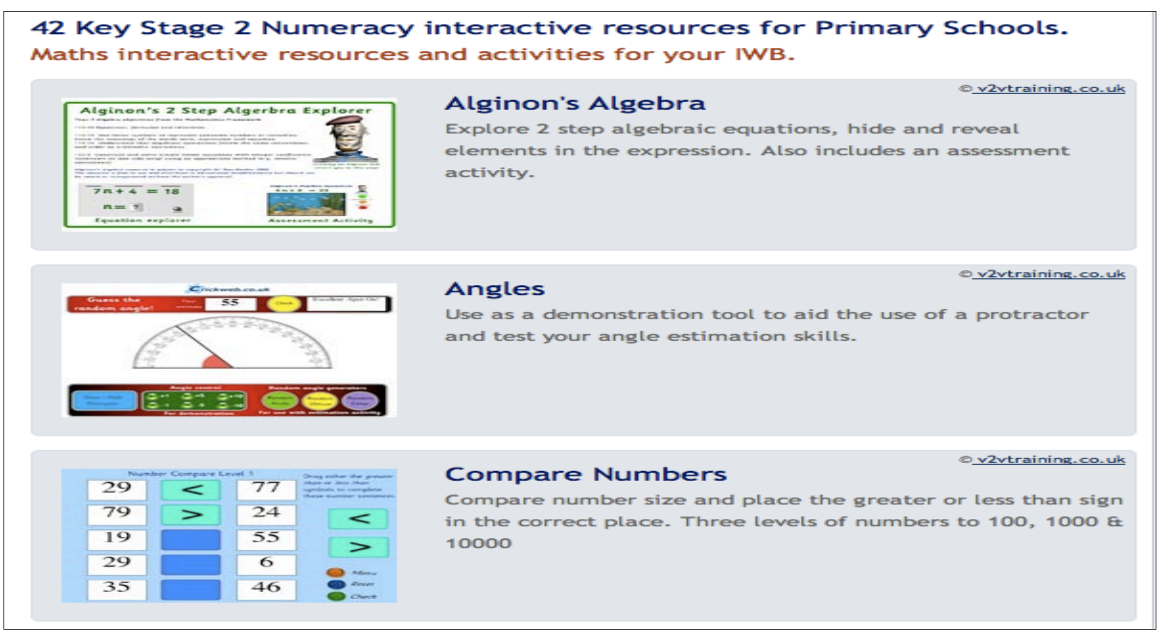
In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Remediation and Enrichment

1.) Explore http://www.americaschoice.org/uploads/Math_Nav_Correlations_Brochures/Math_Navigator_Correlations_GA.pdf as a resource for remediation of many content areas.

2.) Explore *Mathematics Navigator* training manual (America's Choice, 2006). Visit www.americaschoice.org for additional information. Get with a partner and practice role playing as the teacher and struggling student. Discuss how you could use this resource for small group intervention.

3.) Visit http://www.crickweb.co.uk/ks1numeracy.html and http://www.crickweb.co.uk/ks2numeracy.html. Brainstorm about how you could use these websites as a remediation or enrichment activity.



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Write down all the ideas you generate.

4.) Take turns bringing in lesson plans. Members of the learning community can view the lesson plans and brainstorm about ways to remediate and enrich the activities.

5.) Facilitate a mock math lesson that includes remediation and enrichment. Take turns playing the roles of teacher and students.

6.) Supplement math frameworks with remediation and enrichment activities.

7.) Interview a teacher at the grade level above the one you teach. Ask specifically about how you could enrich standards to prepare students for math at their grade level.

8.) Interview a teacher at the grade level below the one you teach. Ask specifically about how you could remediate standards to reach learners who struggle.

9.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

10.) Discussion:

-Share ideas about how you can improve your instruction regarding remediation and enrichment.

-Share experiences about how you remediate and enrich instruction in math. What has worked well? What would you like to learn more about?

11.) Report and discuss findings from observations of elementary math classes or college math methods courses.

Homework Assignments: Remediation and Enrichment

1.) Bring in any resources you have on remediation or enrichment to share with the learning community.

2.) Interview another teacher about ways in which he or she applies remediation or enrichment. Report what you find out at a learning community session.

3.) Prepare an activity that includes remediation and enrichment. Present at learning community session. Ask teachers for feedback.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe a math lesson that includes remediation or enrichment. Provide feedback to the teacher regarding the lesson and how concepts would apply in different grade levels or with different mathematical concepts.

6.) Videotape yourself teaching a lesson that includes remediation or enrichment. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

8.) Generate a list of needs or concerns (support) for parents or administrators to assist in remediation or enrichment.

9.) Organize and host a Family Involvement Night, Parent Education Class, or some other venue for promoting the school-family partnership in math education. This could also involve creating a resource for home use, such as a Math DVD or handbook organized by topic or grade level.

10.) Arrange to observe a local college class that focuses on math remediation or enrichment. Possibilities include Dalton State College, Covenant College, Northwestern Technical College, or University of Tennessee at Chattanooga. Report your findings to the learning community.

Literature & Research: Remediation and Enrichment

Books and Articles

Benko, A., Loaiza, R., Long, R., Sacharski, M., & Winkler, J. (1999, May 1). *Math word problem remediation with elementary students*.

Chavez, S. (2004). Soundoff! If at first you don't succeed . . . Test, test again (Not!). *Mathematics Teacher, 97*(5), 310.

Fuchs, L., Powell, S., Hamlett, C., Fuchs, D., Cirino, P., & Fletcher, J. (2008). Remediating computational deficits at third grade: A randomized field trial. *Journal of Research on Educational Effectiveness, 1*(1), 2-32.

Fuchs, L., Powell, S., Seethaler, P., Cirino, P., Fletcher, J., Fuchs, D., et al. (2010). The effects of strategic counting instruction, with and without deliberate practice, on number combination skill among students with mathematics difficulties. *Learning & Individual Differences, 20*(2), 89-100.

Fuchs, L., Powell, S., Seethaler, P., Fuchs, D., Hamlett, C., Cirino, P., et al. (2010). A framework for remediating number combination deficits. *Exceptional Children, 76*(2), 135-156.

Gentile, J., & Lally, J. (2003). *Standards and mastery learning: Aligning teaching and assessment so all children can learn.* Corwin Press.

Harrington, A. (1995). Is differentiation helpful?. *Mathematics Teaching, 152*, 41.

Nolan, K. L. (2009). Musi-Matics! Coining a phrase that links the arts with math instruction. *Music Educators Journal, 95*(3), 19-20.

McAllister, B., & Plourde, L. (2008). Enrichment curriculum: Essential for mathematically gifted students. *Education, 129*(1), 40-49.

Moyer, P., Dockery, K., Jamieson, S., & Ross, J. (2007). Code RED (Remediation and Enrichment Days): The complex journey of a school and university partnership's process to increase mathematics achievement. *Action in Teacher Education, 28*(4), 75-91.

Riccomini, P. (2005). Identification and remediation of systematic error patterns in subtraction. *Learning Disability Quarterly, 28*(3), 233.

Selby, V. (2009). Storytelling adds meaning. *Mathematics Teacher, 102*(8), 592-599.

Simon, M., Saldanha, L., McClintock, E., Akar, G., Watanabe, T., & Zembat, I. (2010). A developing approach to studying students' learning through their mathematical activity. *Cognition & Instruction, 28*(1), 70-112.

What Works Clearinghouse. (2009). *Kumon Math*. What Works Clearinghouse Intervention Report.

Yunus, H., Hashim, N., Lah, Y., Ahmad, M., & Ahmad, N. (2009). Preschool teachers' instruction: Is it innovative and creative?. *International Journal of Learning, 16*(10), 653-665.

Online Resources

http://www.paulabliss.com/math.htm

http://www.iknowthat.com/com/L2?GradeLevel=-1:6&Subject=Math

http://www.aplusmath.com/

http://school.discoveryeducation.com/homeworkhelp/homework_help_home.html

http://www.eric.ed.gov:80/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/8
0/2e/f3/2a.pdf

http://onlineacademics.org/Math/

http://www.ehow.com/list_6385857_math-remediation-learning-strategies.html

http://nrich.maths.org/public/

http://www.mathwire.com/archives/enrichment.html

http://math.about.com/od/multiplication/a/Multiplication-Tricks.htm

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fwww.ee.ryerson.ca%3A8080%2F%7Eelf%2Fabacus%2F

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fmathforum.org%2Fdr.math%2F

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fforum.swarthmore.edu%2Fk12%2Fmathtips%2Fbeatcalc.html

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fwww.eduplace.com%2Fkids%2Fmhm%2Findex.html

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fmath.rice.edu%2F%7Elanius%2FPatterns%2F

http://childparenting.about.com/gi/dynamic/offsite.htm?zi=1/XJ/Ya&sdn=childparenting
&zu=http%3A%2F%2Fwww.ed.gov%2Fpubs%2Fparents%2FMath%2Findex.html

http://www.homeschooldiner.com/subjects/math/enrichment_math.html

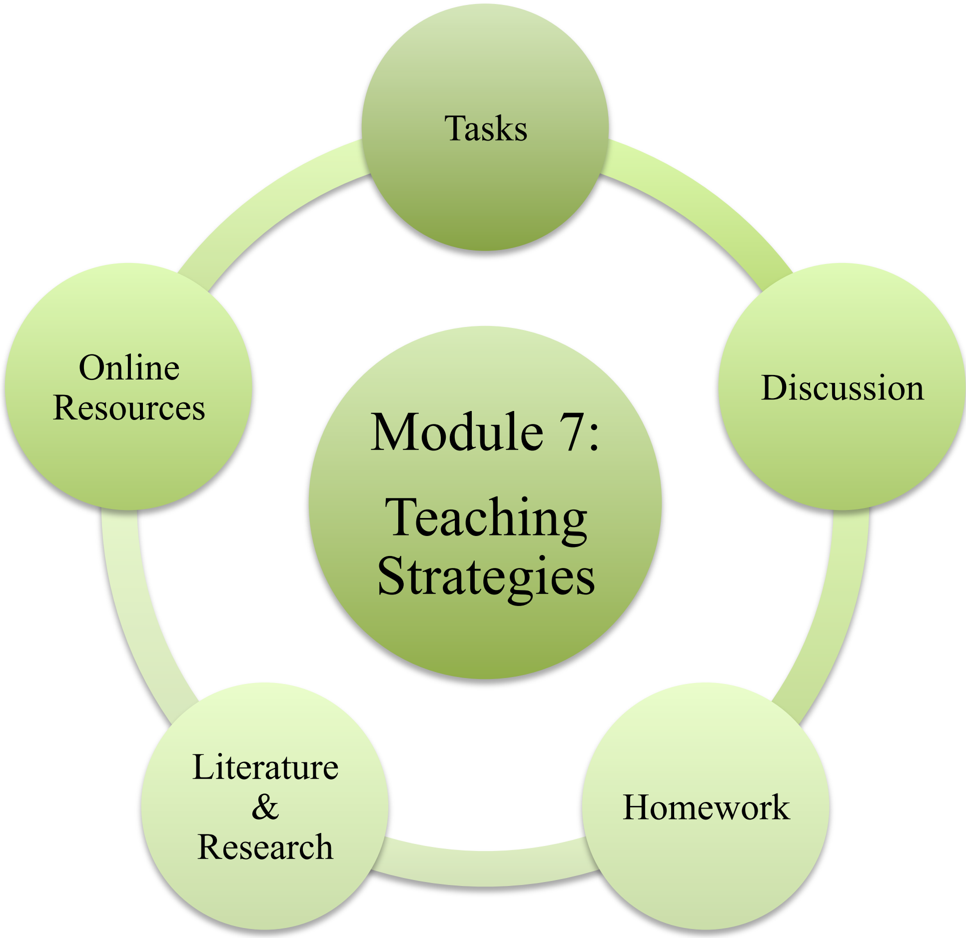
http://www.hawebmedia.com/activites/enrichment/index.html

http://www.hawebmedia.com/activites/enrichment/index.html

http://www.hawebmedia.com/activites/enrichment/index.html

http://www.sadlier-oxford.com/math/mc_enrichment.cfm?grade=2&sp=student

http://www.crickweb.co.uk/assets/resources/flash.php?&file=tangram



Module 7: Teaching Strategies is made up of tasks, discussions, homework assignments, literature, research, and online resources. In order to reap the full benefits of this module, all parts should be completed. However, aspects of the module can be modified or omitted depending on the circumstances of the educational situation. Additionally, parts of different modules can be blended together for a more integrated approach.

Tasks and Discussions: Teaching Strategies

1.) Take one topic at a time, and have learning community members share the big ideas and teaching strategies associated with that topic. Use this time to explore online resources and literature to determine big ideas for each topic. Suggested topics include number sense, fractions, decimals, addition, subtraction, multiplication, division, geometry, measurement, geometry, algebra, data analysis, and problem solving. Structure should start with Grade 1 and progress to Grade 5 to provide a vertical perspective. Teachers should record what they learn in the following chart: (Example)

Topic of Study: Addition	
Big Ideas	Teaching Strategies

*This task will take several sessions to complete.

2.) Videotape yourself using a unique teaching strategy. Share with the learning community and elicit feedback.

3.) Lead the learning community in an activity that includes teaching strategies that have been successful in your classroom. Take turns playing the roles of students and teacher.

4.) Take turns bringing in lesson plans. Members of the learning community can view the lesson plans and brainstorm about ways to incorporate additional teaching strategies into the activities. They may also share ideas for strategies to supplement the lessons.

5.) Facilitate a mock math lesson that includes various teaching strategies. Discuss additional teaching strategies that could enhance the lesson.

6.) Share ways in which you have used online resources in your classroom, or applied new knowledge gained from literature and research.

7.) Interview a teacher at the grade level above the one you teach. Ask specifically about teaching strategies he or she uses to prepare students for math at his or her grade level.

8.) Interview a teacher at the grade level below the one you teach. Ask specifically about teaching strategies he or she uses to reach learners who struggle.

9.) Field Trip! Go to the Computer Lab and explore online resources (attached). Write down ideas for applying what you find in your classroom.

10.) Discussion:

-Share ideas about how you can improve your instruction regarding by applying varied teaching strategies.

-Share experiences about how you teach different math topics. What has worked well? What would you like to learn more about? What do your students struggle with?

11.) Hold a candid discussion about how some teaching strategies can be counterproductive to learning. Another way of thinking of this is how some teaching strategies limit students' understanding or ability to expand skills in higher grade levels. Explicitly show error patterns that you see, and brainstorm about how teaching strategies can sometimes lead to misconceptions. Most importantly, explore appropriate ways to address these misconceptions through utilizing new strategies or modifying some current ones.

12.) Report and discuss findings from observations of elementary lessons or college math methods courses.

13.) Watch several of the www.youtube.com videos located in the online resources for this module. Discuss the pros and cons of each strategy. Analyze how strategies could be beneficial or could lead to misconceptions.

14.) Read *Teaching Student-Centered Mathematics* Volumes 1 and 2: Chapter One - Foundations of Student-Centered Instruction (Van de Walle & Lovin, 2005). Discuss in terms of relevance in your classroom.

Homework Assignments: Teaching Strategies

1.) Bring in any resources you have on teaching strategies to share with the learning community. This would include demonstrating how you use particular manipulatives or online resources to enhance learning. This task would take several sessions to complete.

2.) Interview another teacher about the different teaching strategies he or she uses when teaching particular topics. Report what you find out at a learning community session.

3.) Prepare an activity that incorporates teaching strategies you want to share with others. Present at learning community session. Ask teachers for feedback.

4.) Explore several of the items from the Literature & Research section at the end of this module. Write down any insights you gain. This assignment, and all Literature & Research assignments could be modified as follows:

Assign each member specific article(s) or online resource(s) to explore. Be ready to summarize insights or demonstrate relevant use for information you find.

5.) Observe several math lessons (in multiple grade levels) and write down the different teaching strategies you see. Provide feedback to the teacher regarding the lessons and how concepts would apply in different grade levels or with different mathematical concepts. Share your own teaching strategies with the person you observe and with members of the learning community.

6.) Videotape yourself teaching a lesson that includes different teaching strategies. Share this at a learning community session. Ask teachers to provide feedback about your instruction and the activity itself.

7.) Conduct an internet search for teaching strategies on various math topics. Share what you find with the learning community.

8.) Generate a list of needs or concerns (support) for parents or administrators to assist in learning new teaching strategies.

9.) Arrange to observe math lessons in schools outside the local district. Bring back your findings to share with the learning community.

10.) Arrange to sit in on a Math Methods education course at a local college, such as Dalton State College, Northwestern Technical College, Covenant College, or University of Tennessee at Chattanooga. Specifically observe with teaching strategies in mind. Bring back your findings to share with the learning community.

11.) Organize and host a Family Involvement Night, Parent Education Class, or some other venue for promoting the school-family partnership in math education. This could also involve creating a resource for home use, such as a Math DVD or handbook organized by topic or grade level.

Literature & Research: Teaching Strategies

Books and Articles

Alsup, J. (2004). A comparison of constructivist and traditional instruction in mathematics. *Educational Research Quarterly**, 28***(4), 3-15.

Bracey, G. W. (2000). Trying to understand teaching math for understanding. *Phi Delta Kappan, 81*(6), 473-474.

Burke, D., & Dunn, R. (2002). Teaching mathematics effectively to elementary students. *Academic Exchange*, 91-95.

Burns, M. (1998, April). Can I balance arithmetic instruction with real-life mathematics? *Instructor,* 55-58.

Caron, T. A. (2007). Learning multiplication the easy way. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 80*(6), 278-282.

Cavanagh, S. (2006a). Big cities credit conceptual mathematics for higher scores. *Education Week, 25*(18), 1-3.

Cavanagh, S. (2006b). China takes different tack from U.S. in teaching mathematics and science. *Education Week, 25*(41), 7.

Cole, J., & Wasburn-Moses, L. (2010). Going beyond "The Math Wars". *Teaching Exceptional Children, 42*(4), 14-20.

Chung, I. (2004). A comparative assessment of constructivist and traditionalist approaches to establishing mathematical connections in learning multiplication. *Education, 125*(2), 271-278.

Ciancone, T., & Tout, D. (2001). Learning outcomes: Skills or function? In *The International Conference of Adults Learning Mathematics.* Boston, MA.

Dogan-Dunlap, H. (2007). Changing students' perception of mathematics through an integrated, collaborative, field-based approach to teaching and learning mathematics. In *Joint Mathematics Meetings of the AMS/MAA*. Phoenix, Arizona.

Ediger, M. (2005). Teaching mathematics in the school setting. *College Student Journal, 39*(4), 711-715.

Furner, J. M., Yahya, N., & Duffy, M. L. (2005). Teach mathematics: Strategies to reach all students. *Intervention in School and Clinic, 41*(1), 16-23.

Gersten, R., & Chard, D. (1999). Number sense: Rethinking arithmetic instruction for students with mathematical disabilities. *Journal of Special Education, 33*(1), 18-28.

Gilliland, K. (2002). Why not just use a formula? *Mathematics Teaching in the Middle School, 7*, 510-511.

Graeber, A. O. (2005). Mathematics instruction across the grades: What consultants should know. *Journal of Educational and Psychological Consultation, 16*(4), 349-362.

Hibbs, J. (2004). Thoughts about mathematical discussion. *Mathematics Teaching, 189*, 40.

House, P. A. (2003). “Integrated mathematics: An introduction.” In *Integrated Mathematics Choices and Challenges,* edited by Sue Ann McGraw, pp. 5-6. Reston, VA: NCTM.

Hudson, P., Miller, S. P., & Butler, F. (2006). Adapting and merging explicit instruction within reform based mathematics classrooms. *American Secondary Education, 35*(1), 19-32.

Kamii, C., & Lewis, B. A. (1993). The harmful effects of algorithms . . . in primary arithmetic. *Teaching PreK-8, 23*(4), 36-39.

London, R. (2004). What is essential in mathematics education? A holistic viewpoint. *ENCOUNTER: Education for Meaning and Social Justice, 17*(3), 30-36.

Mann, E. L. (2006). Creativity: The essence of mathematics. *Journal for the Education of the Gifted, 30*(2), 236-260.

May, L. (1996). Extending problem-solving. *Teaching PreK-8, 26*(4), 22-23.

Montague, M. (2003). Teaching division to students with learning disabilities: A constructivist approach. *Exceptionality, 11*(3), 165-175.

Mortiboys, A. (1984). *Numeracy: Linking skills to application*. London: Adult Literacy and Basic Skills Unit.

Mtetwa, D., & Garofalo, J. (1989). Beliefs about mathematics: An overlooked aspect of student difficulties. *Academic Therapy, 24*, 611.

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

Patton, B. A., Fry, J., & Klages, C. (2008). Teacher candidates and master mathematics teachers' personal concepts about teaching mathematics. *Education, 128*(3), 486-497.

Reinhart, S. C. (2000). Never say anything a kid can say! *Mathematics Teaching in the Middle School, 5*(8), 478-481.

Resnick, L. B. (Ed.). (2006). Do the mathematics: Cognitive demand makes a difference. *Research Points: Information for Education Policy,* 1-4.

Sarama, J., & Clements, D. H. (2006). Teaching mathematics: A place to start. *Early Childhood Today, 20*(4), 15.

Saville, B. K., Zinn, T. E., & Elliott, M. P. (2005). Interteaching versus traditional methods of instruction: A preliminary analysis. *Teaching of Psychology, 32*(3), 161-163.

Schifter, D. (November, 2007). What's right about looking at what's wrong? *Educational Leadership*, 22-27.

Theriot, S., & Tice, K. C. (2009). Teachers' knowledge development and change: Untangling beliefs and practices. *Literacy Research and Instruction, 48*, 65-75.

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Van de Walle, J. A., & Lovin, L. A. (2005). *Teaching student-centered mathematics*. New York, NY: Allyn & Bacon.

Wong, M., & Evans, D. (2007). Improving basic multiplication fact recall for primary school students. *Mathematics Education Research Journal, 19*(1), 89-106.

Westwood, P. (2003). Drilling basic number facts: Should we or should we not? *Journal of Learning Disabilities, 8*(4), 12-18.

Online Resources

http://www.learner.org/resources/series32.html?pop=yes&pid=871

http://www.youtube.com/watch?v=yoac4xzIhSw

http://www.math-videos-online.com/

http://www.mathplayground.com/mathvideos.html

http://www.pbs.org/teachers/classroom/k-2/math/

http://www.pbs.org/teachers/classroom/3-5/math/

http://www.pbs.org/teachers/stem/math/

http://illuminations.nctm.org/reflections/index.html

http://www.mathtv.org/

http://www.edutopia.org/math-social-activity-sel-video

http://youtube.com/watch?v=PHwrehm6HO8

http://www.ehow.com/video_4974351_math-teaching-aids.html

http://math4children.com/videos.html

http://www.youtube.com/watch?v=j8ZUIgzmgvw

http://www.youtube.com/watch?v=BXrUSg2Qds8

http://www.youtube.com/watch?v=N1ALx5q6jO4

http://www.youtube.com/watch?v=v6oJ5rw9mys

http://teachertube.com/searchList.php?search_type=video&tags=math

Appendix B: Teacher Interview Protocol

INTERVIEW PROTOCOL: Mathematics Instruction and Professional Development

Participant:	Date
Beginning Time:	Ending Time:

Guiding Questions
In order to improve student achievement in mathematics at ABC Elementary School, what aspects of mathematics instruction should be addressed? What types of professional development experiences do ABC Elementary School teachers perceive will best enable them to increase student achievement in mathematics?

Thank you for agreeing to be interviewed. Your identity and responses will be kept confidential. The data gathered from this study will be reported in a doctoral dissertation and used to inform the design of a professional development program for teachers in mathematics. There are no right or wrong answers. Your participation in this interview is voluntary and you may end the interview at any time.

Background Questions:

How long have you been working in education?

Tell me about your own experience as an elementary student in math class.

How do you feel your own learning experiences in math impact your teaching?

Formal Interview Questions For Teachers:

For Guiding Question #1: Concerning Mathematics Instruction

1. What are the main principles, or big ideas, that guide you in your math instruction?

Possible Probing Questions:

What do you believe about procedural knowledge?

What do you believe about conceptual knowledge?

2. Within your math instruction, how do you help students achieve deep understandings of mathematical concepts?

3. Can you think of math topics in which learning an algorithm, or memorizing a specific strategy, is necessary?

4. What aspects of math instruction do you personally need to learn more about?

5. According to various data that you have examined during the past few years, what areas of math instruction are in need of improvement at this school?

For Guiding Question #2: Concerning Professional Development

6. Professional development is defined as "ongoing learning by teachers to fulfill the purposes of improving instruction and enhancing learning for students." There are many models of professional development that differ from traditional inservice sessions. These include book studies, lesson studies, teacher study groups, collaborative learning communities, etc. If you could design your own professional development program to improve math instruction at this school, what would it look like?

Possible Probing Questions:

In general, what kinds of professional development experiences do you find to be the most beneficial?

What kinds of professional development experiences are not helpful to you?

7. Instructional expectations for math have undergone major changes recently due to the curriculum change, as you know. What are some ways teachers can familiarize themselves with the new instructional expectations?

8. How can teachers increase their knowledge about math content and pedagogy?

9. What do you think teachers can do to increase student achievement in math on the CRCT?

10. What kinds of support do you need in order to teach math for understanding?

11. The end result of this study will be a professional development program for elementary school math teachers. Do you have any final comments or input that could contribute to the program?

Appendix C: Administrator Interview Protocol

INTERVIEW PROTOCOL: Mathematics Instruction and Professional Development

Participant:	Date
Beginning Time:	Ending Time:

Guiding Questions
In order to improve student achievement in mathematics at ABC Elementary School, what aspects of mathematics instruction should be addressed? What types of professional development experiences do ABC Elementary School teachers perceive will best enable them to increase student achievement in mathematics?

Thank you for agreeing to be interviewed. Your identity and responses will be kept confidential. The data gathered from this study will be reported in a doctoral dissertation and used to inform the design of a professional development program for teachers in mathematics. There are no right or wrong answers. Your participation in this interview is voluntary and you may end the interview at any time.

Background Questions:

How long have you been working in education?

Tell me about your own experience as an elementary student in math class.

How do you feel your own learning experiences in math impact your teaching?

Formal Interview Questions For Administrators:

For Guiding Question #1: Concerning Mathematics Instruction

1. What are the main principles, or big ideas, that should guide math instruction?

Possible Probing Questions:

What do you believe about procedural knowledge?

What do you believe about conceptual knowledge?

2. Within math instruction at this school, how do teachers help students achieve deep understandings of mathematical concepts?

3. Can you think of math topics in which learning an algorithm, or memorizing a specific strategy, is necessary?

4. What aspects of math instruction do you believe teachers need to learn more about?

5. According to various data that you have examined during the past few years, what areas of math instruction are in need of improvement at this school?

For Guiding Question #2: Concerning Professional Development

6. Professional development is defined as "ongoing learning by teachers to fulfill the purposes of improving instruction and enhancing learning for students." There are many models of professional development that differ from traditional inservice sessions. These include book studies, lesson studies, teacher study groups, collaborative learning communities, etc. If you could design your own professional development program to improve math instruction at this school, what would it look like?

Possible Probing Questions:

In general, what kinds of professional development experiences do you find to be the most beneficial?

What kinds of professional development experiences are not helpful to you?

7. Instructional expectations for math have undergone major changes recently due to the curriculum change, as you know. What are some ways teachers can familiarize themselves with the new instructional expectations?

8. How can teachers increase their knowledge about math content and pedagogy?

9. What do you think teachers can do to increase student achievement in math on the CRCT?

10. What kinds of support do teachers need in order to teach math for understanding?

11. The end result of this study will be a professional development program for elementary school math teachers. Do you have any final comments or input that could contribute to the program?

Curriculum Vitae

Carrie Dixon Scoggins

livn_4christ@yahoo.com

Experience

2005 – Present: ABC Elementary School – Mathematics Lab Teacher & Interventionist

2003 – 2005: Oglethorpe County Primary School – 2^{nd} Grade Teacher

2002 – 2003: Brookwood Primary School – Pre-Kindergarten Teacher

2001 – 2002: Fairyland Elementary School – Kindergarten Intervention Teacher

Education

2006 – 2010: Walden University – Ed.D. in Teacher Leadership

2004 – 2005: Piedmont College – M. A. in Early Childhood Education

1999 – 2001: State University of West Georgia – B. S. in Early Childhood Education

1996 – 1999: Dalton State College – A. S. in Education

International Practice

Summer 2001: Budapest Hungary – Childcare Program

Summer 2000: Nairobi, Kenya – School Visitations, Performances, and Speaking Engagements

Summer 2000: Kasaali B., Lake Victoria, Uganda – Activities with Children and Sudanese Refugees

Summers1999 & 2000: Jamaica – CCCD Deaf School Volunteer

Summer 1998: Netherlands – Sports and Drama Clinics

Additional Work

Present: Chattanooga, Tennessee – Church Nursery Volunteer

Summer 2008: Chattanooga, Tennessee – Summer Camp Bible Teacher

Summers 1999, 2000, & 2001: Conyers, Georgia – Urban Camp Counselor