PROCEDURAL AND CONCEPTUAL KNOWLEDGE: A BALANCED APPROACH?

By

Patricia Gaffney Kridler
A Dissertation
Submitted to the
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The Requirements for the Degree
of
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Education

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Dedication

This is dedicated to my family and my students. My husband, Brad, has been there for me throughout my various educational endeavors. Without his support, both financially and emotionally, I would never have made it through this process. I would also like to recognize my parents' inspirational role in my life. Without ever speaking the words, you instilled in me the belief that I can accomplish whatever I set my mind to – and so I have. Finally, to all the students who have asked me questions. You continue to help me learn and grow as a mathematics educator. Keep them coming!

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Table of Contents

List of Tables

List of Figures

Abstract

PROCEDURAL AND CONCEPTUAL KNOWLEDGE: A BALANCED APPROACH?

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Mathematics curricula tend to focus either on the development of procedural knowledge or conceptual knowledge yet research support an iterative development of these knowledge types. Research also suggests that teachers should move beyond strictly using curriculum and move toward being the developers of their curricula. Using multiple case study analysis, this qualitative study explored the factors that influenced four middle school mathematics teachers as they planned and implemented mathematics tasks for their students. The participants were influenced by a variety of factors including time constraints, experience with teaching resources, connections with their students, and ability to be organized yet flexible with their planning and teaching. This study further investigated whether balancing the development of procedural and conceptual knowledge with their students influenced the teachers during the planning and implementation of mathematics instruction. The participants fell into two distinct groups. One group gave equal time to the development of the two knowledge types, but treated them separately,

failing to assist their students with connections between concepts and procedures. The second group planned and implemented lessons that evolved from concrete to abstract while making connections between concepts and procedures. Neither group recognized the need for curriculum resources that could assist them with the task of connecting mathematical concepts to procedural skills. The field of mathematics education could benefit from additional research studies that engage teachers in the planning and implementation of units of study that both balance and connect conceptual and procedural knowledge with students.

1. Introduction

On any given day in mathematics classrooms across the nation, a variety of factors impact classroom teachers as they plan and implement mathematics instruction. Factors such as teachers' pedagogical content and mathematics content knowledge, perceptions of curriculum, beliefs, goals, and experience impact the teachers as they plan tasks for their students (Remillard, 2005). In addition, a variety of features of the curriculum influence how teachers interact with these materials. How the materials represent concepts and tasks, the way material is presented, and the physical objects used to represent the concepts influence what materials teachers select for use with their students (Remillard, 2005). Yet another host of factors influence the teachers when their planned curricula are enacted in the classroom. The classroom students play an essential role in this "construction arena" (Remillard, 1999, p. 322) as teachers adjust their planned tasks in response to their students' interactions with the tasks during implementation.

Using multiple case study analysis, this study explored the factors that influenced middle school mathematics teachers as they planned and implemented mathematics tasks for their students. In addition, the impact that curriculum resources had on the teachers was also examined. Finally, and more specifically, this study investigated whether balancing the development of procedural and conceptual knowledge with their students influenced the teachers during the planning and implementation of mathematics instruction.

Background to the Problem

Discussions on what we teach, when we teach it, and how we teach it with respect to mathematics, have been ongoing for quite some time in the mathematics and the mathematics education fields. International comparisons of textbooks have demonstrated that, in the United States, we are trying to teach too much material, too quickly to students (Schmidt, McKnight, & Raizen, 1996). This sentiment has been expressed countless times with reference to the curriculum in the U.S. as "a mile wide and an inch deep" (e.g., Schmidt, Houang, & Cogan, 2002). The results of this national problem have been documented in national and international studies such as the National Assessment of Educational Progress (NAEP) and the Trends in International Mathematics and Science Studies (TIMSS). The United States is not sufficiently progressing in the area of mathematics achievement and, in fact, we are falling further behind when compared to other developed nations (Gonzales, et al., 2004; Perle, Moran, Lutkus, & Tirre, 2005).

One reaction to the national situation was the enactment of the No Child Left Behind Act in 2002. With the admirable goal of ensuring proficiency for every student in reading and mathematics, this act has increased the focus on the performance of all students which should be viewed as a positive change. Unfortunately, many educators have experienced the dark side of testing that came with the law. Although there have been many challenges to this policy and calls to repeal or revise it, the concept of "accountability" is likely to stay a part of the U. S. educational system.

Another response to poor student achievement in mathematics came from the National Council for Teachers of Mathematics (NCTM). NCTM produced several documents including the *Principles and Standards for School Mathematics* (2000), the *Curriculum Focal Points* (2006), and, more recently, the *Guiding Principles for Mathematics Curriculum and Assessment* (2009) and the Common Core State Standards Initiative (2010) in order to address this national problem and to provide guidance to policy makers, researchers, teacher educators, and teachers. Also, the National Science Foundation (NSF) funded the development of a collection of standards-based curriculum materials at the K-12 level to assist teachers with implementing the NCTM *Standards*. A variety of research has been conducted on the effectiveness of these materials, some of which is documented in *Standards-Based School Mathematics Curricula: What Are They? What Do Students Learn* (Senk & Thompson, 2003). In general, the results of these early studies showed an increase in students' problem solving and reasoning abilities, but little if any gains in procedural skills.

Teacher educators play a key role in this problem as they strive to prepare effective mathematics teachers. These educators often have questions about what mathematical content teachers need, what materials they should teach with, and what methods will help ensure that future teachers are prepared to teach mathematics with understanding to all students. There is research that supports the view that exposing teachers and pre-service teachers to standards-based materials and allowing them to struggle with the mathematics helps them learn about how children think, focus on the mathematics content, and make connections between how they learn and how students learn (Frykholm, 2005; Grant, Kline, & Weinhold, 2002; Lloyd & Frykholm, 2000; Ma, 1999; Remillard, 2000). When teachers are exposed to these materials, and more importantly the methods used with them, they appear to change their beliefs about what "good" mathematics instruction looks like (Frykholm, 2005; Kelly, 2001; Spielman & Lloyd, 2004).

The change in curriculum materials and the methods to teach them sparked a fierce, on-going debate in many school districts across the country. The so-called "Math Wars" pit traditional teaching materials and methods against the standards-based materials and methods supported by NCTM and NSF (Schoenfeld, 2004). This battle, not unlike the controversy surrounding phonics versus whole language in the literacy community, takes a one-way approach to mathematics instruction that sets the development of procedural and conceptual knowledge in opposition to each other. The research community has concerned itself with this issue for many years. Discussions of how students learn mathematics with respect to procedural and conceptual knowledge and therefore how they may best be taught are still on-going, but there is a growing consensus that it is the relationship between these two forms of knowledge that is crucial (Hiebert & Lefevre, 1986; National Research Council, 2001). Additional literature (Baroody, Feil, & Johnson, 2007, Riddle-Johnson, Schneider, & Star, 2011; Rittle-Johnson, Siegler, & Alibali, 2001; Schneider & Stern, 2005) also suggests a concepts-first or a bi-directional model may accurately represent how this knowledge develops in children.

Problem Statement

If the development of procedural and conceptual knowledge is indeed an iterative process (Riddle-Johnson, Schneider, & Star, 2011; Rittle-Johnson, Siegler, & Alibali, 2001) then difficulties arise for teachers in classrooms with traditional curriculum materials that focus mainly on developing procedural knowledge. Different, but just as difficult, are the problems faced by teachers when using standards-based curriculum materials that focus mainly on developing conceptual knowledge. In their synthesis of how curriculum influences students and teachers, Stein, Remillard, and Smith (2007) conclude by stating that “Perhaps the most pressing question is how to combine the best of both conventional and standards-based curricula into a more unified and balanced approach” (p. 362). To address this, research seems to indicate a trend toward focusing on teachers, not just as the users of the curriculum, but rather as curriculum developers (Lloyd & Behm, 2005; Remillard, 1999; Stein, Remillard, & Smith, 2007).

An examination of teachers who are viewed as strong in the area of curriculum development as they plan and implement mathematics tasks is essential in order to learn more about the variety of factors that influence such teachers. Through the exploration of these factors, important information can be gathered about curriculum resources that are selected and or modified for use. In addition, such an examination can begin to shed light on whether these teachers focus on balancing the development of procedural and conceptual knowledge and, if so, such an investigation can further our understanding of how that balance can best be achieved.

Purpose of the Study

Recent mathematics curricula literature has been largely focused on the impact that traditional and standards-based curricula have on both teachers and students. Separate from this literature, but intricately connected to it, another branch of existing literature suggests that students develop understanding in mathematics through the iterative development of both procedural and conceptual knowledge. In order to add to and connect the existing literature base, the purpose of this study was to explore the interaction between teachers and their curriculum materials in the context of the classroom in order to learn more about the factors that influence these teachers. Specifically, this study explored whether the balanced development of procedural and conceptual knowledge factored into the teachers' planning and if so, how did the teachers attempt to balance these knowledge types and why.

Research Questions

The following research questions guided this exploration of teacher/curriculum interaction:

1. What factors influence middle school mathematics teachers who have a participatory relationship with their curricula as they plan tasks and implement them in their classrooms?
2. Do middle school mathematics teachers who have a participatory relationship with their curricula select and/or modify resources for use? If so, what factors influence them when they select resources and/or modify the tasks as presented in the resources?

3. Do middle school mathematics teachers who have a participatory relationship with their curricula balance the development of procedural and conceptual knowledge as they plan and implement instruction? If so, how do they attempt to achieve that balance and why?

Research question one was broad in nature in order to capture the variety of factors that influenced the teachers during the planning and implementation of instruction. The second research questions was focused on the resources that the teachers selected for use in order to gain insight into what curriculum materials and other resources the teachers selected, their reasons for selecting these materials/resources and, if applicable, the modifications made to the materials/resources and the teachers' reasons for making these modifications. The final research question further focused this study by asking whether teachers focused on the balanced development of both procedural and conceptual knowledge as they planned and implemented instruction. This final question included an extension in order to gain insight into both the tasks the teachers selected in their attempt to balance the development of the different knowledge types and their reasons for selecting these tasks.

Conceptual Framework

Remillard (2005) offers a framework for the teacher-curriculum relationship that "assumes a perspective that curriculum use involves a participatory relationship between the teacher and the curriculum, and it highlights this relationship as a needed focus of further research" (p. 236). This framework, which is detailed in Chapter 2, has been used to guide the formation of research questions and the research methodology for this study.

Research questions 1 and 2 are focused on answering Remillard's call, mentioned in the quote above, to further explore the teacher-curriculum relationship. Research question 3, focused specifically on the balancing of conceptual and procedural knowledge with students and is clearly connected to this framework through the selection of teachers for the study. Participants for this study were purposefully selected in order to observe teachers who were perceived as having a "participatory relationship" with their curriculum. If teachers had instead been randomly selected for this study, it is possible that the teachers selected could have fallen into a category of curriculum use referred to as following the text. Given that the district involved in this study has adopted traditional textbooks, if the teachers selected for this study were strictly following the textbook, it is likely that the results would have yielded a focus on the development of procedures only. Therefore, in order to effectively answer question 3, it was essential to select teachers who were viewed as having a participatory relationship with their curriculum.

Remillard's (2005) framework detailing the components of the teacher-curriculum relationship along with her framework on teachers' curriculum development (1999) were also used to guide the research methodology for this study. A qualitative, multiple case study analysis was used in order to explore the factors that influenced teachers in both the design arena (planning) and construction arena (implementation) of teachers' curriculum development. Because the curriculum as planned by the teacher can easily be affected and/or modified when it is enacted in the classroom, a qualitative study involving both teacher interviews concerning their plans for instruction and classroom observations of the plans as enacted in the classroom were essential to this study. The use of multiple case studies involving teachers from different schools, at different grade levels, and teaching different content assisted in the generation of a variety of factors that influence teachers during planning and implementation and also allowed for the comparison of themes that are common across cases.

Significance of the Study

The results of this study are significant for research, practice, and policy. In its open exploration of possible factors that influence middle school mathematics teachers as they plan and implement instruction, this study contributes to the current research on teacher-curriculum interaction. The study adds to the existing literature, by focusing on whether the development of procedural and conceptual knowledge impacts teachers as they plan and implement mathematics instruction with their students.

Teacher educators, teachers, and curriculum developers need to ensure that in their quest to steer away from a ‘procedures only’ approach to mathematics education, they do not swing too far in the direction of a concepts only approach. Teachers and students need to learn mathematics in ways that make explicit the connection between concepts and procedures in order to develop a deep understanding of mathematics and to be able to apply it flexibly. By providing examples of how teachers planned for and enacted tasks, the factors that influenced them throughout this process, and the difficulties that teachers encountered in this process, this study offers some insight and suggestions that can be used to guide the development of curriculum materials along with future teacher development tasks. Finally, in noting the significant role that state standards and testing play in teachers’ selection of tasks and resources and the mismatch that teachers find between their curriculum materials and state standards, this study offers some suggestions for the guidance of future state and national policy decisions.

Definitions of Key Terms

Before proceeding any further in this dissertation, it is necessary to define the terms that will be used. Some of the terms used in this paper, such as procedural and conceptual knowledge, mean different things to different people. In order to clarify the meaning of terms that will be used throughout this paper, Table 1 presents key terms and the meaning that will be attributed to those terms.

Table 1

Definition of Key Terms

Term	Definition
Conceptual knowledge	Knowledge of mathematical concepts and understanding of the relationships/connections between concepts (Hiebert & Lefevre, 1986; Rittle-Johnson, Siegler, & Alibali, 2001).
Curriculum materials	Include textbooks adopted by district for use and all associated resources that come with the textbook. Also includes all resources selected by teachers to be used with students including resources such as worksheets, videos, Smart Board activities, and physical and/or virtual manipulatives.
Pacing guide	The district's grade level pacing guides developed using the Virginia Standard of Learning objectives. Details the order the objectives should be taught and the approximate time that should be spent on each objective. It should be noted that some teachers refer to the pacing guide as their "curriculum."
Participatory relationship	Teachers "participate" with their curriculum when they are influenced both by the factors that they bring with them when reading curriculum materials (e.g. mathematical content knowledge, perceptions of students) and they allow various factors of the curriculum materials (e.g. the structure or look of the material, the way concepts are represented in the material) to influence them (Remillard, 2005).
Procedural knowledge	Includes both knowledge of symbols and conventions for their use and the knowledge necessary to apply rules, procedures, and/or algorithms (Hiebert & Lefevre, 1986; Rittle-Johnson, Siegler, & Alibali, 2001).
Standards-based	Based on NCTM's *Principles and Standards of School Mathematics* (2000).
State standards	Virginia's Mathematics Standards of Learning (SOL) that are tested annually in grades three through eight and High School courses in Algebra I and II, and Geometry.

Organization of the Study

Chapter 1 contains the background information to the problem, problem statement, purpose of the study, research questions, significance of the study, and definition of key terms. Also included in this chapter is a brief discussion of the conceptual framework that guided the design of the study. Chapter 2 presents the conceptual framework that provided the foundation for this study and guided the study design. This chapter then describes the literature on how procedural and conceptual knowledge are developed and the impact that this development has on students and teachers. Chapter 3 details the design and methodology of the study. Specifics on the data sources and how the data were collected and analyzed are provided along with an account of the limitations and ethical considerations for this study.

Chapter 4 contains the cross-case findings for two of the teachers involved in the study who were found to balance the development of procedural and conceptual knowledge by providing a separate approach. In Chapter 5, the findings for two other teachers in the study will be presented. These teachers were found to balance the two knowledge types by using a balanced and connected approach.

Chapter 6 presents the results and the conclusions from this study. The research findings across the multiple cases are presented for each of the three research questions. A brief summary of the findings along with their relationship to the literature is presented next. The chapter concludes with some possible implications for research and practice.

2. Literature Review

Should mathematics teachers focus on the development of procedural knowledge, conceptual knowledge, or both with their students? This question has been analyzed and debated by researchers well before Hiebert and Lefevre (1986) stated "Questions of how students learn mathematics, and especially how they should be taught, turn on speculations about which type of knowledge is more important or what might be an appropriate balance between them" (p. 1). Without specifically addressing this question, the current debate over mathematics curricula dubbed the "Math Wars" centers on this very issue. On one side there is the traditional curricula focused on developing students' procedural fluency. At the other end of the spectrum is the standards-based curricula with its goal of helping students understand concepts. All along the continuum in-between are mathematics teachers working with these respective materials and their students in order to enhance student learning.

Conceptual Framework

This study was guided by frameworks that focus on the relationship between teachers and curricula during the planning and implementation of instruction. Throughout this study, teachers' use of curriculum will refer to "how individual teachers interact with draw on, refer to, and are influenced by material resources designed to guide instruction" (Remillard, 2005, p. 212). In her examination of research on teachers' curriculum use, Remillard (2005) described four conceptions of curriculum use and the key assumptions and theoretical perspectives that influence them. These conceptions include following or subverting, drawing on, interpreting, and participating with the curriculum materials. The framework she proposed (Figure 1) focuses on the participatory relationship between the teacher and the curriculum. She stated that this perspective assumes "that teachers and curriculum materials are engaged in a dynamic interrelationship that involves participation on the parts of both the teacher and the text" (p. 221). That is, teachers come to the materials with a variety of factors, as depicted in Figure 1, that influence them as they read their materials but the materials also have features that bring about a change in how the teachers read them.

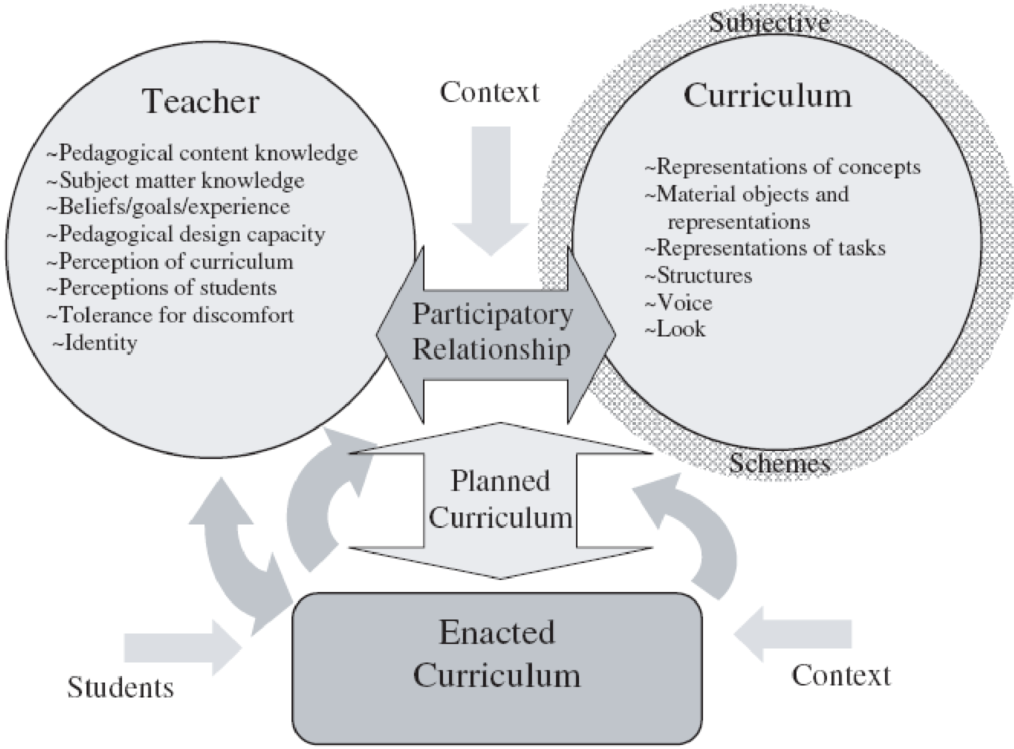

Figure 1. *Framework of components of teacher-curriculum relationship* (Figure repeated on page 153) (Remillard, 2005, p. 235)

In the exploration of factors that influence teachers as they plan and implement instruction, this study also pulled from earlier work by Remillard (1999) that focused on the teachers' role during curriculum development. The model depicted in Figure 2, complements the previous framework by focusing on the planning that takes place in the design arena and the enacted curriculum that occurs in the construction arena. In this model, the design arena encompasses a variety of factors that influence the tasks that teachers select and/or design. The participatory relationship of the teacher with her/his materials is a crucial feature in this arena. The construction arena encompasses what happens to the planned curriculum in the real-world context of the classroom.

Specifically, the focus in this arena is on the adjustments teachers make to planned tasks as the tasks interact with students during implementation. The curriculum mapping arena focuses on how the mathematics content is covered over the course of the year and, because this study only focused on the teachers during a portion of a unit, the curriculum mapping arena did not factor into this study.

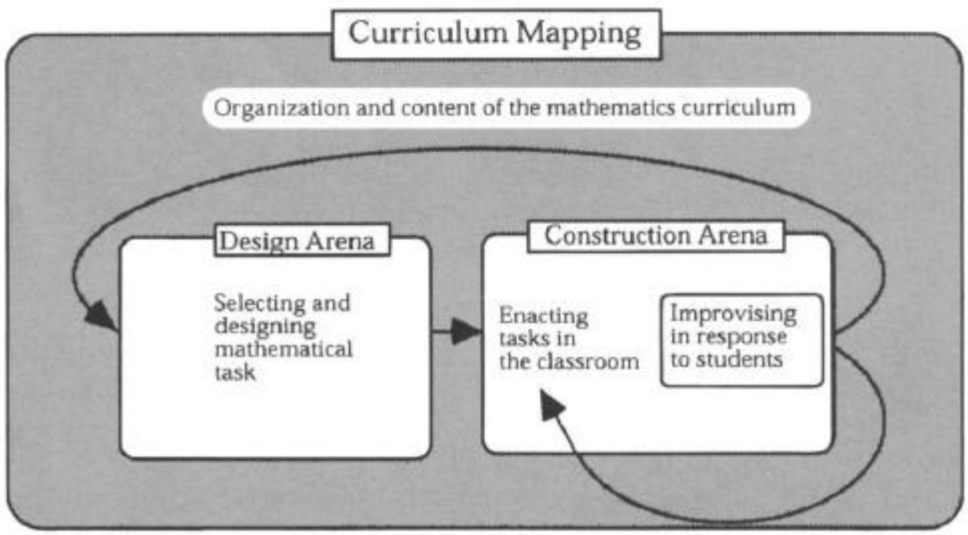

Figure 2. *Three arenas of teachers' curriculum development* (Remillard, 1999, p. 322)

The frameworks presented here support the current study in two critical ways. First, the focus on the participatory relationship between teacher and curriculum was an essential feature of this study. Because textbooks have generally focused heavily on either the development of procedural knowledge (traditional texts) or the development of conceptual knowledge (standards-based texts), teachers who simply follow or draw on their text will most likely design tasks that focus on the type of knowledge presented in their text. In contrast, teachers who have a participatory relationship with their text may be more likely to design tasks that balance these two knowledge types. The second key way these frameworks supported the current study was their focus on both the design and construction arenas. Although many of the factors that influence teachers occur during the planning stages, the students also play a critical role in this process as they interact with the tasks in the context of the classroom.

Remillard (2005) stated that the framework, depicted in Figure 1, contained two assumptions that are also essential to this study.

> Teaching involves curriculum design and that it is multifaceted. Together, these stances imply that teachers are engaged in design work throughout the multiple domains of teaching. Emphasizing the relationships among the participatory relationship, the planned curriculum, and the enacted curriculum allows the framework to represent the cycles of design before, during, and after classroom practice. (p. 236)

The use of this framework to guide the design of this study helped to ensure that the variety of factors that influenced the teachers as they planned and implemented instruction had the opportunity to surface.

In the sections that follow, the literature on the development of both procedural and conceptual knowledge will be addressed. In addition, the impact that the development of these knowledge types had on students and teachers will be presented. The goal of this section is to present these two knowledge types separately, with their individual benefits and drawbacks in order to make a case for the middle ground.

Approach to Literature

Throughout my doctoral studies (2004 through 2012), extensive literature searches have been conducted in the area of mathematics curricula reform and its impact on students and teachers. The results of these searches form the basis for this literature review and guided the direction of this study. In addition, an exhaustive search of peer reviewed journals and textbooks was conducted using the ERIC, Education Research Complete, PsycInfo, and Digital Dissertations databases. Sources were obtained from 2000 through 2012 in order to ensure that all related literature was considered. The following keywords were used during this research: mathematics curriculum, reform, academic achievement, teacher education, mathematics instruction, development, procedural knowledge, and conceptual knowledge.

Procedural Knowledge

Development of Procedural Knowledge

Star (2005) attempted to refocus attention on the development of procedural knowledge by first challenging Hiebert and Lefevre's (1986) definitions of procedural and conceptual knowledge stating that they entwine knowledge type with knowledge quality. The definitions along with many current beliefs about these knowledge types hold conceptual knowledge as knowledge that is rich in connections but procedural knowledge is considered very superficial. Star posited that procedural knowledge can be very rich in connections and went on to argue "against the premise that procedures learned without connections to concepts are necessarily and by definition rote" (2007, p. 134).

In an effort to demonstrate that there are ways for procedural knowledge to be known flexibly without conceptual understanding, Star and Seifert (2006) engaged sixth grade students in equation solving exercises. They concluded that although the students who were encouraged during the study to find alternative methods for solving equations were no more accurate with their solutions than the control group, they were able to demonstrate numerous solution paths without conceptually understanding why the various procedures worked. Hiebert and Wearne (1986) also found that procedures can be executed successfully without connections to the underlying conceptual features of the problem. However, they found that the failure of students to connect procedural and conceptual knowledge during the execution of procedures hindered the students' overall competence. Many of the students gave incorrect explanations of why decimals are lined up during addition and/ or believed it was acceptable to obtain two different answers to the same problem because different methods were used to solve the problems.

Although it may be possible to develop deep and flexible procedural knowledge in the absence of the development of and/or connections to conceptual knowledge, not even Star (2007) advocated for this. His intent was instead to point out that, due to the research community's extensive focus on conceptual knowledge, little focus has been placed on the study of how and why procedural knowledge develops. As a result, not much is known about how to measure procedural knowledge and how to design curricula that may foster procedural fluency (2007).

Student Impact

A quick look backwards to the school mathematics in the past and one can draw the following conclusion: Teaching mathematics procedurally has always worked for some students. The question that remains after that conclusion is: What about all of the other students? The answer to that question lies in the results of national and international assessments and in the diminishing ranks of qualified students entering the fields of science and mathematics.

Although the trends in the National Assessment of Educational Progress (Perle, Moran, Lutkus, & Tirre, 2005) found a significant improvement in mathematics scores from 1978 to 2004 for students in fourth and eighth grades, the same trend did not hold true for students in twelfth grade whose scores remained basically unchanged during that time period. A possible explanation for the increase in scores at lower grade levels could be that mathematical content had been added to the elementary school curricula over this same time frame. One would have a hard time arguing that students in fourth grade today are being exposed to the same topics they were 25 years ago. Algebra, geometry, and statistics were topics reserved for high school when scores were collected in the 1970's. With the increased exposure to additional content at the elementary level, has anything been lost? Snider (2004) argued that the general decline of scores at the middle and high school levels could be due to a lack of development of foundational skills in elementary school due to textbooks that include content that is a mile wide and an inch deep. Could this exposure to additional content earlier be both a possible cause for higher NAEP scores in fourth and eighth grades and an explanation for why twelfth grade scores have remained flat?

In addition to results on national assessments, the results of the Trends in International Mathematics and Science Study have also been published. The most recent report compared the performance of fourth and eighth grade students in the United States to the performance of students in over 25 different countries from 1995 to 2003 (Gonzales, et al., 2004). In this report, the performance of fourth grade students in the United States stayed the same from 1995 to 2003, but relative to their peers in other countries, they lost ground. In 1995, students in four other countries outperformed U.S. fourth graders and in 2003 seven other countries outperformed U.S. students. Although U.S. eighth graders in this same time frame raised their scores, by 2003 there were still seven countries achieving at significantly higher rates than U.S. eighth graders. Some progress has been made in the area of student achievement in mathematics but the overall performance of the nation's students on national and international assessments is still lacking. Based on these trends in achievement, a procedures based approach to mathematics does not appear to be positively impacting students.

Teacher Impact

The mathematics teachers in classrooms today are the product of a system of mathematics education that focused on the development of procedural knowledge. Although some of these teachers excelled in this environment, many did not and as a result have poor self-images of themselves as users of mathematics and poor attitudes toward mathematics as a discipline (e.g. Ball, 1997; Gellert, 2000). In addition, because teachers' experiences with learning mathematics have been mainly through direct instruction, they tend to believe that teacher directed lectures are important if not necessary to the teaching of mathematics (e.g. Kelly, 2001; Spielman & Lloyd, 2004).

Procedurally based teaching methods are well documented in U.S. classrooms. In Stigler and Hiebert's *The Teaching Gap* (1999), and similar studies (Davis & Barnard, 2000; Jacobs, Hiebert, Givven, Hollingsworth, Garnier, & Wearne, 2006), researchers have consistently found instruction that is dominated by procedures and not reflective of the National Council of Teachers of Mathematics (NCTM) *Principles and Standards of School Mathematics* (2000). Also, Snider (2004) stressed that typically 75 to 90% of instruction was organized around textbooks that in turn are mainly procedurally based, cover approximately one concept per class period, and rarely connect concepts.

In addition to teaching the way they were taught, teachers also lack the mathematical content knowledge needed to teach. Due to receiving mathematics instruction that has focused mainly on procedures, many of today's teachers lack what Ma (1999) termed profound understanding of fundamental mathematics (PUFM). In her research, Ma compared elementary teachers from the United States with teachers from China. She found that even when U.S. teachers could remember how to algorithmically solve a problem such as division of fractions, they were unable to explain why the procedure worked and/or come up with alternative computational approaches. Both of these skills are essential for teaching mathematics to children. Also, due to their lack of conceptual understanding of this upper elementary topic, the teachers in this study were also incapable of correctly representing the given mathematics problem in a story problem.

Teachers, especially those in the elementary grades, frequently have poor attitudes toward mathematics and low levels of content knowledge. These teachers, most of whom have learned mathematics in the past, procedurally-based system, clearly are not prepared to teach mathematics successfully to all children. In fact, the United States seems to be in a perpetual cycle of teaching children procedurally which in turn produces teachers who continue to focus on the development of procedural skills.

Conceptual Knowledge

Development of Conceptual Knowledge

Unlike Star's (2005) attempt to focus on the development of procedural knowledge independent of conceptual knowledge, no specific studies that attempt to do the same for conceptual knowledge were found. The research on developing knowledge in the field of mathematics education has, as will be shown in the final section, focused on the development of procedural and conceptual knowledge together. In their determination to develop materials that improve the teaching and learning of mathematics, the National Science Foundation and the developers of standards-based curricula appear to have overlooked this. Possibly due to the fact that mathematics education prior to the introduction of these materials had been purely procedural, standards-based curricula are focused on the development of conceptual knowledge and typically rely on the teacher to make the connections between the concepts and the procedures with little, if any guidance. In the sections that follow, the impact of using standards-based curricula with students and teachers in order to develop conceptual understanding will be discussed.

Student Impact

The introduction of standards-based materials into classrooms across the United States was quickly followed by a variety of research projects designed to determine the impact on student learning and achievement of these materials. Many of the earliest studies are documented in Senk and Thompson's (2003) text, *Standards-Based School Mathematics Curricula: What Are They? What Do Students Learn?* This text covers standards-based curricula from elementary through high school. Regardless of grade level, the research presented by Senk and Thompson consistently found that students engaged with standards-based textbooks improved in the areas of reasoning and problem solving. Student achievement on tests that measured these features was typically found to be significantly higher when students used standards-based text as compared to students using traditional text. In general, there were no significant differences in student achievement in the area of procedural skills.

The research presented in Senk and Thompson's (2003) text has been consistently criticized for a variety of reasons. Many of the studies were completed during field trials of the curricula and changes have been made to the materials as a result of those preliminary studies. In many of the studies, the researchers were also the developers of the curricula and therefore researcher bias was a concern. The most glaring concern that came out of these preliminary studies was the variety of factors that influenced the implementation of the materials, including factors at the student, teacher, school, and community levels. The studies that followed these initial projects have made progress in controlling for and/or addressing some of these variables. Senk and Thompson presented studies at all grade levels but the remainder of this section will summarize the results of recent studies at the middle school level as the current study is focused at that level.

Student achievement. The majority of studies at the middle school level, regardless of the standards-based curricula studied, present results similar to the findings previously mentioned. Studies involving the *Talent Development Middle School Mathematics Program* (Balfanz, MacIver, & Byrnes, 2006), *MATH Thematics* (Billstein, 2003), and *Connected Mathematics* (Ridgway, Zawojewski, Hoover, & Lambdin, 2003) all found that standards-based curricula resulted in higher student achievement in areas involving reasoning and problem solving but no significant improvements in the area of procedures. Reys, Reys, Lapan, Holliday, and Wasman (2003) compared students who had used either *MATH Thematics* or the *Connected Mathematics Program* for at least two years. Student achievement was found to be equal between the students using standards-based materials and the comparison group in all areas except for algebra and data analysis. In these two areas, the standards-based groups' performance exceeded that of the traditional comparison groups.

A few studies involving the *Connected Mathematics Program* (CMP) produced slightly different results while occasionally accounting for different variables. In a study focused specifically on algebraic reasoning, Krebs (2003) found that students who had used CMP for three years increased their conceptual understanding and procedural fluency with functions. In addition, the students demonstrated flexibility by using a variety of strategies and representations to assist in problem solving and were able to apply their understandings to novel tasks. Cain (2002) presented a comparison of CMP schools and non-CMP schools in one district. Overall, the CMP schools performed at a higher level than the non-CMP schools but prior performance levels of the schools was not reported and, in several cases the CMP schools performance level dropped from one year to the next while the non-CMP schools increased. In another study, Riordan and Noyce (2001) took into account a variety of factors such as length of implementation, impact on students at all levels of achievement, and student transiency. The researchers used matched schools and found that the CMP schools significantly outperformed the schools using traditional curricula for students at all levels. It should be noted that the test used for this comparison, the Massachusetts Comprehensive Assessment System, was based on the state's framework which is modeled after the NCTM standards.

One of the more recent studies (Post, Harwell, Davis, Maeda, Cutler, Andersen, et al., 2007) was larger in scale, involving 1400 students exposed to either CMP or *MATH Thematics* over a three year period. The districts and teachers selected had been part of the Local Systematic Change through Teacher Enhancement Initiative and had therefore received extensive professional development on the use of the curricula. This study compared the participating schools scores on the Stanford Achievement Test to the national averages. Although this study adds much to the literature in the area of study design, the results did not differ significantly from those found during the earlier studies. The researchers concluded that computational fluency has always been an issue and that their study did not offer a solution to this problem.

Research has consistently found that students perform better on tests that are aligned with the way that the students are taught (Stein, Remillard, & Smith, 2007). It is therefore necessary to look in depth at not just the curricula that is adopted, but also the way it is enacted. In their exploration of teachers' curriculum use, Tarr, Chavez, Reys, and Reys (2006) found that although textbooks impact what is taught and how it is taught, the teachers' interactions with the textbook influences students' opportunities to learn. In an additional study that considered type of curricula, teacher implementation, and learning environment (standards-based or traditional), no statistically significant differences were found for student achievement (Tarr, Reys, Reys, Chavez, Shih, & Osterlind, 2008). The researchers did find an interaction effect between the learning environment and the curriculum type. When teachers taught in standards-based ways using standards-based curricula, there was a significant impact on student achievement on the Balanced Assessment of Mathematics test, which focused on mathematical reasoning, problem solving, and communication. The results of this study continue to support the findings throughout this section that demonstrated that student achievement was positively impacted when tests were matched to teaching methods and curricula.

Student attitudes. Some of the curriculum impact studies also explored the impact that the materials had on student attitudes. Although Romberg (2003) noted that occasionally students were confused over the two different type of math they believed they were required to learn (the *Mathematics in Context* math and the standardized test math), the students' reactions were typically positive, finding the activities both interesting and challenging. Cain (2002) also found students' reactions to the curricula to be positive with students enjoying the real-life stories, group work, and calculator use. Although not specifically studying student attitudes, Krebs (2003) noted that the CMP students demonstrated a productive disposition and were able to persevere when exposed to difficult problems, averaging 23 minutes to complete challenging or novel tasks.

Star, Smith, and Jansen (2008) studied students' transition between schools using standards-based curricula and schools using traditional curricula to explore what they noticed as different. The researcher found that, although there were a number of significant differences noted by the students, different themes were generated from different sites. Similar to the findings on student achievement, the authors of this study noted that individual teachers appeared to have impacted the experiences of the students within the different sites.

Teacher Impact

Much of the early research on standards-based curricula and its impact on student performance stressed the need for future research to focus on the fidelity of implementation. One result of this has been a focus on researching the impact of curricular reform on both preservice and inservice teachers. The literature on exposing teachers to standards-based curricula and the impact that may have on the use of these materials focuses on three main ideas. First, the idea that much of what is learned about teaching happens "on the job" is frequently found in the literature about teaching and is very relevant to this topic. Second, the notion that teachers benefit from reading and/or studying curriculum materials was discussed regularly in the research. Finally, the view that teachers need to be able and willing to think of themselves as not just users of curriculum, but rather curriculum designers was a theme that is beginning to emerge from the current research on this topic and will be discussed further in the final section of this chapter.

Learning on the job. Exposing teachers to standards-based curriculum materials and methods in their preservice teaching does not always result in the use of these methods and materials in the classroom once teachers begin to teach. There are several factors that have been found to negatively impact teachers' use of standards-based methods once they begin teaching. Grant, Peterson, and Shojgreen-Downer (1996) along with Steele (2001) discussed the negative influence that the school's administration could have on beginning teachers. Grant et al. found that frequently teachers were confused by the contradictory messages put forth by administrations that seem to support standards-based methods yet stress the importance of high stakes testing. The teachers in Steele's longitudinal study received different levels of support from both the administration and the community. Steele found that the teachers who were able to negotiate between what was expected of them (from administrators and the community) and what they knew to be right for their students were more successful in implementing standards-based methods into their teaching.

Although there are arguably many factors that could hinder a new teacher's ability to effectively teach using standards-based methods, there are other factors that teachers are exposed to on the job that have a positive impact on teacher use of standards-based methods. Steele (2001) found that it was much easier for teachers who worked in a supportive environment to incorporate the methods they learned in their preservice experiences. The two teachers followed by Lloyd (1999) felt that their first hand experiences with standards-based curricula in the context of the classroom both enhanced their understanding of standards-based methods and their ability to use the materials effectively with students. The study by Grant et al. (1996) referred to the positive impact that observing other teachers using standards-based methods/materials can have on new teachers as they try to learn what methods will work for them. It has also been found that teachers who believe that they are responsible for the learning of their students and who have both strong content and pedagogical knowledge are also more successful using the standards-based methods and materials (Lloyd, 1999; Steele, 2001).

Much of the literature is beginning to look at the teacher learning that goes on when teachers use standard-based curricula within the classroom. Even though preservice teachers learned a great deal from completing standards-based mathematics activities, Lloyd and Frykholm (2000) found that the teachers learned more and were forced to dive into the content more deeply when they actually taught students using the materials. The teachers surveyed by Grant, Kline, and Weinhold (2002) believed that using curriculum materials that focused both on content and pedagogical knowledge helped them improve the discourse in their classroom which is a strong focus of standards-based methods. Remillard (2000) found that using standards-based curricula with children helped teachers ascertain more about what their students know and how they learn. The teachers in her study found it extremely helpful to watch their students struggle while working on problems and to listen to the alternate solutions of their students. Through this process of observing students completing tasks the teachers were learning more about both mathematical content and about how students think.

In her text, *Knowing and Teaching Elementary Mathematics*, Ma (1999) discussed in detail the concept of profound understanding of fundamental mathematics (PUFM) and how teachers attain this. According to Ma, attaining PUFM occurs through many of the activities discussed in this section and her research demonstrated that this occurs while teachers are on the job. She concludes that "Although their schooling contributes a sound basis for it, Chinese teachers develop PUFM during their teaching careers – stimulated by a concern for what to teach and how to teach it, inspired and supported by their colleagues and teaching materials" (p. 143). The learning that goes on "on the job" is essential learning that cannot be overlooked in the study of how standards-based curricula impact teachers and teaching. Exposure to these materials and methods during preservice education will not be enough to ensure that these methods and materials will be implemented effectively in classrooms. Teachers need to work in supportive environments that offer them the opportunity to continually learn from other teachers, from their materials, and from their students.

Reading the text. Another theme found in the literature on the uses of standards-based curricula with preservice and inservice teachers centers on the concept of studying the texts. One of the activities that the Chinese teachers in Ma's (1999) study engaged in to obtain PUFM was studying their teaching materials intensively. Based on his review of the literature on teacher development activities, Taylor (2002) found that "Using the teacher materials as a guide in a critical manner can be an effective vehicle for professional growth" (p. 138). In their survey, Grant, Kline, and Weinhold (2002) found that, after talking with other teachers, reading the curriculum materials was ranked the second highest by the teachers in its ability to help them understanding the content and lead discourse in the classroom.

Although many teacher education programs currently engage their students in the activity of reviewing and/or comparing different curricula, Lloyd and Behm (2005) suggest using a guided analysis of these instructional materials with preservice teachers. In their study they assigned traditional and standards-based materials to their students to review. They found that teachers who were not familiar with the standards-based materials could have many misconceptions about what they were studying. Although Lloyd and Behm felt that the assignment was a very worthwhile exercise, they suggested "increasing teachers' focus on the depth and type of mathematical understanding that students might gain from different instructional materials" (p. 59). One of the ways they believed this could be accomplished would be to first engage the students in "doing" the activities presented in the standards-based materials before they actually reviewed the materials. Lloyd and Behm believed that if the teachers in their study had been more familiar with the standards-based approach before the analysis, their pedagogical content knowledge might have been enhanced due to connections that the teachers would have made between the mathematical content in the activities and the pedagogical approaches in the materials.

Although Remillard (1999, 2000) agreed with the literature that stated that teachers learn by reading/studying texts, she went further and stated that teachers need to also be able to read their students. Although much of the literature, including Ma (1999), discussed the concept of teachers learning from their students and the benefits that come from this, Remillard's (1999) focus on "reading" the students differed in a significant way. By "reading" the students, Remillard was referring to listening to what the students are saying and adapting the lesson as needed based on the students' interactions with the activity. This idea of not using the curriculum materials as "scripts" to be followed exactly, but rather as resources that can be adapted as the lesson is constructed with students will be discussed at the end of the next section.

Balancing Procedural and Conceptual Knowledge

Development of Procedural Knowledge and Conceptual Knowledge

In order to improve the teaching and learning of mathematics, the National Research Council (NRC) describes the "strands of mathematical proficiency" (2001, p. 5) that should be intertwined. The five strands include conceptual understanding and procedural fluency as well as adaptive reasoning, strategic competence, and productive disposition. The authors continually stress, in order to develop mathematical proficiency, it is essential that these five strands are "interwoven and interdependent" (NRC, p. 5). In describing the benefits derived when conceptual understanding and procedural fluency are interwoven as recommended by the NRC, Baroody, Feil, and Johnson stated:

> Linking procedural to conceptual knowledge can make learning facts and procedures easier, provide computational shortcuts, ensure fewer errors, and reduce forgetting (i.e., promote efficiency). Children who understand procedures

are more likely to recognize real-world applications and be able to adjust their extant knowledge to new challenges or problems. (2007, p. 127)

Using the following analogy, "In good art as in good mathematics, technique and conception go hand in hand" Wu (1999, p. 14) appeared to agree with the recommendations of the NRC. But rather than advocating for a blending of procedural and conceptual knowledge, Wu stated that "conceptual advances are invariably built on the bedrock of technique" (p. 14). Wu, along with Davis and Barnard (2000), presented the need for teachers to learn how to teach skills more effectively and efficiently. This would involve developing conceptual understanding of how/why algorithms work along with developing efficient methods for skill development in order to allow time for activities that develop conceptual understanding.

Baroody, Feil, and Johnson (2007), in their response to Star (2005), stated that although separating procedural and conceptual knowledge might "make sense in theory, psychologically speaking, deep procedural and conceptual knowledge cannot be separated" (p. 119). In support of their perspective on the development of procedural and conceptual knowledge, the authors summarized three implications for research. First, they stated that at least some level of conceptual knowledge is needed in order to obtain deep procedural knowledge and some level of procedural knowledge is necessary to deeply understand a concept. This iterative approach to the development of procedural and conceptual knowledge was also found by Rittle-Johnson, Siegler, and Alibali (2001). In their research involving students' procedural and conceptual understanding of decimal fractions, the authors found that rather than "one type of knowledge strictly preceding the other, conceptual and procedural knowledge appear to develop in a hand-over-hand process" (p. 360). Rittle-Johnson, et al. further stressed that it is essential that both types of knowledge are introduced to children during classroom instruction.

Schneider and Stern (2005), in an effort to improve upon the research of Rittle-Johnson, et al. found that, when children are new to an area of study, it appears that the initial conceptual knowledge that students bring to a task is then used to develop new procedural and conceptual knowledge. Although Schneider and Stern's findings support a concepts first approach, due to the nature of their research it was essential that the participants in their study had little prior knowledge of decimal fractions. This would be equivalent to students' development when starting a new unit of study, but not necessarily applicable to how students' knowledge develops during a unit in which they have both some prior procedural and conceptual knowledge of the topic.

A second implication for research mentioned by Baroody, et al. (2007) and also supported by Rittle-Johnson, et al. (2001) and Schneider and Stern (2005) was that it may take more than just connecting procedural and conceptual knowledge in order for both types of knowledge to be developed deeply. In the work of Rittle-Johnson, et al. and Schneider and Stern, an interactive computer program was used as the intervention. The representation of a number line was used during this intervention and was found to increase both students' procedural understanding with similar tasks and students' conceptual understanding of decimal fractions when comparing their magnitude, comparing their relation to other values, finding equivalent values, and determining reasonable solutions to addition problems. The use of representations, whether provided by the teacher as an intervention or constructed by the students, is therefore another avenue that should be explored further when studying the development of procedural and conceptual knowledge.

The final implication for research that Baroody, et al. (2007) mentioned seems to coincide with how mathematics is taught in other successful countries such as Japan and with the ideas presented in NCTM's *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence* (2006). Baroody, et al. stressed the need for a focus on the big ideas in mathematics and stated that this approach "more than typical procedural, conceptual, or integrated procedural-conceptual instruction – may help facilitate a chain of self-directed and meaningful conceptual and procedural learning in new domains" (p. 127). NCTM is just beginning to generate resources that are intended to support teachers in the development of the recommended focal points at each grade level, but currently teachers have little guidance with how to approach teaching that focuses on big ideas.

In their seminal work in 1986, Hiebert and Lefevre stated that "It now is evident that it is the *relationships* between conceptual and procedural knowledge that hold the key. The skills and understanding issue is important, to be sure, but not because instruction should choose between them" (p. 23). In their summary of research on curricular materials, Stein, Remillard, and Smith (2007) concluded by stating the benefits derived from developing both procedural and conceptual knowledge in students. In addition, the authors expressed concern about the limitations that traditional materials have in the development of concepts and that standards-based materials have when it comes to connecting procedures to concepts. They stated that "perhaps the most pressing question is how to combine the best of both conventional and standards-based curricula into a more unified and balanced approach" (p. 362). From 1986 to 2007 it appears as if research continued to point to the need for development of both procedural and conceptual understanding in students, yet curriculum developers continue to produce textbooks that lean heavily in one direction or the other without much guidance for teachers on how to bring in the missing pieces.

Impact on Students

With all the research supporting the intertwined nature of the development of procedural and conceptual knowledge, it would be expected that searches on how student achievement is impacted by this interactive development would be prevalent. Yet such searches do not turn up any results. A recent study (Tarr, Reys, Reys, Chavez, Shih, & Osterlind, 2008) on the impact of curricula and learning environment presented some interesting findings about the interactions between teaching materials and methods. Although this study is just one of many that continue to show that using standards-based materials improved student achievement on tests of reasoning and problem solving but did not statistically improve student achievement in the area of procedural skills, it also included some brief findings on teachers that blend different methods with different materials (i.e. standard-based methods with traditional materials). Although findings in the area of blending were not significant, they were also not positive. As a result, the authors stressed that coherence between methods and materials may be necessary in order to improve student achievement.

Impact on Teachers

Perhaps it is difficult to find research on the impact of student achievement when taught in ways that blend procedural and conceptual knowledge because there is no research available that studies the process of teaching in ways that interconnect these two types of knowledge. A concern stated previously is that curricular materials do not currently exist that support teachers in this area. Materials are either procedure based (traditional materials) or conceptually based (standards-based materials) and do not effectively connect one type of knowledge to the other. In addition, if Snider's (2004) assertion that 75 to 90% of instruction was organized around textbooks is true, than regardless of the type of curricular materials used in the classroom, teachers are instructing and students are receiving lessons in ways that lean heavily in favor of one type of knowledge over the other.

Script versus Adapt – Teachers as Curriculum Developers

One of the problems currently being discussed in the literature on standards-based curricula is the lack of flexibility of these materials. Based on her experiences with teachers, Lloyd (1999) believed that the design of standards-based materials inhibited good teachers from adjusting what they did in the classroom to meet student needs. One of the reasons she thought this occurred was because reform-oriented teachers who had previously tailored more traditional curriculum to meet their students' needs, might feel that the standards-based curricula had done all that work for them and they should not try and improve upon it. Lloyd stated that even though standards-based curriculum developers had created very specific and detailed learning experiences for students, they could not possibly anticipate the students' reaction to and interaction with these materials. In order to address this, Remillard (2000) suggested that developers need to build into their materials opportunities that help teachers see that they are free to adjust the materials as needed for their students. Because many curriculum guides "tend to offer steps to follow, problems to give, actual questions to ask, and answers to expect" (p. 347), teachers may view the curriculum materials as finished products. Remillard recommended that curriculum developers alter their materials so that as teachers read them they understand the decision making process involved in the suggestions in the materials. If this occurs, teachers may begin to see the materials more as a work in progress that they can successfully alter as needed.

In addition to making changes in curricula, much of the literature attends to the influence of teacher personality on how these types of reforms are carried out in the classroom. In her study of four elementary teachers, Steele (2001) found that the teachers who were able to successfully implement standards-based methods had a well-developed personal commitment to teaching along with professional strength. Grant, Peterson, and Shojgreen-Downer (1996) studied three teachers and their implementation of a district mandated standards-based curriculum. They found that the teacher who implemented the materials in the true spirit of the reform movement was someone they called an "eclectic learner and teacher" (p. 536). This teacher, Carlos, selected what he used in his classroom based on the needs of his students and what he had found from experience worked with them. He pulled from a variety of resources such as texts, other teachers, and in-service experiences in order to create learning experiences for his students.

Grant, Peterson, and Shojgreen-Downer (1996) and Lloyd and Behm (2005) found that teachers who tend to see curriculum materials "as is" seemed reluctant to make modifications to them, but Lloyd and Frykholm (2000) found that even preservice teachers are capable of realizing that change can be good. They reported on one new teacher who stated that "Although I didn't follow it [Teacher's Guide] exactly, I used the best information and integrated my own thoughts and activities to allow the students a good lesson which touched on all important details" (p. 579). Remillard's (2000) experiences with teachers were similar. She found that teachers had different approaches that she termed picking out tasks versus inventing tasks. Teachers who invented tasks did not just select tasks from the text. Instead, similar to the teacher quoted above, these teachers used "the text as a source of mathematical and representational ideas" (p. 338) from which they adapted and invented their own tasks. Lloyd and Behm (2005) suggested that we can improve teachers' abilities to analyze curriculum effectively by "developing teachers' sense of themselves as curriculum decision makers" (p. 59). Remillard (1999) agreed with this idea and concluded that "Curriculum developers and others seriously committed to change in mathematics curriculum and pedagogy need to attend to the teacher's role in developing curriculum" (p. 339).

In a vignette describing an exemplary teacher, McNeil (2001) presented the difficulty experienced by that teacher as she tried to connect the conceptual understanding of addition that her third grade students had developed to the algorithm that students were required to have mastered in the fourth grade. Through the story of Ms. Tilley, it becomes clear that even an experienced teacher who thoughtfully plans and executes lessons with the goal of connecting conceptual and procedural understanding with students could benefit from materials that provide guidance in this area. Research could benefit from studying teachers such as Ms. Tilley in order to determine the factors that influence them as they plan and implement instruction with the goal of moving their students forward both conceptually and procedurally. From this research, support could be built into existing curricular materials that could have an impact on many teachers and their students.

Summary

Because research supports the notion that conceptual and procedural knowledge develop hand-in-hand, it would seem sensible that mathematics curricula should support this development, yet this is not the case. As a result of this missing connection between procedural and conceptual knowledge, the research also suggested the need to cultivate in teachers the idea that they are not only the users of curriculum but the developers as well. Some teachers, such as Ms. Tilley, have been developing their curriculum and teaching using the "big ideas" for their grade level/content area for quite some time. Why have these teachers decided to teach in this fashion? What factors influence them as they plan and implement instruction? How do they select resources and how and why do the alter them? By addressing these questions, this study intends to broaden the knowledge base in this area in order to assist teacher educators, teachers, and curriculum developers in their future work.

This chapter presented the framework and the review of literature that were used to guide this study. The next chapter restates the research questions and presents the justification for the multiple case study design. In addition, the methodology implemented will be described in detail.

3. Methodology and Research Design

Introduction

The purpose of this study was to explore the interaction between teachers and their curriculum materials in the context of the classroom in order to learn more about the factors that influence these teachers. The following research questions guided this exploration of teacher-curriculum interaction:

1. What factors influence middle school mathematics teachers who have a participatory relationship with their curricula as they plan tasks and implement them in their classrooms?
2. Do middle school mathematics teachers who have a participatory relationship with their curricula select and/or modify resources for use? If so, what factors influence them when they select resources and/or modify the tasks as presented in the resources?
3. Do middle school mathematics teachers who have a participatory relationship with their curricula balance the development of procedural and conceptual knowledge as they plan and implement instruction? If so, how do they attempt to achieve that balance and why?

Qualitative Research

According to Maxwell (2005), one of the five different research goals that qualitative research is extremely well suited to address is developing an understanding of meaning. Maxwell explains “In a qualitative study, you are interested not only in the physical events and behavior that are taking place, but also in how the participants in your study make sense of these, and how their understanding influences their behavior” (2005, p. 22). According to Merriam, qualitative research is suited for situations when the key concern is “understanding the phenomenon of interest from the participants’ perspective” (1998, p. 6). In order to gain insight into the factors that influence teachers as they planned and implemented mathematics instruction it was necessary to discuss, during semi-structured interview sessions with the teachers, their plans, their reasons for their plans, along with any modifications that were made to their plans and why. Although classroom observations were used to support or refute the teachers’ perceptions of what was planned for the lesson, the main focus of all data collection was on understanding what was important to the teachers in the context of their classrooms and why. In other words, what meaning did the teachers’ attach to the tasks and resources they selected and implemented with their students and how did their understanding influence the tasks they planned and the way they were implemented in the classroom.

Multiple Case Study Design

A multiple case study design was selected, with each teacher as a separate case, in order to describe and interpret teachers’ participatory relationships with curricula in the real-world context of the classroom with the purpose of describing the factors that influence them during the planning and implementation of tasks (Stake, 1995; Yin, 2003). Case studies are ideal for situations in which there are many variables (Merriam, 1998; Yin, 2003) and teachers' interactions with and implementation of curricula have been shown to vary dramatically due to a multiplicity of factors (Frykholm, 1999, 2004; Grant, Peterson, & Shojgreen-Downer, 1996; Lloyd, 1999). The participants in this study were purposefully selected as the cases (Maxwell, 2005; Miles & Huberman, 1994; Patton, 2001). The teacher selection process, described in detail in a later section, was based on instructional supervisor and principal recommendations along with self-report data. The teachers selected were considered ideal cases for this study because it is recognized that they have what Remillard (2005) describes as a "participatory relationship" with their curricula and therefore were more likely to provide information that would be useful to this study (Maxwell, 2005; Patton, 2001). Qualitative data were collected using a variety of data sources and analyzed at the case level. In addition, a cross-case analysis was completed in order to develop a deeper understanding of the factors that influenced the teachers when they planned and implemented instruction by identifying similarities and differences between the teachers (Miles & Huberman, 1994).

Materials

Teachers used a variety of school and teacher-generated resources as they planned tasks and implemented them with their students. Resources included district adopted textbooks, Virginia Standards of Learning documents, SMART Board lessons and activities, manipulatives, and an assortment of worksheets. The teachers and I documented details of the resources using several of the data sources discussed in the next section and many of the resources will be described in greater detail during the cross-case analysis.

Data Sources

Typical of case study design (Yin, 2003), data collected for this study were collected from multiple sources with the main focus on teacher interviews, lesson observations, and artifacts from the lessons. Where possible, existing protocols and questionnaires were used and/or modified in order to assist with trustworthiness. Permission to implement this study along with the use of the instruments and other data sources listed below was received from George Mason University's Human Subject Review Board on February 11, 2009.

Instruments

Teacher survey. The *Self-Report Survey: Elementary Teacher's Commitment to Mathematics Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003) was administered to most middle school teachers in the district to assist in the selection of participants (Appendix A). Although this survey was designed to measure elementary teachers' implementation of standards-based teaching, the questions were general enough that the survey was still applicable in the middle school setting. The data from this survey were used in combination with supervisor recommendations to select the participants in the study.

Permission to use this survey was granted by one of its authors, John Ross. The survey was found to be reliable (r = .81) in two large samples of K-8 teachers (517 and 2170). Teachers' self-report of their teaching practices on this survey were found to positively correlate with between-school achievement residual (*r* = .35, *p* < .001, *N* = 130 schools). In addition, evidence of concurrent validity was presented through comparing a small sample (*n* = 3) of teachers' responses on their survey to their observed teaching practices. Using another small sample (*n* = 14) of teachers, the authors provided evidence of construct validity when differences in teachers' use of a standards-based textbook corresponded to their scores on the survey. The authors concluded that the survey was "a cost-effective instrument to measure differences between groups of teachers and to select teachers for further inquiry into their practice through interviews and observations" (p. 360). As stated previously, this was the intended purpose of this instrument for the current study.

Participant questionnaire. The *2000 National Survey of Science and Mathematics Education Mathematics Questionnaire* was supplied to the participating teachers prior to any other form of data collection (Appendix B). Horizon Research, Inc. (HRI) holds the copyright on this instrument but grants permission for unlimited use in whole or in part for non-commercial use as long as the instrument is attributed to HRI. The questionnaires were used during the *Looking Inside the Classroom* studies in order to solicit information from K-12 teachers regarding their opinions, their preparation, and their classroom practice and that was its intended purpose in this study.

The participants were asked to complete Parts C and D for the course that was to be observed during this study. The main purpose of this questionnaire was to provide background information on the participants and the classes that were observed. In addition, the teachers' perceptions of their class and their teaching practices in their class were also obtained from the questionnaire.

Other Sources

Audiotapes of lessons. Observed lessons were audio taped and detailed field notes were recorded after each session. The detailed field notes were used to document what took place in the classroom during each observation and to describe instances of teacher-student dialogue that substantiated the development of procedural knowledge, conceptual knowledge, and/or a blending of the two. In addition to preserving the exact words of teachers and students, the use of audio tapes also assisted in capturing teacher tone and response time to students that can get lost in the other methods of data collection. An example of the field notes is included in Appendix C.

In addition to the tape recorder located centrally in the classroom, I took notes by hand during all observations using a *Livescribe* notebook and the *Pulse* smartpen. This research tool records audio and connects it to the handwritten notes. The use of this tool allowed me to capture all diagrams and problems that were recorded in the classroom while also providing a link to what was being said as the diagram or problem was worked on. Although this is not the same as a video recording of the classroom, it allowed for that connection between audio and visual without the added disruption of a video recorder. The tool also allowed me to move near groups of students and capture the teacher-student interactions when teachers were circulating and working with small groups in their classrooms. Although this was the goal of using this research tool, it was not always possible to move freely in the classrooms without disturbing the teacher and/or the students therefore I used discretion in all situations. In the researcher's role as "observer as participant" (Merriam, 1998, p. 101) and using the research tools mentioned above, it was typically possible to interact closely with all classroom members without actually participating in the class activities.

Teacher interviews. Each teacher was interviewed twice for this study. Both interviews were semi-structured in order to allow for comparability across interviews while also allowing for some flexibility in how and when the questions were asked (Shank, 2006); each interview lasted approximately 60 minutes. The first interview for each participant occurred prior to any observations. The initial interview protocol is included in Appendix D and the main focus of this interview was to gather information about the teacher and her goals for the lessons that would be observed. Specifically, questions were asked in order to gain an understanding of the content that would be covered during the observation period, the purpose for selecting the tasks to be used with students, the variables that influenced the teachers as they planned, and the possible variables that may influence them during implementation. The second semi-structured interview occurred after all classroom observations and was used to get the participants' perception of the factors that influenced them during the study and to clarify what was observed during the implementation of the lessons. In addition, another, less structured, set of questions were focused on the teachers' beliefs about the development of procedural and conceptual knowledge. The focus of these questions was adapted as needed for each teacher based on what had occurred during the initial interviews and all observations. Finally, any teacher specific questions regarding particular instances that occurred during the study were asked at the end of the final interview session. The baseline protocol for the final interview is included in Appendix E.

All interviews were audio taped and transcribed. Although other data sources were necessary to this study and assisted in supporting the findings, the focus of this research was on the teachers and the factors that influenced them as they planned and implemented instruction. Therefore it was essential that the exact words of the teachers were captured and critically analyzed in order to answer the research questions.

Teacher logs. The teachers were asked to keep a daily log in order to capture their goals for each lesson and their thought processes behind the resources that they selected to use for each lesson. Although teachers were reminded about this log at the beginning of the observation period, not all teachers completed the log daily. Due to the time commitment required of the teachers who participated in this study, I did not feel it was appropriate to further impose on the teachers for any missing teacher logs. A copy of the format of the teacher log provided to the teachers is included in Appendix F.

Teacher lesson plans and classroom artifacts. Although it was originally planned to collect copies of teachers' lesson plans for this study, the participants in this study did not develop detailed lesson plans. Two of the participants did create elaborate SMART Board documents that guided the instruction during the observation and beyond and copies of these documents were obtained. Copies of textbook resources, student handouts, and all other resources used during the observations were collected to document the tasks that students were engaged with.

Daily summary forms. A daily summary was completed immediately following each observation. This was done in order to pull together and summarize the observed instruction as well as any informal conversations with the teachers. An example of a completed form is included in Appendix G.

Participants and Setting

District Information

The district where this study took place is located in a semi-rural area of Virginia. All five middle schools in this district accommodate students in the sixth through eighth grades and mathematics courses taught range from sixth grade mathematics through Geometry. A request was made and permission was granted by the Assistant Superintendent of Instruction to conduct the study in this school district on January 22, 2009.

This district was selected for two reasons. First, due to the amount of observational time required for this study, the sites need to be within a reasonable distance from my home. Other surrounding districts would require extensive travel times that would likely be further impacted by traffic congestion. The other, more critical, reason is the relationship that I had with the selected district. I previously taught middle school mathematics in this district for 10 years. Through my tenure with this district, professional relationships have been built with many of the teachers. Of the five teachers eventually selected for this study (see selection process in the next section), three were previously known to me. Although this can be viewed as a liability in research, due to the nature of this study, positive, trusting relationships were necessary in order to engage the teachers in the meaningful, thoughtful discussions required to explore the research questions.

There is some evidence to support that any previous relationships that existed between the participants and me may have served to put the participants at ease during observations as well as made them more forthcoming during interviews. For example, field notes from the observations of one of the participants not previously known to me show the teacher made a variety of careless mistakes during the observation period. The anecdotal records made during those same observations noted concern that the teacher may be uncomfortable due to my presence. Concerns about the impact that observers may have on those they are observing have been noted in the literature (e. g. Merriam, 1998), therefore, I considered the possibility that the participants in the study may have made some adjustments to their routines during the period they were observed. When the participants were asked at the end of the interview session if they did anything different due to my presence in the classroom, all of the teachers laughed and made a short, usually joking, comment about something that occurred during the observations. The teachers' comments are brought up here in order to lend support to the notion that having a prior relationship with teachers, although always a limitation in research, may aid in breaking down barriers between observer and observed in order to see the truth more clearly.

Participant Selection Process

The selection of teachers as cases was a key aspect of this multiple case study. Of crucial importance to this study was that the teachers selected needed to have a participatory relationship with their curriculum materials. As defined previously, teachers that have this type of relationship with their curricula bring to the planning process a host of factors that may influence them (see Figure 1). In addition, these teachers are also influenced by factors inherent within the curriculum materials. For this reason, purposeful selection of the participants was necessary (Maxwell, 2005; Miles & Huberman, 1994; Patton, 2001). As mentioned previously, I had professional relationships with several of the teachers in this district and therefore it was essential that I distance myself from the selection process. Therefore, in order to select appropriate participants while also removing myself from the selection process, a scheme was developed that included totaling scores from three different sources in order to select the participants.

First, the instructional coordinator for mathematics was asked to provide a list of 10 middle school teachers that she believed, based on her experience, have a participatory relationship with their curricula (see Appendix H for coordinator letter). In order to clearly identify the type of teachers needed for the study, the following characteristics were provided in the letter:

1. Teacher uses a variety of teaching strategies from a variety of curriculum materials
2. Teacher views curriculum materials as a resource
3. Teacher has strong pedagogical content knowledge and subject matter knowledge
4. Teacher selects classroom tasks based on student needs

The instructional coordinator was also asked to rank the teachers from 10 to 1 with the teacher she believed to be the most effective in designing tasks for students ranked 10th.

The second source of data came from the five middle school principals. In a similar letter, the principals were asked to recommend two mathematics teachers in their school that they believe are most effective with students (see Appendix I for principal letter). Again, the meaning of the term “participatory relationship” was specified for them using the descriptors mentioned above. The instructional coordinator and four of the five principals responded to these requests. Several attempts were made to gather recommendations from the remaining principal, but I never received the requested information.

The final source used to select the participants for the study was a survey that measures teachers’ implementation of standards-based teaching, the *Self-Report Survey: Elementary Teacher’s Commitment to Mathematics Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003), which can be found in Appendix A. Appointments were made with the mathematics department heads at the five middle schools in order to determine an appropriate time to come to the school to meet with the teachers and administer the survey. During the meeting at each school, teachers were given the informed consent form for the survey (see Appendix J) along with the survey (Appendix A) and then the purpose of the survey and how to complete it was reviewed. In order to maintain confidentiality, the teachers did not write their names on the surveys. All surveys were assigned a number and I kept a separate key linking teacher names to these numbers. In all schools but one, I was able to administer the survey. Due to scheduling issues between this one middle school and myself, I met with the department head and explained the procedure and he administered the survey to his mathematics teachers. The teachers at this school returned the consent forms and the surveys to their department head in sealed envelopes and I picked up the documents later in the week.

Surveys were completed by approximately 90% of the middle school mathematics teachers in the district. I then hand scored the surveys and an average score was calculated from 1 to 6 for each of the teachers. A high score on this survey is reflective of teachers who implement standards-based teaching practices (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003).

A spreadsheet was created to organize these data. If teachers were recommended by the mathematics instructional coordinator, they received a score of 1 through 10 based on the number she assigned them. In addition, teachers received a score of 3 if they were recommended by their principal. Finally, teachers received a score reflective of their average score on the survey. Once these data had been collected, they were recorded and scores from all three sources were totaled in a spreadsheet. The results, ranked in order from highest to lowest are provided in Appendix K.

The selection process described above was used to remove any researcher bias from the selection process and to provide some assurance that the teachers selected would have a participatory relationship with their curricula. The instructional coordinator's recommendations were weighted more heavily than the other data sources because her position provided her with knowledge of teaching practices throughout the district. The recommendations from principals and the teachers' survey scores, although not weighed as heavily, provided balance to the participant selection process by adding the perspective of school administrators along with teachers' self-perception.

Once this process was complete, I met with six of the top ranked teachers to explain the study and ask their consent to participate. During this process, the potential participants were made aware of the overall purpose of the study and what would be required of them if they agreed to participate. In order to avoid the introduction of bias into the study, the potential participants were not informed that I was interested in determining if the balanced development of procedural and conceptual knowledge factored into their planning.

Five of the six teachers agreed to participate in the study. These teachers then signed the informed consent forms (Appendix L) and were given a copy of the *2000 National Survey of Science and Mathematics Education Mathematics Questionnaire* (Appendix B) in order to gather background information on the teachers about their teaching experiences and their perceptions of teaching. Because sections C and D of the questionnaire required the participants to focus on the specific class that was to be observed, these sections were reviewed with the participants and they each selected the class period that they wanted to use for the study. The questionnaires were left with the teachers so that they would have time to complete them and were typically returned to me during the initial interview. Also during these preliminary meetings, I worked with the teachers in order to create a tentative schedule for the initial interviews and the observations.

In order to achieve benefits from multiple case study analysis, it is recommended that from four to ten cases be selected (Stake, 2006). Based on this recommendation and researcher time constraints, the initial goal was to include from four to six participants in the current study. After the five teachers agreed to participate and I developed a schedule for interviews and observations for these teachers, there was insufficient time to include any additional participants. Impacting this schedule was the district's spring break and the state's Standards of Learning tests administered in May. The last set of observations was scheduled in mid-April in order to attempt to avoid the possible impact of state testing on the results of the current study.

Participants

Five teachers participated in this study: Lynn Smith, Ginger Harris, Lea Turner, Judy Baker, and Kath Mitchell (pseudonyms are used to protect the anonymity of the participants).The teachers taught at three different middle schools within the same school district. Table 2 summarizes the teachers' backgrounds and the content covered during the observations. Further details about each of the five participants and their classes are provided in the appropriate case analysis chapters.

Table 2

Participant Description

Teacher	Experience	Grade/course	Content covered
Lynn Smith	8	Algebra	Multiplying binomials
Ginger Harris	27	6th	Fractions, decimals, percents
Lea Turner	12	7th	Area and perimeter
Judy Baker	27	6th	Geometric patterns
Kath Mitchell	10	Algebra	Quadratic functions

Although five teachers were selected and participated in this study, one of the teachers, Judy, was dropped during the analysis phase of the study. Judy was one of the teachers previously known to me before the study and spoke freely and candidly during interviews and casual conversations. During the final interview, Judy stated that she would have done things differently if I had not been observing her classes. She clarified that, due to the testing immediately before and after the school's spring break, she would have normally focused more on the review of those tests during the time period I was there. She stated that in order for me to observe what a typical unit in her class might look like, she taught a short unit on patterning instead. The data collected by Judy was analyzed but, due to Judy's admission of such a major change in plans, her findings were not included in this paper.

Data Collection Procedures

Once the participants were selected and the schedules were arranged, the data collection procedures were similar for all participants. The initial, semi-structured interview was held with each participant approximately one to three days prior to the observations and the teacher was then observed teaching the agreed upon class for a period of approximately five consecutive school days. Then, typically within one or two days of the last observation, the final interview was held. There were slight modifications to this procedure that were made to accommodate either school or teacher needs. For example, one teacher was observed for six days, but on one of those days an end-of-unit test was administered. Another teacher was observed for a day and then the students needed two days for a district quarterly assessment. I did not observe during those two days because of concerns that my presence may disrupt the students. I then observed for three more consecutive school days in that participant's class.

On any given day in a mathematics classroom, a variety of different activities may be observed. A teacher may be demonstrating and having students practice a skill, allowing students to discover a concept, or assisting students with making connections between the concepts they have been working with and algorithms that allow students to efficiently work with those concepts. The timeframe for the observations was therefore selected in an attempt to encapsulate a range of classroom activities.

Initial Interview

The initial interview with each teacher was held within a few days of the beginning of the scheduled observation period. For example, for several of the teachers the interviews were held on a Friday and the observations started the following Monday. Two of the teachers were observed immediately following the school district's spring break and therefore the initial interviews with these two teachers were held on the Friday before the break. The main goal of the initial interview was to gain information about the class that I would be observing and the teacher's plans for the observation period. A semi-structured interview (see Appendix D for the interview protocol) was held in order to allow for comparability across interviews while also allowing for flexibility in how and when the questions were asked (Shank, 2006).

I initially planned to obtain copies of teacher lesson plans during this interview but I quickly discovered that none of the participants in this study used formal lesson plans. Therefore, questions were asked in order to gain an understanding of the content that would be covered during the observation period, the purpose for selecting the tasks to be used with students, the variables that influenced the teachers as they planned, and the possible variables that may influence them during implementation. All interviews were audio-recorded and transcribed as soon as possible after the interview.

Observations

Each teacher was observed for approximately five consecutive school days. The goal of these observations was to gain information about the tasks that were used in the classroom and the factors may have influenced how the tasks were implemented in the classroom. During the observation period, copies of all the resources used by the teachers with the students were obtained. In order to summarize what occurred during each observation, audio was captured from two separate sources. A digital recorder was centrally placed in the classroom in an attempt to encapsulate each observation. In addition, I enlisted the use of a relatively new tool to assist in data collection. A *Livescribe* notebook and *Pulse* smartpen were used to record field notes during the observations. The *Pulse* smartpen records audio and links it to what is written in the notebook. Using this tool to record diagrams or problems written on blackboards and other surfaces allowed me to connect the visual to the audio that was simultaneously occurring. Also, all notes recorded in the notebook were linked to the audio that was occurring at that moment.

Immediately following each observation, I completed a daily summary form (see example in Appendix G). I used the field notes recorded in my notebook, with the assistance of the linked audio as needed, to complete this summary. In addition to recording descriptions of key events during the observation on this form, I added comments from any informal discussions that the participant and I may have had that day. Also, the form had areas for me to record codes for possible factors influencing the teacher along with developing themes in the research. At the end of the form, I recorded interesting events or other thoughts I had after each observation along with any questions I had for the participant. These last sections provided me with the opportunity to reflect on and analyze what had occurred during each observation. The main purpose of this form was to allow me not only to record the main events that were observed but to also reflect on what was observed in order to gain an understanding of what occurred and why it may have occurred (Maxwell, 2005; Miles & Huberman, 1994).

As soon as possible after the observation, detailed descriptive field notes were developed. These notes were written while playing back the audio on the digital recorder supplemented as needed with the audio from the *Pulse* smartpen. The purpose of the detailed field notes was to capture, with as much detail as possible, everything that occurred during each lesson. These notes then provided a running record of what occurred during each observation. In addition to describing the lesson and what occurred in the classroom, the notes included summaries of conversations along with capturing the teachers and students exact words as needed. While the detailed field notes were written out using the audio recording, I simultaneously reviewed my notes in the *Livescribe* notebook in order to match what was being said to any anecdotal notes I had made in the notebook. As the detailed field notes were being documented, possible codes indicating factors that may have been influencing the teachers were inserted. An example of a section of the detailed field notes from an observation is included in Appendix C.

Final Interview

The final semi-structured interview occurred after all classroom observations and the protocol consisted of three distinct sections (see Appendix F). The first section was used to get the participants' perception of the factors that influenced them during the study and to clarify what was observed during the implementation of the lessons. This section of the interview typically occurred as set up in the protocol although occasionally questions were asked in a different order in response to the participants' answers.

A second, less structured, set of questions were focused on the teachers' beliefs about the development of procedural and conceptual knowledge. The focus of these questions was adapted as needed for each teacher based on what was discussed during the initial interviews and what had occurred during all observations. I used this section of the interview protocol as a resource as I let the participants guide the direction the discussion took (Shank, 2006). As the interview progressed, I referred back to the questions in this section in order to ensure that the necessary topics were addressed. If needed, follow-up questions were asked.

Finally, specific questions regarding particular instances that occurred during the study were generated for each teacher and asked at the end of the interview session. These questions were also adapted as needed based on the teachers' responses to previous questions in the final interview. All final interviews were audio taped and transcribed.

Teacher Logs

The teacher was asked to complete a log (Appendix E) for each session that was observed and provide it to me prior to the next observation. The purpose of this form was to capture the teachers' goals for each lesson and their thought processes behind the resources that they selected to use. Teachers typically emailed the logs to me, although occasionally hard copies were provided instead. As noted previously, all participants did not complete this document on a daily basis but I did not believe it was appropriate to further inconvenience the teachers by pressuring them to complete the form.

Classroom Artifacts

Copies of all artifacts used by the teacher in the planning and implementation of the lesson along with artifacts used by the students during the lesson were collected. Although it was originally planned to collect copies of teachers' lesson plans for this study, the participants in this study did not develop detailed lesson plans. Two of the participants did create elaborate SMART Board documents that guided the instruction during the observation period and copies of those documents were obtained. Copies of textbook resources, student handouts, and all other resources used during the observations were collected to document the tasks that students were engaged with.

Data Analysis

As is typical of qualitative research, the data analysis began with the first interview and continued throughout the data collection process and the writing of the findings therefore creating two, main phases to this study. Although a portion of the analysis occurred during the data collection phase of the study, a significant portion of the analysis occurred after the data collection had ended. In addition, data were analyzed both within- and across-cases (Merriam, 1998; Miles & Huberman, 1994).

Analysis during Data Collection

The data collection phase of this study occurred over a relatively condensed time period due to a variety of factors including location of the schools, number of participants at each school site, and the timing of the district's spring break. A critical issue was the need to complete all observations by mid-April so that the Virginia Standards of Learning tests, administered in mid-May, did not have the potential to become the sole factor in the teachers' planning and implementation of tasks. Data analysis during the data collection phase was therefore hindered due to the large amount of data collected during the interviews and observations of the participants over a relatively short period of time. In addition, due to the limited amount of time for data analysis, this phase of the study was strictly focused on within-case analysis.

In order to assist with the data analysis during this phase, I completed daily summary forms (Appendix G) after each observation. One purpose of this form was to summarize the daily observations by documenting key events that occurred during each teaching episode along with noting any information that came out of informal conversations between me and the participants. The form also had a section for recording my on-going thoughts about the study and possible questions for the participants. Finally, there were two columns on either side of the *description of the event* column that allowed me to start recording my thoughts on what factors may be influencing the participants and possible themes for the study. Starting with the very first observation, I began recording potential factors on this form which laid the ground work for the coding scheme that was developed later. The daily summary form, as implemented in this study, served as cross between a summary form (Miles & Huberman, 1994) and a researcher memo (Maxwell, 2005) in that it both kept of record of key events and assisted me with synthesizing the data as the study progressed.

Listening to the audio tapes from the observations and developing detailed field notes from these tapes also assisted with the data analysis during the data collection phase. This activity occurred as soon as possible after each observation, but not necessarily on the same day. As described previously, along with summarizing events and conversations that occurred during the observations, these detailed notes frequently documented the exact words of the participants so as to have the potential to provide support for the findings. The field notes were completed in an Excel file (see Appendix C for a partial sample) and were chunked in order to assist with future coding and analysis. As can be seen in the sample in Appendix C, the chunks were numbered in consecutive order so that, as the analysis progressed, the given context of the various chunks of data would not get lost. As the notes were created, I began coding some of the data using the constant-comparative method of data analysis (Glaser & Strauss, 1967; Merriam, 1998) for each teacher.

As the study progressed, it was evident that a record of potential codes would be needed therefore a coding scheme (see Appendix M for the final version) was developed to keep track of the codes, the categories they represented, and a brief description of the category. The number of categories grew as the study proceeded and codes were used across cases. The coding initially involved organizational categories (Maxwell, 2005). Because the focus of the study was on the factors that influenced the teachers, organizational categories such as *resources* and *hands-on* quickly surfaced. Eventually more substantive categories (Maxwell, 2005) emerged from data sources and were added to the coding scheme. This will be discussed further in the next section.

The teachers' responses to interview questions were essential pieces to this study, so it was necessary to capture their exact words from this data source. Although it is helpful for a researcher to transcribe her own interviews so as to become familiar with her data immediately (Merriam, 1998), due to time constraints I was only able to transcribe the initial and finial interview for one of the participants. The remaining interviews were sent out for transcription. Given that I did not have immediate access to the transcriptions and because, during data collection, I was busy documenting the observations, analyses of the interviews occurred after data collection.

Analysis after Data Collection

Due to the amount of data collected over a short time period, the majority of the data analysis occurred after data collection. The data were first organized, coded, and analyzed at the case level for each teacher. The results of these within-case analyses were then used in order to analyze the data across the cases.

Within-case analysis. During the data collection phase, all electronic data (teacher logs, daily summaries, field notes, etc.) were organized into folders for each teacher. This process continued after data collection and resulted in electronic folders for each teacher organized by interview and observation dates. A separate, physical folder was also kept for each teacher in order to hold any data that were not electronic such as the original teacher questionnaire and classroom artifacts.

The process of sorting, coding, and analyzing data followed the same path for each of the five participants. All data sources were reviewed starting with the initial interview transcripts, then working through the data collected during the observations, and concluding with the final interview transcripts. The use of different data sources and methods, although used to triangulate data and assist with issues of validity, also assisted with the analysis of these data. The initial interviews allowed me to gain an understanding of the teachers' perspective about their plans and their reasons for selecting and modifying tasks to use in the classroom. The observations allowed me to draw inferences about those perspectives that might not have been obvious from the interview data alone. The final interviews again provided the teachers' perspectives on the factors that influenced them during the planning and implementation of tasks and selection of resources and were also used to check the accuracy of what was observed. Combined, these two different methods of data collection allowed me to gain a stronger understanding of the factors that influenced the teachers during this study (Maxwell, 2005).

After the collected data were organized as described above, the next step was to fully enter the "code mines" (Glesne, 1999, p. 135). In order to proceed through the coding process, a coding document (see Appendix N for an example of a section from one of these documents) was created using an Excel spreadsheet for each teacher. This document was created by reviewing all data sources, selecting chunks of text, copying and pasting the text into the coding document, and giving the text an initial code. The chunks of data ranged from a sentence to a complete paragraph and were selected based on their ability to stand alone as a complete thought separate from the context they were pulled from. Due to the exploratory nature of this study, all the teachers' interview data were coded along with most of the data from the other sources. In order to preserve the original context of the data, each chunk also included a code that connected the data to the document it came from and, if applicable, a page and/or line number. The purpose of this open coding process was to place all data into an initial category for further evaluation and comparison. The category names came from different sources (Merriam, 1998) but were mainly reflective of what was found in the data, especially as the data pertained to the research questions. In addition, some of the category names came from the participants' words and others, such as the terms focused on procedural and conceptual knowledge, came from a combination of the research literature and the research questions in the study. The developed coding scheme (Appendix M) was fluid and categories were added and occasionally condensed as needed.

After all the data for a teacher had been entered into the coding document and given an initial code, the data were sorted by the code names. At this point, the data within each category were re-examined. The main purpose of this was to further break down the original codes into several sub-codes (Glesne, 1999). Eventually, each chunk of data was given from one to three levels of codes in order to capture multiple levels of meaning in the data. For example, *modifications*, which was a main category, was typically sub-coded to reflect whether it was a resource that was modified or whether the direction of the lesson was modified due to a student question or misunderstanding. At the same time, the data were also reviewed to ensure that they fit in their initial category. If, during this review, a chunk of data was determined not to fit, it was re-coded into a category that was determined to be more reflective of the text's meaning. After this process was complete, the data were re-sorted, this time including a sort of the sub-codes. The document was again reviewed to look for any inconsistencies in coding and adjustments were made if needed.

Before the coding document was considered complete and ready for further analysis, the data were sorted again. This time the sort was by the document that the chunk of data came from, its location in that document, and the actual text. This was necessary because, during the initial coding of all data, it was unclear where some of the data best fit. As a result, some data were placed into the document multiple times with different initial codes. When this final sort was done, the data that had been inserted multiple times could easily be relocated and further examined with all sub-codes to determine which main category it best fit. At this point, a decision was made as to which level one code best fit the data and the duplicate data were deleted. Occasionally, some data were judged to fit in more than one category. Due to the exploratory nature of this study, if a decision could not be made as to which code best fit the data, both codes were used and that chunk of data remained in the document more than once.

Once the coding document had gone through the process described above, the data were further analyzed by exploring the document to look for patterns that would assist in answering the research questions. To begin this process, pivot tables were created using the three levels of codes. Although qualitative research should not focus on generating frequency counts (Maxwell, 2005), the results of the pivot tables were used to guide the analysis of the factors that appeared to have the most influence on teachers based on the regularity with which they occurred. The categories that were the most prevalent for each teacher were explored in depth to learn more about what these factors were and how they were impacting the teachers.

Although the pivot table results were used to guide the analysis, focused sorting and reviewing of the data in the coding document was used to answer each research questions. Research question 1 explored the factors that influenced each teacher during the planning and implementing of tasks. In order to answer this question, the data containing codes that occurred more frequently were explored in depth in order to look for patterns within and connections between these data. Research question 2 investigated the resources that the teachers used, any modifications that were made to these resources, and the reasons for making the modifications. In order to answer this question, data sorts were done using the codes for *resources* and *modifications* at all three levels of coding.

The final research question examined whether the teachers focused on the balanced development of procedural and conceptual knowledge. The teachers were not made aware of this research question prior to the study and none of the participants specifically addressed this in the initial interview using those words. Occasionally the participants, using their own words, made reference to factors that influenced them that could be interpreted as balancing these knowledge types in the initial interview. When this occurred, these ideas were further explored in the final interview in order to verify the participants' meaning. In order to answer research question 3, the data were sorted using the codes that were specific to this topic and explored for patterns and themes within these data. When applicable, connections were also made between the results of this analysis and the results from research questions 1 and 2 for each teacher.

Throughout the data analysis for each participant, it was essential that I continue to keep the whole experience with the teacher in focus. Therefore, periodically during the analysis of teacher data, I would go back and review all the collected data. Typically, I would review the data in order from the initial interview, through the observations, and then the final interview. This review of the data in chronological order assisted me with focusing on the meaning of the data within its original context and with the development of themes throughout the data. Also, when needed during the analysis, I would go back to the actual data source in order to review a specific chunk of data within its original context. Because meaning can get lost when data are broken out into individual chunks, this step helped to ensure that the original context and meaning of the data were attended to during the analysis.

For the within-case analysis, I initially created four separate cases, one for each teacher. During this exercise, I focused on analyzing all three research questions for each teacher. These chapters were very lengthy and detailed and therefore did not become part of this dissertation. However, the cases included descriptions of critical incidents from the data, common themes, and a description of factors that connected to the teachers' implementation and planning of curriculum. Through this writing/analysis cycle, themes became apparent across the cases. The cross-case analysis will be further described in the next section.

Cross-case analysis. In order to explore the variety of factors that influence teachers during the planning and implement of instruction, data were collected from multiple cases. After the detailed chapter was written and analysis of each case was concluded, matrices summarizing the findings for each of the teachers were created and possible themes were noted. In order to investigate possible themes that cut across cases, additional matrices were created. These cross-case matrices employed a variable-oriented strategy (Miles & Huberman, 1994) in order to assist with the exploration and description of common themes found throughout this study. Although these matrices, found in Appendix O, focused on the major themes found for all teachers for each of the three research questions, common themes were also found that wove across questions.

Through the writing of individual teacher cases and the further analysis of the individual and cross-case matrices, the teachers were found to fit into two distinct categories. These findings are presented in chapters 4 and 5. In addition, the findings across cases are summarized by question in the final chapter. The cross-case matrices were used as an organizational tool that allowed me to visually see not only which themes were common among the teachers, but also provided details specific to each of the teachers. This let me see, for example, that making connections was an influential factor for all the teachers in this study, while also not losing sight of the specific ways the individual teachers made connections.

Limitations

This study is limited in several ways. First, it is a small scale study that is focused at the middle school level in one district. Because of this, it is not possible to generalize the findings to other grade levels and/or middle schools in other non-comparable school districts such as urban districts. The factors that influence teachers at different grade levels and in other districts could conceivably vary widely from the findings in the current study. Due to time constraints, the proposed study only allowed the observation of teachers for a limited time. Although it is posited that a five to seven day timeframe would allow for a variety of instructions strategies to be observed, a longer time frame may have revealed different strategies and/or different influential factors. Finally, because the observations were scheduled with the participants, a further limitation of this study could be that the participants may not have planned their typical instruction. Due to the quality of the teachers selected based on supervisor recommendations and the information gathered from the interviews, it is believed that this concern should not be considered a major limitation.

Internal Validity

Issues involving the validity and reliability of qualitative studies and, in particular, case studies are very common. In order to address some of these concerns, I implemented several strategies, recommended by Merriam (1998), that have been shown to enhance the internal validity of qualitative studies. These strategies will be discussed in the following sections.

Triangulation. Through the use of a variety of data sources, I was able to provide support for the findings. Data collected using the daily summaries and the field notes of the audio taped sessions were compared with teacher perceptions collected during the interview sessions and informal discussions. In addition, copies of the teacher's logs along with student artifacts were used to provide additional support of the findings.

Member checks. Verification of my interpretations of what occurred during classroom observations and/or clarification on the purpose of various parts of the planned and observed lessons occurred during the final interview sessions, informal discussions (documented with field notes), and through teacher logs. During the final interview, I asked questions in order to confirm or refute my interpretations of classroom experiences. In addition, I asked specific questions about the teachers' initial plans for the lesson as depicted in the teacher logs and any changes that may have occurred during the implementation of the lessons. Although the main focus of the interviews was to gain information on the process that the teacher was going through during the planning and implementation of the lesson, these sessions also served as a member check in order to provide support for my interpretations of events.

Long-term observations. The nature of this study requires the observations to be conducted over a long period of time. In order to capture a variety of classroom activities, the observations occurred daily for approximately five days. Due to my time constraints, longer periods of time were not possible as discussed previously.

Researcher bias. Having been a classroom teacher for ten years, I have had experiences with both traditional and standards-based textbooks. Throughout my teaching career, I have consistently had a participatory relationship with my textbooks resulting in the development of curriculum to meet the needs of my students. Although I have always taken this approach to planning instruction and could therefore be considered biased, this approach is supported and currently encouraged in the literature (Remillard, 2005; Stein, Remillard, & Smith, 2007).

Ethical Considerations

Due to the relationship that I had with the district in this study, several of the participants were known to me. Although this is typically a concern, it is believed that the previously developed relationships enhanced the study by placing these particular participants at ease during the interview and observation phases of the study. In addition, the teachers selected for this study came highly recommended by both their instructional supervisor and their principals and could therefore be considered exemplary teachers in their district. The interview sessions focused on how these teachers plan and implement instruction and it is believed that these exemplary teachers had little to hide in this area.

4. Balanced yet Separate

Introduction

This chapter presents the cross-case findings for two teachers, Lea and Kath, who were found to present a balanced approach to the development of procedural and conceptual knowledge with their students. This balance was achieved by the ways they approached engaging their students in separate activities while devoting an equal amount of time to develop both knowledge types. The following section will provide a short introduction of each teacher followed by the findings.

Lea Turner taught both sixth and seventh graders at her current school. Although she had taught for 12 years, the majority of those years were in a different district and her former school was on an alternating day block schedule. Lea described the seventh grade class would be observed as having students at "both ends" of the ability spectrum. She stated that some of the students would be recommended for advanced coursework next year but that some were very low, stressing both with skills and their self-esteem. When I asked if there was anything she would like to tell me about her class before the observations, she stated that she has an open environment in her classroom and sometimes that may seem chaotic. She also stated that sometimes they yell out and she has to emphasize speaking one at a time adding that "They like to contribute, this class, sometimes in a positive way, sometimes not" (initial interview, 3/20/09).

Lea was observed during a week where she was reviewing and extending the concepts of polygons, quadrilaterals, area and perimeter. The unit started out with the students comparing and contrasting examples of polygons and non-polygons in order to derive a definition of what makes a polygon. The students then used geo-boards to create examples of triangles and quadrilaterals and further classified these shapes as a whole class. The following day the students used a worksheet to match quadrilaterals to all the possible names that may be appropriate. The remaining three days were focused on solving for area and perimeter of irregular shapes.

Kath Mitchell had taught for 10 years at the high school and middle school levels with most of her experience focused on the teaching of eighth grade pre-algebra and algebra I. She was the gifted and talented mathematics teacher at her school and therefore taught a variety of courses including algebra I and geometry. The course I observed was an eighth grade algebra I course. Kath described her students as advanced because they were in algebra, but then stated

> I would say that less than half of the class, though, is prepared to be in an algebra class, as far as their development goes, and an intermediary class would have been very nice. And it is quite obvious that they are not where they need to be to understand the material. But these are the students who did well last year in pre-algebra, and passed their SOL, and they're here with me. (initial interview, 4/3/09)

There were a few students in the class who had taken algebra I the previous year and were repeating it. There were also about six students who participated in a remediation algebra class held daily during an earlier class period and taught by Ms. Mitchell. Kath further described her class as “a mixed ability class, it's not what I would normally consider the typical algebra class, because they're all over the place” (initial interview, 4/3/09).

Kath’s classes had finished a unit on operations with polynomials and factoring right before their spring break and she was beginning a unit on quadratic functions. I observed the class the week they returned from their break and, in order to review prior material and connect it to where they were going, Kath had the students first factor several expressions and then change the expressions to equations set to zero in order to determine the solutions to the quadratic equations. The next two days were also very procedurally based. The students solved quadratic equations during the course of playing a bingo game one day and, the following day, Kath reviewed the quadratic formula and the students practiced solving quadratics using the formula. The last two days engaged the students in exploring the maximum area of rectangles with fixed perimeters in order to connect the concept of the maximum and minimum of a quadratic function to a real world application.

Findings

Lea and Kath were found to approach the planning and teaching of mathematics similarly. They each stressed that they had experience with a variety of resources that they selected from and used with their students to guide instruction. They were also found to be very flexible with their instruction, changing their plans frequently in response to their students’ reactions. Finally, Lea and Kath were both found to present a balanced yet separate approach to the development of procedural and conceptual knowledge with their students.

Resources

Lea and Kath had a variety of different resources at their fingers tips that they purposefully selected in order to meet the needs of their students. Another influential factor in the selection and implementation of resources was the ability of the resource to assist students with making connections. As will be discussed in more detail in another section, Lea and Kath also flexibly adjusted their use of resources as needed based on their students' reactions to the activities and time.

"Well, I'm using a variety of resources, not necessarily the textbook." Kath and Lea discussed and used resources from a variety of different sources during the study, but one finding is worth noting because of its absence. Although I never specifically asked any of the teachers involved in this study about their textbook use, they all brought it up during the discussions. Lea only briefly mentioned the textbook stating "I guess I go to the book, the text, more for homework, they don't like those workbook pages" (final interview, 3/30/09). There was no further discussion about the text and, during the observations, Lea and her students were never viewed using the textbook or its associated resources. Lea did clarify how her students' notes took the place of a textbook as a resource stating,

> Where taking notes becomes important to them is they don't have their math book. So when I give a class assignment I say, "You can use your notes, you can use your calculator, you can use your pencil, you can use your brain. Not me or

> your neighbor". It tends to make them, next time, take better notes, because they know they're on their own. (final interview, 3/30/09)

Kath referred to the textbook as something that was "at home with the students, to use as a resource" (initial interview, 4/3/09) while her use of the textbook was limited to selecting problems for use for in-class and homework practice. She defended her limited use of the textbook stating,

> I use the [pause] I don't use a textbook a lot. I think that [pause] for some of it, I think it's just the material isn't presented in a way that I think the students will understand. Sometimes it's just too much, too much information given to them. (final interview, 4/21/09)

However, Kath did use a variety of problems from the textbook and its resources during class and for homework. The problems came from either a textbook or workbook and were written on the board by Kath for her students to copy. She purposefully selected problems so that they met her instructional goals for the day. For example, on the day she taught the quadratic formula she justified her selection of problems as "I just used a variety of problems from the workbook; some factorable, some with no real solutions, etc. to give them the opportunity to see different types of graphs and multiple ways to arrive at the answers" (teacher log, 4/16/09).

"I've got lots of bells and whistles to pull out of my bag for that." Lea appeared to have a vast amount of experience with the curriculum she taught and, with that experience, came a plethora of resources. When asked what influenced her when she selected resources for her class she stated,

> Probably past history. Because I notice, now that I'm teaching sixth grade, I have no past. Well, actually, it's 15 or 20 years ago past, and I don't even have anything from there. So I am kind of, like, making it up as I go. Seventh graders, I have an idea of what I have used in the past that worked, and I try that. (final interview, 3/30/09)

Lea used her past experiences with students and with resources to assist her with selecting activities for use in her classroom. She seemed very aware of a typical seventh grader's strengths and weaknesses with the content and used that background knowledge to assist with her selection of resources. When asked what features she liked about the resources she was planning on using during the observations she stated "With the quadrilaterals, they like the games. It keeps them interested. Same thing, they have to work, they have to think. They're competitive, so I use all the characteristics of a middle schooler, hopefully make it work for me" (initial interview, 3/20/09).

Lea explained that she had taken a variety of classes over the years and had two file drawers full of resources as a result of all her experiences. It was clear during the initial interview that Lea had a lot of experience teaching the content that would be observed. When we discussed resources, she mentioned that she had not yet been through all her files, but that "I like to start with what, trying to find out what they know. So I give them a comparison, where they have to figure out on their own what makes a polygon a polygon" (initial interview, 3/20/09). A little later she added "So, I believe I have a couple of activities where I match the characteristics with the names of the quadrilaterals. I think I have two, or that's my plan" (initial interview, 3/20/09). So, even though she had not planned out exactly what would be observed the following week, she was able to recite several different resources that she eventually ended up using based on her past experiences with teaching the content.

Kath also discussed how she had a variety of resources she had gathered from various workshops, from cutting and pasting existing material, or from creating her own material. When justifying some of the resources she might use before the observations she stated,

> I think it's more interesting than what the book has to present. That's not to say that I may not [pause] that I won't use some of the word problems from the book. I may do that. But I think it's just more interesting, and will be more engaging for the students. (initial interview, 4/3/09)

Kath discussed the various opportunities that she has had to learn about the material in the observed unit stating "At [pause] probably in NCTM [National Council of Teachers of Mathematics] conferences or VCTM [Virginia Council of Teachers of Mathematics] conferences, where teachers have presented strategies that have worked for them, and I have compiled some good activities and engaging activities for the students in that way" (initial interview, 4/3/09). She later referred to her ability to find alternate resources as needed stating "So, I never know. But I do have a lot of resources in my file cabinet to pull from. So, you know, it would be something [pause] there should be something in there that's presented in a different way" (final interview, 4/21/09). During the final interview she clarified why she picks and chooses from a variety of resources stating,

> I don't know. I think it's really important for the teacher not to stick with just one resource, use the textbook [pause] and I know that some people are very comfortable with that. But I think that there are so many other ways to look at a topic, and to present it, even in just the way [pause] the words that are used in presenting it. So, I feel it's really important that a teacher look at more, for more than one resource, yes, I think it's just pulling from a variety of resources. (final interview, 4/21/09)

"To make a picture in their head." Assisting their students with making connections was stressed by Lea and Kath frequently. Lea stressed that she liked using manipulatives because they make her students think and it helps them to remember by given them something visual to connect to. Early in the interview she stated "I try to do hands-on activities, only because I have seen they [the students] will remember" (initial interview, 3/20/09).

During the observations, Lea used a variety of resources that could be classified as hands-on. The area and perimeter concepts were explored several different ways that involved the use of grid paper. Students first made shapes on grid paper to meet certain specifications that Lea had written on the board such as "create a polygon with an area of 15 square units" (field notes, 3/25/09). Another day they used teacher created shapes on grid paper with irregular areas in order to explore and share different methods for finding the area of the shapes.

Lea's opening lesson involved using geo-boards to create various triangles and quadrilaterals. The students then used the examples they created to classify the polygons as a whole class. Geo-boards with student made examples were brought up and grouped together in “families” by the students based on their characteristics. The students then copied this visual representation into their notes for future reference. Lea justified why she selects these types of hands-on, visual resources stating,

> The reason I like to use them is it makes the kids have to think. It's not me telling them what to do. They come up, and especially with the polygon sort, what I have found, and I have been doing this just for a few years, they come up with almost the exact definition from the book. And they just beam when they can sound just like the book. So, I use that one, because I hope it sticks in their head, of what a polygon has to be. (initial interview, 3/20/09)

Kath’s focus on connections presented itself in her use of a real world situation that modeled a quadratic function. The activity that Kath used to make this connection was developed from a *Connected Mathematics* activity and involved finding the dimensions of various pens that could be used to house a pygmy goat. The goal of the activity was to find the pen with the largest area. In explaining her reasoning for selecting certain resources, she justified her use of the *Connected Mathematics* activity stating “But they are at the point where they don't see any meaning in what we're doing. So I definitely have [pause] I do want to make that connection with them” (initial interview, 4/3/09).

During this activity, the students created a graph of the length of the pen versus the area of the pen so that they could determine which pen had the maximum area. This was followed by a whole class discussion on what caused the shape of the graph to be a parabola versus the line that came from graphing the length versus the width of the pens. Kath guided her students through a discussion that included connecting the units involved in calculating area to the shape of the parabola that represented a quadratic function. Her focus on making connections so that her students would understand the mathematics they were investigating was clearly stated in her final interview. When asked if she would be connecting the activity to the formulas for the maximum of a parabola, she clarified that her purpose was only “Just understanding the shape of the graph, and what it's saying to them, and why would that be a maximum point, why would that be a minimum point, and just understanding, just interpreting what the graph means” (final interview, 4/21/09).

Summary. Clearly using a variety of different resources was important to Kath and Lea as they planned and implemented their instruction. They both had access to a wide range or resources they had gathered over the years from various sources and they both shared similar beliefs about the use of the textbook. Although Lea and Kath stressed the use of materials that would assist their students with making connections, Lea attempted to achieve those connections with hands-on materials and Kath focused more on real world connections that modeled the mathematics. Kath and Lea’s vast experience with students and resources also played a key role in their willingness to flexibly adjust their instruction as needed which will be detailed in the next section.

Organized Versus Flexible

Kath presented an organized plan during the initial interview, but then proceeded to present the information in a different way during the observations. Lea was an experienced teacher, especially when it came to the seventh grade curriculum. Her experiences with various resources and her students' reactions to them assisted with her preparedness to teach the lessons but may also have hindered her ability to flexibly react to her students' reactions to the activities. Although Lea and Kath had some differences in how they planned and implemented lessons, they both presented organized lessons and also flexibly adapted their plans for similar reasons. Their similarities and differences will be presented in the following sections.

"I fly by the seat of my pants." When the coded data for Kath was reviewed, not many selections were coded with the category *flexible*. Yet, when I look at the big picture for her, the opening sentence of this paragraph fits her perfectly. The plan she described during the initial interview was much different than the plan she implemented during the observations. She flexibly modified her plans and how she implemented them based on her observations of her students and their needs.

Based on the initial interview, Kath had planned on first having her students graph quadratic functions by hand and then compare their graphs. Next, she had planned to move on to factoring. She discussed that she would then allow her students to create graphs on the graphing calculators to look at the different aspects of the parabolas and finally move on to word problems. What was actually implemented in class was quite different from this initial plan and Kath hinted at that stating "I think I've covered just about every, what's in my plan. Whether or not it will actually happen, who knows?" (initial interview, 4/3/09).

I remember being surprised the first day when Kath opened her unit on quadratic functions not with graphing functions but with factoring polynomials. She may have wanted to move onto graphing after reviewing factoring but, as she described in her log to me “I modified the lesson by slowing down the pace because the students had forgotten how to factor polynomials” (teacher log, 4/14/09). In addition to slowing down the pace she added “I simplified the notes for the students and I chose easier problems than I had originally planned. I did this because the students had difficulty recalling the material prior to spring break” (teacher log, 4/14/00). Because of her students’ difficulty with remembering previously learned skills, Kath modified her entire presentation of the unit.

As her students were working through the procedural aspects of solving quadratic equations, Kath realized that they had not made connections between the procedures and what the solutions meant. During the final interview when she described the factors that influenced her as she implemented her lessons she stated,

> So, instead of jumping right into motion problems and the equations that I knew would confound them, we spent a couple of days looking at fixed perimeter and area, and making some connections with [pause] between that and the quadratic patterns. And I think it helped them, I think it was worth the time. (final interview, 4/21/09)

Kath described herself as someone who flies by the seat of her pants and the data collected during this study support this description. She described her flexible approach to implementing lessons as,

> Well, I mean that I may come in [pause] I know what we're going to, but I may come up with a [pause] I may think of something else that would [pause] that

> could be better. And so I may change, you know, 10 minutes before class I may find some material that I think, "Oh, this would be better, this would be better" and I will change. So, I don't necessarily stick with what I think I am going to do. It changes. (final interview, 4/21/09)

"I happen to know what my plan was." Lea was influenced by a variety of factors throughout this study, but she did know what her plan was for her students. Because she did not have formal lesson plans, it appeared as if her plan was laid out in her head yet she was able to stay organized and focused on her objectives for this topic. She had a variety of resources at her fingertips and she demonstrated a deep knowledge of her state's objectives all of which seemed to assist her with her preparation to teach the content and with her organization.

Lea used a variety of handouts during the study and these resources were copied and cut to size when the students arrived in her classroom. She didn't appear to have all her resources for the week laid out, but instead seemed to take into account her students' interaction with the activity on a given day before finalizing what activity and resources she might need for the next day. One example of this was when, due to her students' difficulties with the lesson on the fourth day, Lea revised her plans for the last day. Lea reflected on the modifications she made to her plans that day stating "I was planning to do more rote application of the area formulas. But we needed more reinforcement on the 'why these work' understanding" (teacher log, 3/27/09). I believe it was her strong background with the content and her vast knowledge of appropriate resources that allowed her to appear organized on any given day yet also flexibly adjust her plans based on her students' needs.

Lea taught three sections of seventh grade mathematics and the course that was observed followed the other two. Like other teachers in this study, Lea stated that she flexibly adjusts what she does based on her experiences with her other classes. In describing how she modified her lessons she stated,

> But if I see something didn't work in first [period], and I can't get it to work after modifying it in third [period], I scrap it and then we do something else for fifth [period]. That's why fifth was, I thought, a good time for you to come in, because usually by fifth we have it perfected. (final interview, 3/30/09)

Interestingly, according to Lea, her fifth period did not react to some of the lessons as well as her other two sections did. When asked if she could go back and make any changes to the observed lessons, she mentioned the lesson that occurred on the fourth day describing it as "That was kind of miserable. And I don't know why for them, because it worked really good with the other two classes" (final interview, 3/30/09).

It was noted during several of the observations that Lea's expectations of what her students would do seemed to impact her and make her less flexible in her reactions to students' questions, answers, and actions. The most vivid example of this occurred during the fourth day when the students were using two shapes to combine and create a sketch of a polygon. The shapes that the students worked with were a 6 by 6 inch square and a right triangle that had sides that measured approximately 4 inches, 4 ½ inches, and 6 inches. When Lea sketched the triangle on the board at the beginning of the lesson, it did not resemble a right triangle based on its orientation and its shape. I noted “I am confused because the triangle is a right triangle and what is drawn on the board does not look like a right triangle” (daily summary, 3/26/09). It became clear that she expected the students to find the area of this triangle by using the hypotenuse as the base and measuring the height from that base. I came across a group that had found the area using the legs of the right triangle as the base and height and when Lea came over and noted what they had done she was confused. She then stated “OK Miss Professor I may need you on this one” [referring to me] (daily summary, 3/26/09). When I commented that it would work because it was a right triangle she stated “I haven’t had any do it this way, that’s cool” (daily summary, 3/26/09).

The episode described in the above paragraph was confusing to me because I saw a right triangle and it was my expectation that the students and Lea would use the dimensions of the legs to find the area. It seemed that it was just as confusing to Lea because she did not view the triangle as a right triangle and expected her students to measure the base and the height of the triangle another way. Based on her comments, I concluded that her other classes did not notice that the polygon was a right triangle either, but that may have been due to how she presented it. It is unclear whether her expectations came from her own perceptions of the shape or how her students in her previous two classes had solved the problem. What is clear is that her expectations resulted in her being surprised and slightly confused when her students presented another approach that she had not expected.

Summary. Kath and Lea had years of experience teaching the content that was observed along with a variety of resources to teach it. This experience allowed them to easily plan and modify plans based on their students' reactions to what occurred in the class room. When I looked back at all the data, it was clear that Lea and Kath did not necessarily have organized plans, but they certainly had explicit goals for what they wanted to accomplish. The way in which they ended up getting there depended heavily on their students reactions to the lessons presented. On a daily basis, I found Kath and Lea to be very organized teachers who consistently planned and implemented their lessons with their students' needs in the forefront.

Balanced yet Separate Approach

The main objective of this research was to explore whether teachers who have a participatory relationship with their curricula balanced the development of procedural and conceptual knowledge with their students. Kath and Lea were found to present a balanced approach in that they spent approximately the same amount of time developing procedural knowledge with their students as they did developing conceptual knowledge. Although their approaches were similar, there were some differences. The following sections will present each of their approaches separately and then summarize the findings.

"They get the formula." As stated, Lea embraced the use of hands-on resources because she believed they gave her students something to connect to. In describing the lessons that would be observed, she seemed to believe that her students already had an understanding of the formulas, but lacked a deeper understanding of the concepts of area and perimeter. Because of this she stated,

> Perimeter and area is where I want to focus, because I'm still seeing in the seventh grade that they have trouble with what to do. They get the formula, but they don't get what they're doing. So I'm hoping to go dig up some tiles and do some area work on graph paper. (initial interview, 3/20/09)

Lea had a variety of resources that she had been using over the years and she focused on selecting resources that would further develop her students' conceptual understanding of area and perimeter because, based on her experiences with her students, she believed that to be an area of need.

It appeared as if Lea consistently tried to develop her students' conceptual knowledge while also recognizing the need to make connections to the procedures. She achieved these goals with varying levels of success. In describing one of her lessons, she stated that her objective was for her students

> To be able to understand the formulas for area and perimeter. To make a "picture" in their heads. To be able to apply the appropriate formulas for the task being determined. I was hoping the graph paper would help them identify why we multiply the height and the base for the area, and to add the sides when solving for perimeter. I'm not sure it worked. (teacher log, 3/25/09)

Time was an issue for Lea throughout this study and it certainly impacted her as she tried to balance the development of procedural and conceptual knowledge with her students. Based on the observations and Lea's interview comments, it appears as if, because of the limited time in class, class time was reserved for activities that focused on conceptual understanding and homework was devoted to more procedural tasks. So, whereas Lea attempted to balance the development of both of these knowledge types with this approach, the connections between the concepts and the procedures were not made explicit for the students. During a discussion, Lea seemed confused as to why her students were not making these connections stating,

> I think maybe it's because they didn't' get enough conceptual before. So the little bit I did wasn't enough to understand. And now it's all just mixed up, because they understand the [pause] they know to use the formula, but they don't know what works for the formula. . . . And it's almost like they're more confused. Or maybe they would have done [pause] I mean, the squares, the graphing. They got it. Well, there is three here and there is five there and that's why you do it, because you get all those squares in there. But then they don't take that over when there aren't the squares on the paper, and see 3 times 5. So I don't know what [pause] I don't know what we messed up with them. (final interview, 3/30/09)

Later in the interview, Lea seemed to recognize that this lack of connection between concepts and procedures may have been the cause of her students' confusion. During this discussion she stated,

> I think the activities on the graph paper helped them because they could find it and they could make it, like the warm-up. But as soon as we took that graph paper away, they couldn't figure out what to do. . . . But then that homework that night

didn't have squares on the page. And I do have a worksheet that has squares on the page that they could work on, but I didn't give it because of time. I thought, okay, they did it with squares, now let's see if they can do it without the squares kind of thing. And they couldn't. (final interview, 3/30/09)

"The chicken or the egg?" If one looks purely at the amount of time spent on various activities, Kath did present a balanced approach to the development of procedural and conceptual knowledge. Yet when all the data are analyzed, it appeared that Kath was more focused on which came first. When asked which she felt was more important to focus on when planning lessons, the development of procedural or conceptual knowledge, she responded "The chicken or the egg? It just depends. I would like [pause] ideally, it would be the conceptual knowledge" (final interview, 4/21/09). On several occasions she stated that, if she could change anything about the observed lessons, she would change the order she presented the information. At the beginning of the final interview she said "So, I was [pause] I knew that I was eventually going to do some real−life applications, but I probably should have started [pause] done those first, and then gone into the factoring and other things (final interview, 4/21/09).

Even though she recognized that she should have started the quadratics unit with the conceptually based *Connected Mathematics* activities, Kath stated that there have been other situations when she has started with procedures first. She stated "But there are cases when I would start with the procedures, and then look at the problems more and more in depth. So it just depends upon what it is, and what I perceive their [her students] needs to be" (final interview, 4/21/09). So although the order is important to Kath, it appears that she believed there is not one fixed way to present information to students. Which knowledge type is presented first seems to depend on the students and/or the topic.

In hindsight, for the topics covered during this study, Kath believed that developing her students' understanding of the concepts should have come first. When asked what factors influenced her during the study, the first question in the final interview, she responded "Well, one of the factors is that I probably did cover the material backwards. And I could tell that the students were not really understanding what they were doing, in solving the quadratic equations. They weren't making connections" (final interview, 4/21/09). Her first sentence was not an answer to my question and it seemed as if she just wanted to start the discussion by pointing out what she would have changed. But the next two sentences do focus on why she altered her plans. She realized that her students needed to explore quadratic functions first before they would be able to make connections to the procedural skills needed to solve them.

Although Kath focused on which knowledge type should come first during the discussions on the development of conceptual and procedural knowledge, she also brought up how time was a factor. When asked to describe any areas that were difficult for her when she attempted to balance the development of these knowledge types she responded "Well, in general, it is a time factor, and how much am I willing [pause] how much time am I willing to devote to a certain topic" (final interview, 4/21/09). I asked if she was referring to how much time she should spend on the development of conceptual knowledge and she clarified,

> The [pause] yes, the [pause] how much time can I allow for that. And then, what happens if I go ahead and devote that time? And I think they have it, I think they've got it, and then I realize that they didn't. You know, I've spent a chunk of time on something, and I really thought they understood, and then the assessment shows me that they're still foggy. (final interview, 4/21/09)

So, in addition to which should come first, concepts or procedures, Kath seemed to struggle with how much time to allot to the development of these knowledge types.

Specific knowledge-type resources. Both Kath and Lea were found to present a balanced yet separate approach to the development of procedural and conceptual knowledge with their students. One of the ways they achieved this is through the use of resources that focused specifically on the development of either conceptual understanding or procedural skills. Although Kath did not discuss using different resources in order to assist her students with developing procedural knowledge and conceptual knowledge, that is what was observed. During the first three days of the observations the students were developing the procedural skills needed to solve quadratic equations. The resources that Kath used to assist with the procedural aspects of solving quadratic equations came mainly from the text. As described previously, the problems were purposefully selected to meet the instructional goals for the day. Problems from the textbook resources were used for both in-class practice and homework. In contrast, during the last two days the students were engaged in activities to assist them with gaining conceptual understanding of quadratic functions. For these explorations, Kath presented activities developed from ideas she found in the *Connected Mathematics* series. These activities focused specifically on developing an understanding of quadratic functions and what the maximum point of the parabola represented.

Lea also used knowledge-specific resources with her students but had a different approach. The resources selected for use during class were all focused on assisting her students with understanding the concepts. During the initial interview Lea described why that was her intended focus as “They get the formula, but they don't get what they're doing” (initial interview, 3/20/09). During class, her students used a variety of manipulatives and hands-on materials and the activities focused on understanding the concept of area. In contrast, the homework assignments that Lea selected for much of this study were strictly focused on developing procedural fluency with the area formulas. She used worksheets from a variety of sources and modified them as needed to fit the procedural skills she wanted her students to master. Contrary to her initial thoughts that her students understood the formulas, she found that they failed to complete some of these homework assignments because they did not understand how to apply the formulas.

Summary. Both Lea and Kath presented a balanced yet separate approach to the development of procedural and conceptual knowledge with their students. Lea approached her unit believing that her students could already apply formulas but that they didn’t understand why they worked. Because of this, her class room instruction focused extensively on exploring the concept of area. Kath focused more on the order in which she presented the material stating that she should have presented the material in a different order. Both teachers used resources that exclusively focused on developing procedurally fluency or conceptual understanding without explicitly making connections between the two. Also, both teachers mentioned the importance of having enough time to be able to successfully develop both conceptual and procedural knowledge with their students.

Conclusion

Lea and Kath both taught in class rooms that were full of energy and these teachers worked extremely hard at keeping their students engaged in learning. It was frequently noted that their students were a very influential factor as they planned and implemented instruction. Lea and Kath were always organized and prepared to teach their lessons and they both flexibly adjusted their plans based on their students' needs and reactions to the lessons.

Lea and Kath had a variety of resources that they had accumulated or developed over their years of teaching. Kath pulled resources from a variety of sources with certain resources selected to develop procedural fluency and other materials engaged the students in activities to assist with their understanding of concepts. Lea incorporated resources that allowed her students to visualize the concepts during class and selected resources focused on procedural skills for homework. Although, during this study, there was a good balance between procedural and conceptual activities, neither teacher explicitly focused on making connections between the concepts and the procedures. Finally, a lack of time was a factor that was mentioned by all the teachers in this study and it may have played a key role in how Lea and Kath balanced the development of procedural and conceptual knowledge.

5. Balanced and Connected

Introduction

This chapter presents the cross-case findings for two teachers, Lynn and Ginger. These teachers were found to balance the development of procedural and conceptual knowledge with their students using a connected approach. As with the previous chapter, a short introduction of each teacher will be provided and then the findings will be presented.

Ginger Harris was a sixth grade mathematics who had taught for 27 years. She described the observed class as an average group of students that had a range of abilities. Some of her students participated in her morning remediation sessions during homeroom and she described other students in her class as having very high ability in mathematics. Ginger also described her class as very quiet and stated that, although she had focused on improving their communication skills throughout the year, this remained an issue.

Ginger was observed teaching a unit on fractions, decimals, and percentages. In discussing this unit during the initial interview, she stated “I think this topic is kind of overwhelming for them. And so it becomes overwhelming for me too because of trying to break it down and make it make sense to them” (initial interview, 3/20/09). She went on to say that although it may not be her favorite topic, she enjoyed teaching it because of all the real world connections. The observed classes began with a group activity that focused the students' attention on real world applications for fractions, decimals, and percentages. The following day the students used fraction pieces along with fraction, decimal, and percent measurement rings in order to name the pieces using all three representations and organize the data to explore patterns. The next two days were spent doing a combination of note taking, pattern exploration, and practice finding equivalent representations. During the final day of observations, the students practiced converting between fractions, decimals, and percentages on laptop computers using a variety of software programs.

Lynn Smith had taught for 8 years, teaching the eighth grade pre-algebra curriculum and Algebra I. She also had experience teaching on an alternating day block schedule in a different school district. She served as the gifted and talented mathematics teacher in her school and, as such, taught several different content areas to both seventh and eighth graders. The observed class was an eighth grade algebra class and Lynn stated that the group was fairly homogeneous but that I may notice a few students who really stood out and a few others who were slightly below the ability level in the class. Because this was an eighth grade algebra class, the overall ability level of the class would be considered high for eighth graders. Lynn described her class as a little on the silly side but that they were very comfortable in the classroom. She added that they did not hesitate to ask questions and that they usually asked very good questions which enhanced the classroom discussion.

The observed class had just finished a unit on solving systems of equations and inequalities and was getting ready to begin a unit on multiplying binomials. Lynn stated that the two topics did not really flow together, but that she was trying to follow the district's newly developed pacing guide. She did mention that the unit would allow her to review previous topics such as combining like terms and exponent rules with her students. Also, following this unit, the students would move into factoring and then quadratic functions.

Lynn began the unit by engaging her students in a whole class review of some skills and vocabulary they would need and an overview of the topics they would cover. During the observations, the students were involved in multiplying binomials using a variety of methods. They began by using *Algeblocks* to model multiplying binomials and then connected that method to an area model. The class also explored distributing and then derived the FOIL (first, outer, inner, last) method for solving binomial multiplication problems. The vertical method was also demonstrated and throughout these different methods, students were encouraged to try out the different ways to solve the problems and determine which method they preferred. During the final observations, special binomials were explored.

Findings

Lynn and Ginger were found to approach the planning and teaching of mathematics similarly in three main ways. First, they were both very organized teachers yet they were also found to be extremely flexible for similar reasons. Making connections between mathematical concepts, to topics previously reviewed, or to the real world was also found to be a very influential factor for Lynn and Ginger. Finally, both teachers presented a balanced yet connected approach to developing procedural and conceptual knowledge with their students.

Organized Yet Flexible

Of the teachers in this study, Lynn presented the most organized plan for what was observed. On the other hand, after the first interview session with Ginger, I was not sure what to expect during the observations. Yet, I can clearly remember sitting in Ginger's classroom one day after several observations and thinking that she was probably the most organized teacher that I had ever met. After all data were analyzed, both of these teachers were found to be extremely organized and yet very flexible with the planning and teaching of mathematics as will be explored in the following sections.

"I'm a very organized person." Evidence of Ginger's need to be organized was found just by looking around her classroom. On the back wall was a heating unit that had stacks of pre-cut papers lined up and stacked up for future use. Each student table contained a pencil box with all supplies necessary for students including highlighters, scissors, and glue sticks. On several occasions there were clipboards on the students' tables with the required worksheets that they would be using that day. On the days she used hands-on resources such as a manipulative or the laptop computers, everything was organized and ready to be accessed by the students.

During the initial interview, Lynn presented a well-developed plan, was able to describe it to me in detail, showed me most of the resources she would be using, and discussed the few possible modifications that she might need to make to her plans. She described what would be observed stating,

> From there I've got four areas that I want to cover. And again to keep me organized we're going to do an area model, we're gonna do distributing, the FOIL, we're going to do a vertical method, and we're gonna talk about special binomials. and discover those. So from the area model we will do Algeblocks and I will model the Algeblocks plus there's a little video clip and I've got the link all set up ready to go so it'll just automatically go there. And then I've got sample problems for the kids to model with the Algeblocks. Then I'm gonna show them a 2 by 2 grid where, if they don't feel comfortable with the Algeblocks or if it confuses them and I realize I need to switch gears a little bit, then I've got a 2 by 2 grid, an *x-y* axis where the kids will write the expressions along the sides and fill in the boxes [this is the four square method]. (initial interview, 3/4/09)

Based on the observations and the teachers' responses to the interview questions, it became clear that both Ginger and Lynn were incredibly organized and effective teachers. Through the data analysis it also became clear that there were several key factors that assisted these teachers with their planning and organization while also providing them the flexibly to implement their plans. These factors will be explored next.

"If I didn't have my interactive notebook, I couldn't do my homework."

Both Ginger and Lynn incorporated a variety of classroom routines and materials that assisted them with staying organized. One resource they both relied on to keep themselves and their students organized was the use of interactive notebooks. During the initial interview, Lynn provided me with a quick overview of what her interactive notebooks were stating,

> An interactive notebook is basically a textbook. But it is written by the students. In the interactive notebook, they will, it will provide them with the SOLs, the objectives, um a title. Then the students will have vocabulary and teacher generated work pages where it's notes that I don't want to spend time in class, them copying down, but that I feel that are very important for them to know. So then they'll glue them into their interactive notebook and they'll highlight vocabulary words or key phrases. And then they'll describe in their own words what the SOL was stating, what the objective was stating or define a vocabulary word. Then they'll provide examples. They'll provide their own logic over on the side. There in their own words a description of how to solve if they had to teach it to someone else. (initial interview, 3/4/09)

Lynn's frustration with typical note taking led her to introduce interactive notebooks with her students, but she also stated that textbooks are often difficult to read and many of her students could not understand what they were saying adding,

> So I would take the concepts in the book and break it down into words that they could understand. And it just evolved into the fact that this is their textbook. This gives them all the examples. This has all their notes in it, they can go back in, they can make changes, they can add notes. (final interview, 3/17/09)

Lynn described in detail how she gradually develops these notebooks with her students over the school year starting with many teacher generated notes and then slowly turning over responsibility to the students. The observations were made later in the year and, although I observed some guided note taking, the students were also noted routinely taking out their notebooks without being directed by Lynn. By this point in the year, it appeared to me that Lynn and her students had fully integrated the use of this resource into their daily routine and it was a tool that they all found useful.

In the initial interview, Ginger had mentioned that she uses interactive notebooks and I inquired about some of the materials that I had noticed on the back heating unit. She responded that they were all cut out and ready to go. She then described what I would see during class as,

> And you will see them. They will all be laid out, and I will say, "Okay, go get your notes," and they [her students] will go back and they're all in order, sequence, and they will go assembly line, pick up, pick up, pick up, go back to their seats, glue it in. (initial interview, 3/20/09)

Evidence of this exact process occurring is documented in the field notes on several occasions. For example, I wrote the following note describing what was observed on the second day,

> Notes are in back in order - tells students to "head back there." I am impressed with how orderly [quietly as I listen once again to the tape] this occurs. Students get what they need and start gluing. All notes are cut to size, students have glue sticks in pencil boxes on their tables. There are also highlighters and scissors in these pencil boxes which students use as needed. (field notes, 3/24/09)

"Big umbrella." Ginger and Lynn both referred to the Virginia's Standards of Learning (SOLs) and their district's pacing guides as tools around which they organize their instruction. When asked about the factors that influenced her as she planned and implemented instruction, Ginger responded,

> The number one factor was the SOLs that needed to be covered for this grade level. And then I looked at what had previously been covered, which we already have in the pacing guide, and then kind of took an idea of where it was going, and kind of fit it in there, and looked at a time frame, too, because I knew I didn't have the two weeks that I would have wanted. So, I just kind of pick and choose what's going to get me to those goals in that time frame. (final interview, 3/30/09)

She further referred to the SOLs as the "big umbrella" that everything fits under but that she was free to present in any way she wants. She summarized this as,

> So, yes. The SOLs, big umbrella. Pacing guide is wonderful to kind of set the whole tone, but even that I have kind of tweaked, swapped lessons, because it is kind of fluid. And then, from there, because it's up to me to do it, I just have to think about the sequence of it, and what I want to implement. (final interview, 3/30/09)

Lynn expressed similar thoughts about the state standards and her district's pacing guide. She mentioned that she was trying to follow the pacing guide this year in order to provide feedback to her district based on its implementation. In response to a teacher log question asking if there was anything she would change about a day's lesson, Lynn's response demonstrated how she perceived her pacing guide as a flexible document, stating,

> Yes, I think I would have changed the pacing guide to include covering all the rules of exponents prior to introducing multiplying polynomials. That is how I have taught the material in the past. I am trying to follow the county pacing guide so I can offer my comments at the end of the year. (teacher log, 3/9/09)

So, although Lynn and Ginger both organize their planning around the state standards and their district's pacing guide, they also expressed that they had flexibility with how those standards were planned and implemented within their classrooms.

"It keeps me better organized." Lynn's use of the SMART Board as a planning and instructional tool appeared to assist with her ability to be organized yet flexible. After we completed the initial interview, she proceeded to show me the SMART Board lesson that she had developed and it provided a framework for the plan she had just described to me during the interview. During the observations, the SMART Board lessons that she showed me were used each day.

The SMART Board and its associated software was a resource that Lynn used to keep herself organized. She referred to it as a "template" (initial interview, 3/4/09), and I noted during one of the daily summaries that she moved effortlessly between the SMART Board screen, the white board, and the Algeblocks, writing,

> The SMART Board activity provided a framework for the lesson. Though she went back and forth between the white board and the SMART Board and the

> blocks, the lesson, as laid out on the SMART Board was an effective resource for both teacher and students. (daily summary, 3/9/09)

The lesson that she developed would not necessarily stand alone if, for example, another teacher were to use it. It truly was a framework that she worked from and added to by going up to the board and adding examples and/or assigning problems for the students to complete.

Similar to Lynn and the other participants in this study, Ginger did not develop formal lesson plans. She did however create what she called her SMART Board lessons which, for the observed unit, consisted of a 50 slide presentation that included examples of worksheets, copies of notes, slides designed to walk the students through activities, and links to video clips and other on-line activities. She described the process she used to create this document as,

> I usually start by, yes. A lot of it is just thinking, like, on what we've already done. And I use the SMART Board a lot, so I come up with a SMART Board lesson, like a series of things I want to present, and how I want to present it. (initial interview, 3/20/09)

She restated the planning process she goes through during the final interview, again stressing,

> And I just, I brainstorm a bunch of different things. I come up with all these different questions, and then there are all these pages. And with the SMART, you can just pull the pages and put them in the right place. So I try to come up with some kind of sequence that makes sense. (final interview, 3/30/09)

It was evident from the discussions with Ginger during the interviews and from observing her using the SMART Board and its corresponding software with her students that this tool enabled her to flexibly plan and implement her lessons. During an informal observation during her planning period, I noted her talking to her computer screen as she reviewed her SMART Board plans. She first referred to the "yucky, boring stuff" that she had planned but then her face lit up when she remembered she could bring in a "spy guys" video clip. She finished her discussion with her computer by reviewing that she would use the Versa Tiles and then bring in the computers on Friday (daily summary, 3/24/09), demonstrating her use of this resource as a dynamic tool that she adjusted as needed instead of a roadmap that must be followed. She discussed how this particular tool allowed her to make adjustments as she proceeded and to document those changes as follows,

> I go through and I sort it out. And I might change it next year, based on what happened in the classroom and say, "Oh, that didn't work so well," then I make adjustments and, or I will change it right away, because sometimes I'll forget a whole year later. So I make changes already on my SMART Board, so that when it comes up next year I'm like, "Oh, that didn't work so well, so I've implemented something new," and then make notes in their interactive notebook about it, for my notebook. (final interview, 3/30/09)

"Subject to change." Evidence of Ginger's flexibility was found in both the interview transcripts and data collected during observations. She discussed her inability to stick to her plan on several occasions. During the initial interview Ginger stated,

> And I get so frustrated that I can't just go by, I'm a very organized person. My house is very organized. My life is very, I mean, but I can't organize, I can't do it. I can't just go to a plan book and say, “This is what we will do Monday, this is what we'll do Tuesday,” and stick to that. I just can't do it, because it does change from one to the other. (initial interview, 3/20/09)

She then described a recent incident in which she needed to adjust her plans,

> So I had to go back and, and I have these all laid out, and I've got my files up there, and everything is in their little pocket. That's the organizational part. But then I'm like, “I can't keep that like that; I have to go back and make that change.” So I yank it out, and I make the change again, make new copies. (initial interview, 3/20/09)

Several factors were found to influence Ginger and enable her to be flexible with her plans, but the most influential factors were probably her perceptions of her students’ needs and her students’ reactions to what occurred in class. In describing a specific incident that occurred before the observations, she stated “Like I inserted a whole other thing from last night, took my laptop home. Did that because I realized they don't know how to say the fractions” (initial interview, 3/20/09). Later, she described that, in general, “It's them responding to what I give them, sometimes, that makes me go back and say, ‘Whoa, that was bad.’ And I will admit that was, yes, that needs to go back, and we need to talk about that” (initial interview, 3/20/09).

Lynn was also found to flexibly adjust her plans based on her students. It was noted that she routinely employed effective questioning strategies throughout her lessons in order to gauge her students' level of understanding. She then adjusted her plans as needed based on her students' responses. During the first few observations, Lynn frequently responded to her students' answers with "Well I don't know, what is it" (daily summary, 3/9/09), forcing them to reason out the rules of exponents and whether those rules would work for all examples. I also noted that when they were playing one of the review games and an expression needed to be simplified, she consistently asked the students what the expression would be and why (daily summary, 3/9/09). The students appeared to be very used to her questioning strategies and, rather than assuming their answers were incorrect, they typically went on to justify their answer when she questioned them.

The manner in which Lynn routinely asked probing questions and then flexible adjusted her plans based on her students' responses seemed to be one of the most influential factors for her. I documented an example of this in the field notes during a lesson that was focused on reviewing how like terms can be combined (3/13/09). Due to her students' responses to her questions and the misconceptions that came out of those responses, the lesson detoured for about 11 minutes and was completely directed by Lynn's probing questions and her students' responses to them.

When Lynn was asked at the end of the initial interview if she could foresee any factors that might impact the lessons as she had them planned, she responded "Hmmm [pause] well [pause] the students will be the only thing that will really impact it" (initial interview, 3/4/09). During the final interview, I asked what factors had impacted her during the observed lessons and she candidly responded,

> Well [pause] the looks on the kids' face [laughs]. If they're looking at me like I have no idea what you're talking about. Then I know that I am heading in the wrong direction so I need to come back and re-approach it a different way. The questions that the kids ask [pause]. Whether or not they can verbalize their understanding, if they understand things and tell me what's going on. (final interview, 3/17/09)

From the observations of Lynn's classes and the interviews, it was found that one of the most influential factors for Lynn was her students' reactions to her questions and the classroom activities in which they were engaged.

Summary. Lynn and Ginger were found to be extremely organized teachers who flexibly adjusted their teaching based on their students' needs. They both incorporated the use of interactive notebooks that were used to keep their students organized and keep a record of what had been learned. Lynn and Ginger also used the SMART Board as a planning tool that allowed them to develop a framework to keep themselves organized while enabling the flexible adjustment of their plans as needed.

Connections

In addition to being both organized yet flexible teachers, another common finding for both Lynn and Ginger was the importance they placed on making connections with their students. Frequent connections were made to previously learned content and real world examples. In addition, both teachers stressed the importance of using hands-on material to provide their students with something with which to connect their understanding. The ways in which connections were made with their students will be explored in the following sections.

“We don't cook with decimals.” The purpose of Ginger’s first lesson was to have her students brainstorm real world applications of fractions, decimals, and percentages. Although the considerable amount of data coded this way was the result of this focus for the lesson, the fact that Ginger opened the unit with this emphasis demonstrated the importance she placed on these connections. In exploring the data, it became clear that, through Ginger’s questions, the students were not merely making lists of how fractions, decimals, and percentages were commonly used, but they were also focused on developing an understanding of their meaning within that context. For example, one group discussed how food packaging provides the percentages of both the ingredients and nutritional values. Ginger produced a box of oatmeal that claimed it contained “100% rolled oats” and she asked her students what else was in the container. The group responded that there would be nothing else and Ginger stated, "it was just rolled oats -100%! No room for anything else" (field notes, 3/23/09).

In addition to the real world connections made during her opening activity, connections to both money and test scores were made frequently to assist Ginger’s students with converting among fractions, decimals, and percentages. Because most students have a strong understanding of money, these connections were made for examples involving 25% and 75%. Ginger would follow up discussion about these percentages with questions to connect, for example 75/100 to 3/4, by asking the students how many quarters they would have if they had 75 cents. Discussions about grades and tests scores also came up several times and, although Ginger did not assign grades using fractions, she noted that several teachers did. When students were trying to convert 22/25 to a decimal fraction and a percentage, Ginger connected it to a test on which a student correctly answered 22 out of 25 questions and she wanted to know what percentage that would be. As a group, they discussed this and decided that it would be equivalent to 88% which the students obtained by thinking about receiving a score of 22 four times.

During the observations, Lynn consistently guided her students to make connections among concepts, to real world situations, or to previously learned concepts and terms. These connections appeared to be part of her routine as they occurred quite naturally in her class discussions on a variety of topics. Also, as her students explored different methods for multiplying binomials, she helped guide them to make connections among the various different methods they were exploring.

My field notes contain varied examples of Lynn making connections ranging from quick and simple to more complex and time consuming. Examples such as her crossing her arms in front of her when referring to intersecting lines (daily summary, 3/6/09) or flexing her muscles when reviewing the term power during a review of the vocabulary needed for exponents (field notes, 3/9/09) were just a couple of the simple types of connections that appear as part of Lynn's routine. Lynn also used questioning strategies to help her students make connections on several occasions. For example, when she was re-introducing the Algeblocks to her students, she guided them through a discussion on what they had previously used the blocks for and what each of the pieces represented.

Lynn's math specialist background seemed to influence her, as several of the methods she presented were connected to methods the students may have used in elementary school. Before she introduced the four square method, she demonstrated how they could decompose 22 multiplied by 13 into (20 + 2) multiplied by (10 + 3). Using this example, Lynn, with the assistance of volunteers, led the class through the four square method to solve this problem. This easily accessible introduction to the four square method was then connected to using the same method to multiply two binomials. Another method that she presented for multiplying binomials was the vertical method and, before demonstrating that, she reviewed a double digit multiplication problem on the board validating the procedure. This demonstration was then quickly connected to multiplying two binomials vertically.

Making connections was clearly an influential factor for Lynn and Ginger and it presented itself quite naturally during the implementation of their lessons. Although the above section contains just a snapshot of the various connections that were noted during the study, it was clear to me that these types of connections were routine for these teachers. Another important connection for both Lynn and Ginger was the linking of concepts to procedures. This type of connection, rather than occurring naturally, was planned for by both teachers and will be detailed in the next section.

"Well, I wanted to take something visual and concrete and start with that before we went to the abstract." During the observations of Lynn, that was exactly what she did. Her plan was to first allow her students to use Algeblocks to explore finding the area of rectangles made from binomials and then eventually connect that to the more abstract method of *foiling* for multiplying binomials. She described her reasoning for developing the lesson in the final interview, stating,

> Where it, by showing them with the Algeblocks that you have to put one term vertically you have one term horizontally, or one binomial vertically, one binomial horizontally, then you're finding the area, that your breaking it into components. . . . So I think by putting the Algeblocks in their hands, that gives them a strategy that gives them a visual that they know I am finding an area and this is how I need to go about doing it. (final interview, 3/17/09)

A key factor for Ginger during the observed unit was to get her students to see the patterns between fractions, decimals, and percentages so that eventually they will be able to convert among them. This emphasis on the development of patterns was noted several times during the observations. During the second day of the unit, the students used measurement rings to name fraction pieces as fractions, decimals and percentages and recorded the information on charts. After reviewing the task for the day with her students, she told them that they should start looking for patterns as they went through the activities. Ginger walked up to her SMART Board and stated,

> If I had 50% how is that related to the fraction I wrote and how is that related to the decimal I wrote? So as you are working through, see if you notice any patterns that would kind of make it easier to go from one to the other to the other. (field notes, 3/24/09)

During this same activity, the students were required to highlight a 10 by 10 grid in order to visually record the number of squares out of 100 that was the percentage. Ginger pointed out to the students that although they could shade in any 50 squares to demonstrate 50%, it would help them see the pattern better if they kept them all shaded together.

Ginger also used the 10 by 10 grids to help students visually connect the conceptual understanding of what 9% and 90% look like on the grid to the procedure required to write these percentages as decimals. Because this is a confusing area for most students and because her students were uncertain when recording 9 hundredths and 90 hundredths during the activity, Ginger had a student shade in 90% versus 9% on a grid. Ginger focused on which version was bigger at several points in the demonstration to help reinforce that 90 hundredths was more than nine hundredths.

Summary. Ginger and Lynn placed a strong emphasis on making connections with their students. Some of these connections occurred naturally in the implementation of their lessons and were occasionally made in response to a student question or comment. Other connections were planned by the teachers in order to assist their students with connecting their conceptual understanding to mathematical procedures.

A Balanced and Connected Approach

The main objective of this research was to explore whether teachers who have a participatory relationship with their curricula balanced the development of procedural and conceptual knowledge with their students. Lynn and Ginger were found to present a balanced approach with their students and, through the analysis of all the data, their approaches were found to be similar. In the following sections, each of their approaches will be presented separately and then the findings will be summarized.

“Tools in their toolbox.” Based on her experiences with students and how they learn, it appeared during the study as if Lynn fully embraces teaching students a variety of methods for solving the same problem. She made this clear during the initial interview, stating,

> I'm a teacher that likes to show math in lots of different ways. And I tell the kids to choose the best method that they feel the most comfortable with and there's not a wrong method as long as they can explain it and they come up with right answer and the method works. There is more than one way to solve a math problem. So I like to show them at least three to four different methods for most topics. (initial interview, 3/4/09)

During the observations, Lynn had her students explore four different ways to multiply binomials. They first explored multiplication of binomials using the Algeblocks and then they progressed to using what she called the four square method which was another model that focused on area. As the students practiced problems using the four square method, one student came up with a short cut that was eventually connected to the FOIL method. Finally, Lynn demonstrated how to multiply binomials vertically and connected that to the procedure for two digit multiplication. When assigning homework on multiplying binomials at the end of the fourth day, Lynn said to her students,

> You can choose whatever method you want to solve these problems, I really don't care. If you want to use Joe's method, cause we haven't really discussed Joe's method that much, we'll do that on Friday. If you like the box method, the four square method you can use that, if you like the Algeblock method, you can use

> that. Cause I'm gonna show you a couple of other ways. We're gonna discover that there is more than one way to solve this problem. And I want you to choose which method is the easiest for you, the one you understand the best. (field notes, 3/11/09)

It is clear that Lynn believed that students learn in different ways, and what is important to her is presenting material in a variety of ways so that her students find a method that they understand and with which they can be successful. During the final interview, Lynn was asked why she presented the material in the order that she did. She discussed the importance of starting with something "concrete to build on" (final interview, 3/17/09). Although she never stressed this during the previous discussions, it was clear from the observations that Lynn presented the different methods in order from the concrete method to the abstract. In addition, she continually made connections among the different methods. Following a demonstration of the vertical method at the end of the unit, Lynn told her students "So this is just another tool that you can put in your tool box" (field notes, 3/16/09). This statement seems to validate what I believe to be the most influential factor for Lynn as she planned and implemented instruction: providing her students with multiple strategies to ensure that all her students find a method with which they are successful and that allows them to understand the mathematics.

In addition to providing her students with a variety of well sequenced strategies to solve problems, many examples of Lynn linking concepts to procedures and procedures to concepts were observed. When the students were reviewing the rules for multiplying exponents using the SMART Board games, Lynn employed her questioning strategies to link the procedures back to the conceptual understanding of exponents. When students matched an expression such as $(x^3)(x^2)$ to x^5, Lynn would ask the students how they knew they were right. The students would then explain that x^3 was equal to x times x times x and x^2 was equal to x times x and that equaled x^5. During my reflection following this observation, it was noted how Lynn was able to take her students from the rules for multiplying exponents back to demonstrating their understanding of the concepts of exponents and how it "appears as if the students were comfortable with this way of thinking about exponents" (daily summary, 3/9/09).

Later in the study, the students were exploring an example of multiplying a binomial by a trinomial and there was general confusion over how to multiply e by e^2. In this example, Lynn had the students explain the problem to her conceptually so that they were able to determine the answer. She described how she approached this and her students' responses as,

> And then I ask them "Can you draw me a picture? What does this really mean? What does e^2 really mean? If you were to write it out with no exponents what does that really mean?" And right away they could tell me it was e times e. So I said "OK well put it all together, what do you have?" They said "*e* times *e* times *e"*. I said "Well, how do you write that, simplify that for me". (final interview, 3/17/09)

Although the two previous examples are very similar, in analyzing the data, it became clear that one way that Lynn attempted to balance procedural and conceptual knowledge was to consistently link back and forth from one to the other depending on the situation. If a student knew an answer, Lynn would employ questioning strategies to ensure her students' understanding and, in their answers, her students would link their procedural knowledge to their conceptual knowledge. When students were confused about how to complete a procedure, Lynn would take them back and work on developing or revisiting their conceptual knowledge on the topic so that they were able to link it to the procedure.

Lynn was able to express what was observed and explain why providing students with a variety of strategies helped them make the connections between conceptual and procedural knowledge, stating,

> They've got that little tool, so to say, in their toolbox, that strategy where they know I can break this down, and I can visually draw this and I know what this means. So if I can take this big problem with all these exponents and break it down into individual pieces and then put it back together, I know how to come up with an answer. And that's what I want to give to the kids. I want to give them strategies so that no matter what math class they go into even if they're in a Science class and they come against something that they've never seen before, that they have enough background, [she pauses] conceptual understanding, to take whatever it is, break it down into baby simple things, like Algeblocks, an area model, putting the little blocks together and then adding up all the little blocks that you had. (final interview, 3/17/09)

"Yes, I pull from everything." During the interviews, Ginger stated that every lesson was driven by the Virginia Standards of Learning (SOLs). Even though the influence of the SOLs was only subtly noted during the observations, Ginger explained why these standards influenced her selection of resources, stating,

> Yes, I pull from everything. And then, when I go to the SOLs, I know, it's SOL driven, but I go to see what kind of questions they're going to be asked. I mean, I don't want them to be totally blindsided by the way I presented it like I was that first year. I present it one way, and the SOL tests ask it a totally different way, and they can't make that, they can't make the jump [meaning her students]. I want them to see it that way, plus 10 more ways. (initial interview, 3/20/09)

Ginger made clear in her statement above that even though presenting the material as her students will experience it on the SOL test was important to her, it was just as important to her that she represent the material in a variety of different ways. She clearly expressed this in the initial interview,

> So we're going to do lots of that kind of stuff. And I have a lot of other, like, stuff planned to kind of drill it in. You will see Versa Tiles, you will see those fraction circles that we just bought, our Principal just bought us, so I want to use those, SMART Board. Yes, I just want to do a lot of stuff, let them see it a bunch of different ways. (initial interview, 3/20/09)

During the observations, Ginger clearly demonstrated this approach. From the opening lesson which attempted to connect the concepts to real world examples, through the use of the measurement circles to assist the students with discovering concepts, and on through several methods for students to practice what they had learned, Ginger employed a variety of resources in order to allow her students to see the material in different ways.

Ginger's selection of resources demonstrated that physically engaging her students with the manipulatives so that they better understand the material was important to her. Specifically, the activity with the measurement rings engaged the students in inserting pieces of fraction circles into the different rings so that they might connect the physical fraction piece to the different approaches to represent fractions, decimals, and percentages while at the same time realizing that they are all equivalent ways to represent the same thing. Also during this activity, the students were directed to shade a 10 by 10 grid that represented the percentage they were exploring. This provided the students with another opportunity to visually connect the fraction piece with its equivalent representation in a shaded grid.

Although Ginger stated that "I present it a variety of different ways so I can get their hands on things" (initial interview, 3/20/09), her hands on approach was not just limited to the development of concepts as described above. The use of the Versa Tiles, which she described as "just different" and "cool" (initial interview, 3/20/09) allowed her students to physically manipulate tiles as they procedurally solved problems. If the students worked out all of the problems correctly, the tiles formed a design. This enabled the students to self-check their work and it also brought in the "cool" factor that Ginger mentioned. Another manner through which she introduced a hands-on approach to show things differently was through the students' use of laptops. Although the activities on the laptops again had the students practicing the procedures for converting between fractions, decimals, and percentages, it was done in a different way that seemed to be very engaging for all of the students.

When asked during the final interview whether she thought it was important to focus on the development of procedural or conceptual knowledge when planning, Ginger stated “How about both?” and then added,

> I think you need to have both. I think the big picture, and I think that's why I started last week's lesson with, you know, "When do you see fractions, decimals, and percents?" I wanted them to see the big picture, because as it gets broken into parts, those little procedure parts of doing this, and forcing it to 100, you kind of hope that some of that still remains. And sometimes it gets lost in just the doing of it. . . . So, I think it has to be a good combination of both. (final interview, 3/30/09)

Ginger expressed a desire to develop conceptual knowledge with her students because she has seen how students fail to remember even simple procedures because the rules don’t make sense to them. Because of this she stated “I don't want to jump right ahead to say, ‘Oh, you just take the decimal two places to the left.’ That's just kind of the, you know, the rule, and that's it” (initial interview, 3/20/09). Later in her log she stated the reason she designed the measurement ring activity was that “I didn’t want this lesson to be ‘just the rules’. I wanted them to discover on their own how the three related, how they represent the same amount, but in different ways” (teacher log, 3/24/09).

During the interviews, it became apparent that Ginger also recognized the need for developing procedural knowledge with her students. She discussed that at some point the students were going to have to be able to “do the work” (final interview, 3/30/09). She also pointed out that, on the state tests, the students would not be given the fraction pieces to match up and that they would therefore be expected to make the leap to those conversions. Her desire to address this appeared in her selection of resources during the planning and implementation arenas. As discussed previously, the use of Versa Tiles and the *Study Island* activities provided the students with the opportunity to practice converting between the different representations. Also, during the initial interview while showing me her SMART Board lessons, Ginger stated,

> But then I realized I really didn't have any of the rules in there. And you start looking up what the actual rules are, going from decimal to percent and percent to fraction, and this [pointing to one resource] gets wordy. This [pointing to another resource] was like a really nice little quick, "Here is what you do, and here is what you do back again". (initial interview, 3/20/09)

Ginger recognized the need for her students to understand and be able to do the mathematics. Through the sequencing of her lessons, she was able to balance and connect the activities she engaged her students with. During this study, Ginger planned and implemented tasks that flowed from the “big picture” of how fractions, decimals, and percentages are different ways of expressing the same value to the state objective of converting among these different representations. She described this as,

> So, what can I do, and what's a good sequence, that I don't spend too much time on one thing, and that it all flows together, that they know something the day

> before so they can apply it on Tuesday, then what they've learned on Tuesday, they can take it to Wednesday. (final interview, 3/30/09)

The goal of this sequencing of events or flow of activities was two-fold. First, Ginger emphasized the need to design this sequence so that her students would be able to understand the material. She stressed this influence, stating,

> That is pretty much the pattern for every single thing, because I think, I'm trying to think like a kid, and how it would make sense to me, if I was sitting out there and didn't understand. Because there were times when I was sitting out there and didn't understand. So, I'm thinking, "If this would have happened first, this would have happened, second, this would have", I really do consider the sequence, and what's going to make the most sense to the kid, probably the below-average kid that's out there, thinking, "This math just doesn't make any sense to me". (final interview, 3/30/09)

Second, Ginger recognized the need for the sequencing of events to lead to her original objective which she had previously described as guided by the SOLs. In this case, that would be for her students to be able to convert among fractions, decimals, and percentages.

Although Ginger consistently communicated her desire to have her students engage in a variety of different activities, she also recognized that she did not have enough time to present the material in all the ways she would have liked. Because of this, she expressed that it was essential that she sequence the activities so that they would flow in a way that was logical and would allow her students to understand the material.

Ginger clearly stated that, no matter the topic, she is always focused on how she will get her students to the final goal in the time she is allotted.

Summary. Lynn and Ginger attempted to balance the development of their students' procedural and conceptual knowledge during this study by providing them with a variety of sequenced activities and assisting their students with making connections. Lynn stressed presenting her students with a variety of tools so they could pick the method that they understood best. The observations of Lynn also indicated that she consistently focused on assisting her students with linking between their procedural and conceptual understanding. Ginger also stressed a desire to present material to her students in a variety of different ways. She focused heavily on how she sequenced her activities so that her students would understand the mathematics they were studying and be able to apply it.

Conclusion

Lynn and Ginger taught different content areas at different schools and at different grade levels, yet they both presented a similar picture. These teachers were very organized and incorporated similar tools that assisted them with their organization. These tools also allowed them to flexibly adjust their plans based on their students' needs and reactions to lessons. Ginger and Lynn both used interactive notebooks in place of textbooks in order for their students to have an organized system to record what they learned. An interactive notebook can easily be adjusted to meet the needs of all students and it appears that was a feature that these teachers found useful. The SMART Board was used as a planning and teaching tool in each of their classrooms. These teachers described their SMART Board lessons as a framework that they used to guide them and it was clear from the observations that this tool played a significant role in the teachers' abilities to stay organized and focused in the classroom while also remaining able to flexibly adapt their lessons.

Ginger and Lynn planned lessons with the goal of assisting their students with making connections and they also adjusted their implementation of lessons as needed to help their students with making these connections. They both presented their students with a variety of methods and activities in order to assist their students with understanding the mathematical topics under study. Lynn stressed providing her students with a variety of "tools" to choose from and Ginger focused on finding a variety of activities and then sequencing them such that the mathematics would make sense to the students. In the end they presented what was found to be a balanced and connected approach to teaching mathematics. This approach enabled their students to explore the mathematical concepts while also connecting that conceptual understanding to the procedural understanding need to successfully "do the math."

6. Results and Conclusions

Results

The purpose of this study was to explore the interaction between teachers and their curriculum materials in the context of the classroom in order to learn more about the factors that influence these teachers. Specifically, the following research questions were addressed:

1. What factors influence middle school mathematics teachers who have a participatory relationship with their curricula as they plan tasks and implement them in their classrooms?
2. Do middle school mathematics teachers who have a participatory relationship with their curricula select and/or modify resources for use? If so, what factors influence them when they select resources and/or modify the tasks as presented in the resources?
3. Do middle school mathematics teachers who have a participatory relationship with their curricula balance the development of procedural and conceptual knowledge as they plan and implement instruction? If so, how do they attempt to achieve that balance and why?

During the data analysis phase, the findings for each teacher were each developed in four detailed cases. These case analyses focused on answering the above stated research questions as they pertained to the individual teachers in this study. While this analysis was occurring, matrices summarizing the findings for each of the teachers were created and possible themes were noted. In order to investigate possible themes that cut across cases, additional matrices were created. These matrices found in Appendix O, employed a variable-oriented strategy (Miles & Huberman, 1994) in order to assist with the exploration and description of common themes found throughout this study. The matrices along with the analysis in the four cases were used to create the results of the cross case analysis presented in the previous two chapters. The following sections will summarize the findings for each research question across cases, present the conclusions as they pertain to the current literature, and discuss the implications for research and practice.

Research Question 1

There were four main factors that were found to influence the middle school teachers in this study as they planned and implemented tasks in their classrooms. Making connections came out strongly in the analysis of the data for each teacher along with being well organized while at the same time being flexible. Time limitation was a significant factor for all three research questions but had varying levels of influence for the different questions and teachers. The final influential factor for research question 1 was the teachers' experience with the curriculum and different strategies for teaching it. These factors are summarized in the following sections.

Connections

Making connections became a consistent theme for all the teachers in this study. The teachers made connections throughout the observed lessons in a variety of ways. In addition, during the interview sessions the teachers frequently justified their plans for their lessons by stating that the activities and resources that they would use would assist their students with making various connections.

It became clear that making connections with their students was an influential factor for the teachers just by observing what they did on a daily basis. Connections between mathematics and real world applications for mathematics occurred naturally in many of the classrooms. Occasionally they were planned, such as in Ginger's introduction to applications for fractions, decimals, and percentages, but many times they were just a natural extension of the lesson or in response to a student's question. Another type of connection that occurred quite naturally in each classroom was the connection to previously learned material. Although Lynn did mention in her interviews that she had planned some games to do this, many instances were observed in which she and the other teachers made these types of connections "on the fly" while they were teaching. Connections between what the students were currently learning and previously learned vocabulary were also commonplace during most of the observations. Frequently noted during the data analysis was the teachers' use of questioning strategies in order to guide the students toward making connections or the teachers' making a connection based on a student's question about a concept.

During the interview sessions, the teachers frequently referred to planning activities and selecting resources that would assist their students with making connections. Both Lynn and Kath stressed showing students multiple ways to solve problems and how important it was to allow their students to make connections between those methods as they explored them. Ginger focused much of her planning and instruction on linking different representations for fractions, decimals and percentages together in order for her students to gain a solid understanding of these concepts. Also, although Ginger never specifically stated that she was trying to connect the conceptual understanding of the relationships between fractions, decimals, and percentages to the procedures for converting between these representations, the intent of the logical progression of her lessons was clear. She also frequently stated that she was trying to get her students to see the big picture before exposing them to procedures. All the teachers stressed the importance of the use of manipulatives in their lessons to enable their students to "see" the mathematics and therefore make connections to the procedures they were following.

Organized Yet Flexible

Another influential factor for teachers as they planned and implemented instruction was the desire to be organized while recognizing and acting on the need to be flexible. It was clear from the observations that the teachers were all very organized. Because the observations occurred near the end of the third quarter, the daily routines of the classrooms were clearly established. Although classroom rules and norms were not verbalized, they were understood. At some point in each of the classrooms, manipulatives were used and the teachers were always fully prepared. The required materials were organized and ready to be distributed and the teacher was prepared for any misuse of the materials. Although all teachers exhibited this trait, I can still remember how impressed I was with Ginger's ability to be organized. I can visualize her room and how all the materials were set up for easy access by the students. I also remember how efficiently she was able to get her students to gather their notes and glue them into their interactive notebooks. For Ginger, as well as all the teachers in this study, this level of organization made what happened in the classroom run so smoothly and effortlessly, yet clearly many factors had to be planned for and organized beforehand.

Even though none of the teachers in this study presented me with formal lesson plans, they all had definite goals for what they intended to accomplish with their students and could describe different ways in which they might meet those goals. Their goals were centered on the state's Standards of Learning that the teachers saw as the big picture of what they had to teach. The lessons that they presented were organized and well-structured even though no formal plans had been written. Their ability to do this so well should not be a surprise as the teachers chosen for this study were purposely selected because they were thought of as developers of their own curriculum.

Through the observations it was clear that the teachers were very organized, yet they all stressed in the interviews that they might need to adjust their plans because of their students. The influence that the students had on their teachers' plans was evident in their words and in their actions. Lea's addition of a mini-lesson on the Pythagorean Theorem due to her students' misconceptions about the length of a diagonal line is just one example of how the teachers adjusted their plans to meet their students' needs. In addition to being flexible with their implementation of lessons, the teachers also viewed their district pacing guide as a flexible document. During the planning of lessons, they used this document to guide them but also stressed that they felt the freedom to readjust what they taught and the length of time required to teach it based on their students' reactions to the content.

I believe that the teachers' strong content knowledge and their years of experience with the curriculum played a major role in their ability to be so organized yet react flexibly to their students' needs. The teachers were all well aware of the big ideas that they needed their students to understand and they had a variety of tools to fall back on to help them along the way. Both Ginger and Lynn used one tool in particular, the SMART Board, extremely effectively. It was noted that they used this tool to assist them with both the planning and implementation of their lessons. Their SMART Board lessons provided Ginger and Lynn with a framework for their plans while also allowing them to flexibly adapt their instruction based on their students' reaction to the lessons.

Time Constraints

It was no surprise to find that time limitation was an influential factor for the teachers. It impacted Lea slightly more than the others for two reasons. First, it was near the end of the third quarter and she was required to give a district test soon after the observations. The limited time before this test and her need to cover certain concepts before that test impacted what content she taught while I was present. In addition, Lea mentioned several times that she had previously taught on a 90-minute block schedule and she still had difficulties fitting in the types of activities she likes to use with students due to the time constraints of her current classroom. Lynn also had taught on a block schedule and discussed her preference for longer classes in order to implement more effective lessons. All the teachers showed evidence that they continuously kept time in mind as they planned and implemented lessons. As stated in previous chapters, they had a variety of activities from which to select but they were limited due to the amount of time they could allot to teach the concepts. They frequently mentioned that they selected a particular activity or had to leave out another activity due to time.

Tools in Their Toolbox

The teachers in this study were efficient and flexible with their planning and implementation of lessons because they had so much experience with both teaching and seeking out various resources. This experience provided them with what Lynn called their "tools in their toolbox." At the time she was referring to her students' tools, but it became obvious that both she and the other teachers in this study had a variety of tools from which they could select.

Lea and Ginger specifically discussed how their past experiences had provided them with a vast supply of resources to select from and modify based on their students' needs. Although all the teachers had obviously spent time looking for resources, it became apparent that time constraints sometimes limited them to using materials and activities that they had prior experience with – the tools in their toolbox. These available tools and the teachers' experiences with them therefore influenced what they planned for their students.

Most of the teachers were also influenced by their philosophy that students' learn differently and therefore they need to present material in a variety of different ways in order to fill their students' toolboxes. Ginger exposed her students to a variety of different representations for their unit on fractions, decimals, and percentages. In her quadratic function unit, Kath expressed a desire to show her students different ways to solve problems, and during the observations she allowed her students to investigate several methods for finding the solutions to quadratic functions. Of all the teachers, Lynn probably was the most influenced by the need to show her students multiple ways to solve problems. She discussed it many times with me and I heard her state over and over again to her students that "there is more than one way to do a math problem." Student choice in what "tool" they used was also very important to Lynn. She firmly believed that students need to have many tools from which to choose and the freedom to make those choices – just like the teachers in this study.

Research Question 2

The second research question in this study explored the factors that influenced teachers when they selected and/or modified resources for use in the classroom. The teachers used a variety of different resources, which is to be expected because I observed different grade levels working on different content. One common theme was that the district-supplied textbook did not play a major role in any of the classrooms. In addition, all the teachers in this study stressed the importance of selecting resources that would allow the students to make sense of the mathematics they were studying. In the sections that follow, the resources used and/or modified and the justification for their uses will be summarized.

The Role of the Textbook

As mentioned above, the teachers in this study rarely relied on their district-supplied textbook and associated resources for instruction. The few times that textbook resources were observed in use during the study, the resource was used for procedural practice of either a skill explored in class or previously studied. For example, Ginger purposefully selected problems from the students' workbook to practice converting between fractions and percentages for homework one night. One concern the teachers had with using the textbook and its associated resources was that it did not match their state standards and district pacing guide. Therefore, in order to use the textbook, the teachers needed to skip from section to section depending on the content. It was also noted that the teachers had to be careful when selecting problems from the textbook and its resources. Both Ginger and Kath were observed selecting specific problems from the texts to assign for homework. They justified their selections by stating that they picked problems that their students could complete successfully and that matched the skills they wanted their students to practice.

Three of the teachers stated in their interviews that the textbook was a resource for use at home either by the students or their parents. Although some teachers did use the supplemental resources pages and the student workbook occasionally for homework, none of the teachers used the textbook in the school setting. As a possible replacement for in-class reference materials, several of the teachers used interactive notebooks. The students in Lea's classroom were observed taking out their notebooks in the middle of a lesson and gluing in the activity on which they were working. When asked about this later, Lea stated she had a very informal notebook policy but that many of her students had come to recognize that it helps them study and therefore they keep up with the notebook. Ginger and Lynn had a much more structured approach to notebooks that they described to me during their first interviews. It was later observed how routine the use of those notebooks had become in each of their classes. Lynn further described the notebook as an organization tool for both herself and her students. She stressed that the notes she provided for her students to glue into their notebooks and then add to were more accessible to all students when compared to the notes provided in the textbook.

Teachers' selection of resources appeared to be guided by the district's pacing guide along with the state's Curriculum Framework. Because standard textbooks cover a variety of concepts, many of which are not part of the state's curriculum, I believe that they had become too cumbersome for the teachers in this study. For the same reason, the textbooks may actually have become too cumbersome for the students. The teachers in this study had moved from studying textbooks and using those resources to studying their curriculum framework and developing and/or locating resources that matched their needs. Many of the teachers had also moved their students away from using the textbook as a resource by implementing the use of interactive notebooks in order to provide notes and examples for the students to study.

Different Ways to See Mathematics

Another consistent theme in this study was that the teachers believed that selecting visual and/or hands-on resources would assist their students with the understanding of concepts. In the five, observed classes, the teachers presented the following different concrete activities: multiplying binomials using Algeblocks; creating and extending patterns using a variety of manipulatives; sketching shapes and then using grids to find the area of the irregular polygons; creating a plot (quadratic) of the relationship between the area of rectangles that have a fixed perimeter; and using rings with fractions, decimals, and percentages to show equivalency. The teachers in this study selected resources that were appropriate for teaching the concepts they were exploring. They discussed how their past successful experiences with the manipulatives and/or activity were what influenced them to continue using them with their students. They also stressed that using hands-on or visual materials, although sometimes difficult to manage, was a very effective way to engage their students in mathematics.

Two other big ideas came out of my discussions with the teachers about their use of manipulatives. Many of them stressed the need for the students to "see" the mathematics. Lea spoke about wanting to make a "picture in their heads." The activities that were observed and mentioned above created clear pictures for the students to make a connection. In addition to helping students understand mathematics, several of the teachers stressed the need to present material in more than one way in order to reach all students. Lynn probably expressed this need most consistently. Although she was skeptical about using the Algeblocks because of past experiences, she also noted that some students need that visual in order to understand the procedures on which they would be working. During the observations, she presented several different methods for multiplying binomials and always stressed to her student that if they liked that method, they could use it. If not, they could use one of the other methods they had learned.

Teachers in this study clearly believed in presenting material to students in ways that engaged them and assisted them with developing an understanding of the concepts. The visual and/or hands-on materials used presented the students with opportunities to make connections to the mathematics they were working on. During this study, the teachers provided their students with multiple ways to make sense of mathematics as well as multiple ways to "do math."

The Impact of Time

Time was a factor that came up repeatedly throughout this study. When discussing the factors that impacted them while planning and implementing instruction, the teachers frequently brought up not having enough time to accomplish everything they would like to be able to complete with their students. In the area of resource selection, time was again a limiting factor in that it limited what resources the teachers could use with their students and also, some teachers noted that they had limited time to locate resources.

Lea and Ginger mentioned that the lack of time prevented them from using all the resources they had to teach concepts. For the unit covered in this study, Ginger created a SMART Notebook file that contained a multitude of notes, activities, and links that she showed me during the initial interview. She mentioned that time would most likely limit what she could accomplish during the observations and it did. Even though they were not able to use all the existing resources they had, both Lea and Ginger also mentioned that they found it difficult to find new resources due to a lack of time. This forced both teachers to readjust their plans, occasionally shifting the resources they were using in order to accomplish their objectives within a given timeframe.

Even though the teachers didn't formally discuss it with me, their decision to use manipulatives contributed to their lack of time to use other resources. The time required to implement a lesson using manipulatives and the management skills needed to implement these lessons are factors that typically keep many teachers from using them. As discussed in the previous section, the teachers in this study stressed their belief in the importance of using these resources to help their students understand and "see" the concepts. I believe that because these teachers had previously seen the benefits of using these resources, they did not bring them up as having contributed to their lack of time.

The SMART Board as an Effective Teaching Resource

Although Lea had SMART Boards in her room, she did not use this resource during the observations and Kath did not have a SMART Board. On the other hand, Ginger and Lynn used their SMART Boards as integral parts of their teaching. Even though all teachers in this study did not use this resource, the consistent use of this tool daily in two of the classrooms warrants its discussion in this section.

Although all teachers in the study were found to approach teaching with an organized yet flexible approach, I believe the use of the SMART Board as a resource enhanced this capability for Lynn and Ginger. Both of these teachers used this resource as a planning tool. They had their week's lessons laid out using the Notebook Software provided with this tool. Embedded in each of their Notebook presentations were notes for their students to copy, games for the students to interact with, sample problems to work out together, and links to websites to demonstrate concepts and practice skills. They described their presentations as a framework that they flexibly used to guide their instruction for the week. Ginger further described it as a resource that provides structure for her students as well as herself because her students had grown accustom to its purpose as a teaching tool.

Due to the nature of the Notebook Software, Lynn and Ginger were able to readily adjust their plans. Not only were they able to alter what they did on a day-to-day basis, but they also could easily adjust their plans in the middle of a lesson. Lynn transitioned effortlessly from her whiteboard to the SMART Board daily depending on her goals and the reactions of her students to the lesson. Ginger was noted to skip activities due to lack of time and move fluidly onto another section of her lesson. She mentioned that she would try and include the activities that she had to skip in her review sessions later in the year. She stated that because the activities and links were already set up in the Notebook software, they would be easy to access when she needed them later.

Modifications to Resources

Research question 2 focused on the resources the teachers selected and the factors that influenced them when they selected and/or modified those resources. The previous sections summarized the findings on the factors that influenced the teachers as they selected resources. The teachers were all found to modify most of their resources and for very similar reasons. These motivations will be recapped in this section.

The teachers in this study modified their resources for two main reasons: to meet their students' needs and to meet the objectives in their state standards. As stated previously, the teachers frequented modified their lessons based on their students' needs. When it came to resources, this also held true. Frequently in their teacher logs, informal discussions, and interviews, the teachers mentioned how they adjusted resources based on their current or past students' reactions to the materials. For example, Ginger mentioned she had made modifications to the *Study Island* site that would require her students to reach an 80% success rate before they could move onto a game. This was based on her previous experience with her students and this resource. She believed that most of her students would be able to achieve this success rate independently and then move onto the games allowing her to be free to assist other students that were still struggling with the concepts.

The state standards were a guiding influence for the teachers as they planned instruction and were also frequently mentioned as the teachers' rationale for modifying resources. All the teachers discussed how their textbooks and many of the other available resources did not exactly match the state standards. If the teachers used the textbook resources during this study, they were careful to purposefully select problems and activities that met their objectives. Some teachers mentioned how they took existing resources and then modify either the directions or how they are used during implementation in order to focus the students' understanding on the state objectives.

Teachers were also noted to have created their own worksheets, either by cutting and pasting different resources or developing new worksheets, in order to best match the resource to the state standards.

Research Question 3

When the purpose of this study was explained to the teachers, they were informed that I was exploring the factors that influenced them as they planned and implemented instruction and as they selected and modified resources. Prior to the observations, they were not informed that I was also exploring whether they balanced the development of procedural and conceptual knowledge with their students. This was because I did not want to influence the activities and resources selected and/or their reasons for selecting them.

Research question 3 focused on how the teachers attempted to balance the development of procedural and conceptual knowledge with their students and why they did this. The teachers were not directly asked whether they attempted to balance these two knowledge types during the interviews and none of them directly brought this up when discussing the factors that influence them. Therefore, in order to answer this question, information gleaned from the observations of the teachers and their justifications for their actions was reviewed in order to gain insight into how the teachers approached the development of procedural and conceptual knowledge with their students.

The findings from the first two research questions made it clear that the teachers involved in this study engaged their students in activities that provided them opportunities to "see" the mathematics in what they were doing. All the teachers used some type of visual or hands-on material for the students to work with in order to assist them with making connections between concrete and abstract thinking and the teachers stressed they wanted their students to make sense of the mathematics they were studying. Even with this strong focus on assisting their students with conceptually understanding the mathematics they were studying, the teachers clearly recognized the need for their students to be able to "do math." When they referred to doing math, they all meant being able to procedurally solve problems.

Balanced Yet Separate Approach

Two of the teachers in this study approached the development of procedural and conceptual knowledge with what I call a balanced yet separate approach. During the observations they worked through activities with their students that engaged them in developing conceptual understanding and procedural skills with the topics they were covering but did so using separate activities. Their approach will be summarized in this section.

Lea expressed to me during the initial interview that she felt her students were able to use the formulas for area and perimeter, but that they did not understand these formulas or why they worked. It was therefore a goal of hers to present the material to her students in a way that assisted them with their conceptual understanding of area and perimeter. During the final interview she restated that she felt it was important for students to develop conceptual understanding first so that it would carry over when they "do" the math. She also stated on several occasions that she likes her students to discover the concepts, but that sometimes she needs to just tell them what to do. What was observed in Lea's classrooms each day was a very engaging activity that focused on developing her students' conceptual knowledge of area and perimeter. Each night, the students were assigned homework that required them to apply the procedures for solving area and perimeter. Toward the end of the sessions, Lea expressed both surprise and concern about the fact that her students did not seem to be able to successfully connect the tasks they were doing in class with the formula sheet and its procedural applications for finding area and perimeter. Lea's balanced approach to developing conceptual and procedural knowledge focused on providing class time for concepts and homework time for procedural skills with little connection between the two.

When Kath was asked what she felt was more important, the development of conceptual or procedural knowledge with her students, she interpreted the question to mean which knowledge type should be developed first. Interestingly, she was the only teacher who presented the procedural skills first and then followed that up with activities that focused on the conceptual understanding of the topic she was teaching. We discussed this and she felt that how she presents material depends on the topic and her students. In this particular case, her goal was to connect her students' procedural knowledge of factoring, which they learned before their break, to how they could use factoring to solve quadratics. After they spent time on these procedures, her class then spent a couple of days on problem solving activities that focused on developing a conceptual understanding of quadratic functions. Kath justified including these activities because she had time available before the state test. She also discussed with me that time limitation was occasionally an issue when attempting to balance the development of these two knowledge types. In addition, Kath expressed frustration when she referred to other units when she had spent a lot of time trying to develop her students' conceptual knowledge, only to discover that her students were not able to do the procedures afterward.

Another interesting finding pertaining to Kath's approach to balancing the development of procedural and conceptual knowledge was her use of resources. Kath had access to two different textbook resources, one that approached mathematics procedurally and the other that focused more on the conceptual understanding of mathematics. It was noted that she used and adapted these two resources strictly for their intended purpose. That is, her mathematics textbook was used to pull sample problems for procedural practice and the *Connected Mathematics* text was used to present problems that engaged the students in understanding the concepts.

Both Lea and Kath had their students participate in activities for procedural practice and activities that helped them understand the mathematical concepts they were exploring. I refer to them using a balanced yet separate approach because the teachers devoted about the same amount of time exposing their students to each of these types of activities yet connections between the activities were not observed or discussed. These teachers shared the frustration they felt when they take the time to assist their students with conceptually understanding a topic only to discover that their students cannot successfully transfer that knowledge to the procedural skills – the "doing" part. Kath and Lea seemed to notice that their students were failing to make the needed connections between their activities, yet they did not seem to recognize that there are ways to assist their students with those connections and that is part of the teacher's job.

Balanced and Connected Approach

Two of the other teachers in this study balanced the development of procedural and conceptual knowledge with their students differently than Lea and Kath. Rather than engaging their students in separate activities for each of the knowledge types, Lynn and Ginger used an iterative approach, going back and forth between these knowledge types while assisting their students with connections between them as they progressed. In order to differentiate this approach from Lea and Kath's balanced yet separate approach, I termed Lynn and Ginger's approach balanced and connected.

Lynn repeatedly expressed her belief that children need to be exposed to a variety of ways to solve similar problems so that they can select which method they understand best and with which they are successful. She also believed that students need to make connections in order to understand what they are learning; I noted her doing this multiple times during each of the observations. Although Lynn stated that she thought that developing conceptual knowledge was more influential for her students' understanding of topics, she also recognized the need for developing procedural fluency. Again, through the observations, multiple instances were detected of Lynn not only asking students for an answer to a procedural question, but also asking them to justify how they came up with the answer and/or why they thought it was correct. Lynn seemed to be continually checking not only to see if her students could "do it" but also it they understood what it was they were doing. This was very much a part of her routine and I was impressed by how consistently she applied this questioning strategy.

Lynn's beliefs and consistent approach to checking for understanding seemed to be woven into what was observed during this study. It was found that Lynn regularly tried to link the conceptual understanding that she was attempting to develop with her students using Algeblocks and the four square method to the procedures for multiplying binomials. She also worked well in reverse, asking students to connect the procedures they were working on to the concrete methods they had explored. This back and forth connection happened easily and naturally in her classroom and, even though I only observed a small snapshot of her year, it appeared as though this approach was part of her daily routine.

Ginger did not express the same belief system as Lynn, yet the end result seemed to be similar. During the discussions, Ginger stressed that she believed students need the hands-on experiences first in order to discover relationships and have something to which to connect the procedures. She clearly recognized the need to develop both procedural and conceptual knowledge with her students and was firmly against just showing students how to procedurally complete a problem without making that connection. Her past experiences with students had convinced her of the ineffectiveness of that strategy. Ginger referred to multiple topics on which she begins with hands-on activities in order to give the students something to link back to when working on procedures. It was clear from the observations and her interview comments that this was her standard procedure.

Ginger often referred to providing students with the big picture and that is exactly how she started her unit on fractions, decimals, and percentages. She started with the big ideas and then worked her way down through the procedural parts making connections throughout her lessons. Ginger also frequently referred to planning her lessons so that everything flowed together. She discussed how she sequences her lessons so that they build and connect in order for her students to make sense of the mathematics they are studying.

Although both Ginger and Lynn effectively assisted their students with making connections between the conceptually knowledge and the procedural knowledge needed for the topics they were covering, neither of them ever specifically stated to me that it was important to link the concepts to the procedures in order for students to understand the mathematics. Yet, during the observations and interviews, it became clear that assisting their students with connections of all types was essential for these teachers. Ginger discussed how her lessons flowed and Lynn spoke of providing her students with multiple ways to solve the same problem, but both teachers were developing lessons that connected the concepts they were exploring to the procedures they would need to solve problems.

The Role of Teaching Resources

During the final interview, each teacher was asked if they could think of any modifications that could be made to teaching resources that might assist them with balancing the development of procedural and conceptual knowledge with their students. Many times the teachers’ responses did not exactly correspond to this question so I attempted to restate the question in order to focus the teachers' answers. I was rarely successful because the teachers continually misinterpreted the question. Several of the teachers referred to items they would like to have such as tables, manipulatives, and activities for the SMART Board but did not specifically address how these items might help them balance the development of these two knowledge types. Lea specifically addressed the lack of time in her current class period as an obstacle that keeps her from using some teaching resources, such as *AIMS* (Activities Integrating Mathematics and Science), that she believes help develop conceptual knowledge. The sole use of textbooks was something Kath brought up and discouraged stating that teachers must look at other resources as well. Lynn mentioned how she would like to see textbooks provide projects that get developed over the course of the unit. Interestingly, her current textbook had such projects along with some of the strategies that Lynn used to teach her unit. Apparently Lynn's dissatisfaction with textbooks had discouraged her from using them as a resource and she was unaware of the features they could offer her.

In a couple of instances, the teachers brought up examples of professional development that had assisted them with balancing the development of conceptual and procedural knowledge. Lea mentioned a course she had taken that presented her with ways to represent integer operations so that students would gain a better understanding of the concepts and have something to connect the rules to for these operations. On several occasions, Ginger referred to a district-sponsored class she had taken on fractions. She discussed how, when she taught that topic, she felt that she was able to present a unit that allowed her students to gain a strong understanding of the algorithms for operations with fractions. In discussing how she prepared for that unit she stated,

> And so I went to that notebook and said, "Okay, here is the stuff I needed." And there it was. I mean, it was all, I had already thought about it. Here is exactly the steps I'm going to go through, and here is the sequence I want to use, and then I kind of tweaked it again, and, but it was nice, having that there. (final interview, 3/30/09)

It appears as if Ginger was provided a notebook that guided her as she took the class and worked through problems. This notebook then served as a teaching resource that she used to guide her as she planned her unit. But even though she had this resource and we discussed it during the interviews, she did not refer back to it when asked about having resources that could assist with balancing the development of conceptual and procedural knowledge.

Conclusions

The conceptual framework used to guide this study was depicted in Figure 1 (shown again on next page). This framework represents the participatory relationship that the teachers in this study had with their curriculum. When the teachers selected for this study approached their curriculum, they were impacted by a variety of factors, but the curriculum materials also had features that brought about changes in how the teachers interpreted and used them. This framework also encompasses the impact that the students had on the enacted curriculum. It was clear in this study that the teachers' planned curriculum was influenced by what occurred in the real-world context of their classrooms. This framework takes into account the adjustments the teachers made to their planned tasks as the tasks interacted with the students during implementation.

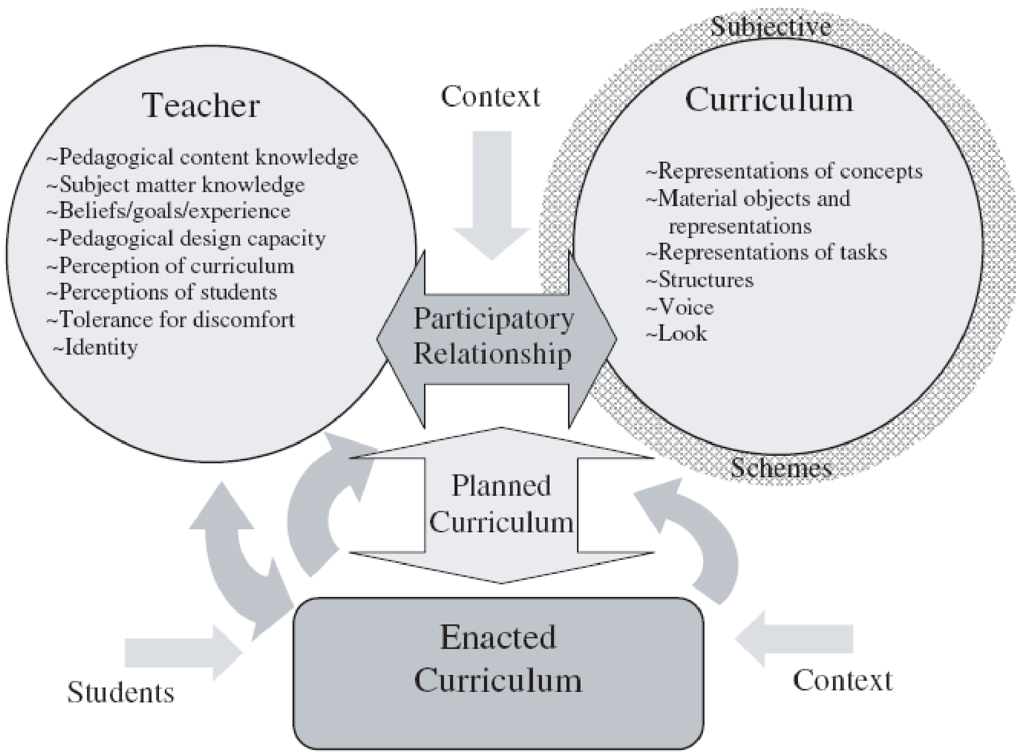

FIGURE 3. *Framework of components of teacher-curriculum relationship* (Figure repeated on page 15) (Remillard, 2005, p. 235)

This framework was used as a guide as I designed the study to account for as many influential factors as possible. The initial interview questions were designed to be open-ended but also to focus the teachers' attention on the planning and implementation arenas as well as resource selection. During the final interview, the teachers were provided with additional opportunities to discuss influential factors as well as reflect on specific instances that occurred during the implementation of the lessons. Finally, the observations and the associated detailed field notes allowed me to explore how the teachers' perceptions of influential factors played out in the context of the classroom.

As discussed previously, several main factors influenced the teachers as they planned and implemented instruction. The tools the teachers had readily available in their "toolbox" and their past experiences with them influenced the activities they selected. Their beliefs that students need to see math in multiple ways and make connections in order to understand the concepts also influenced which tasks they implemented and the materials they selected to use with these tasks. They organized their instruction around their state standards, but firmly believed that they had flexibility in implementing those standards. This organized yet flexible approach was also noted to influence their entire cycle of lesson planning and implementation. Finally, time limitation was found to influence all the teachers in this study. They all had to limit what they planned and implemented based on a lack of time and therefore the teachers selected what they believed would be best to get the job done in the allotted time.

The middle school teachers purposefully selected for this study were found to select and modify their resources. Due to a mismatch between the district- provided textbooks and state standards, the teachers were found to spend a great deal of time locating, modifying and/or developing resources that matched the objectives in their state's curriculum. Another common theme for all teachers was their focus on selecting resources that would allow their students to make sense of the mathematics they were studying. The teachers all incorporated the use of representations, either manipulatives or visuals created by the students, which is an area that has been found to assist the linking of conceptual and procedural knowledge with students (Rittle-Johnson, et al., 2001; Schneider & Stern, 2005). Finally, two teachers in this study were found to use the SMART Board and its associated software as both a planning and teaching tool. This tool provided their lessons with both the structure to guide the lesson and the flexibility to adjust for students' needs.

The participating teachers in this study all had a strong focus on assisting their students with understanding the concepts they were covering. This was clearly demonstrated when they described the factors that impacted them when they planned instruction, in their selection of resources used to teach the material, and during the observations in their classrooms. In each of the classrooms, it was found that the teachers were balancing the development of procedural and conceptual knowledge with their students as well. How they attempted this balance was an area in which differences were found. Two of the teachers approached this balance by providing their students with activities that either focused on the development of conceptual knowledge or procedural knowledge. There was no noticeable attempt to connect the activities. Another pair of teachers presented sequenced lessons that not only balanced the development of these two knowledge types, but also made connections between them.

The most interesting finding was that, unlike Ms. Tilley (McNeill, 2001), none of the teachers in this study seemed to note the difficulty in achieving this balance. In addition, the teachers did not seem to recognize that most teaching resources do not provide guidance on how to connect or balance the development of procedural and conceptual knowledge. Only Ginger, who had taken a class that provided her with a well sequenced and balanced unit of study on fractions, seemed to recognize the value of having such a teaching resource. Even though she clearly saw the benefits of using this resource, she did not reference how she might appreciate having similarly developed units for other topics.

In her text, *Knowing and Teaching Elementary Mathematics,* Ma (1999) discusses in detail the concept of profound understanding of fundamental mathematics (PUFM) and how teachers attain this. According to Ma, attaining PUFM occurs through a variety of activities and her research shows that this occurs while teachers are on the job. One of the activities in which the Chinese teachers in Ma's (1999) study engaged to obtain PUFM was studying their teaching materials intensively. One explanation for this finding could be that this study focused on teachers who were not just users of curriculum materials, but instead were "curriculum developers," This focus was guided by research (Lloyd & Behm, 2005; Remillard, 1999; Stein, Remillard, & Smith, 2007). Possibly, because the teachers in this study had been developing their own materials to match the state standards for so long, they had grown accustomed to creating their own resources. I believe that these teachers looked at developing their own curriculum materials as their best option and no longer looked at their teaching materials for guidance. Instead, as the curriculum developers, they were the ones responsible for picking and choosing resources from their toolbox to meet the state objectives and the needs of their students. I think Ginger summarized this best stating "And then, from there, because it's up to me to do it, I just have to think about the sequence of it, and what I want to implement" (final interview, 3/30/09).

Implications for Research and Practice

This study explored the factors that influenced middle school mathematics teachers who had a participatory relationship with their curricula as they planned and implemented instruction. In chapters 4 and 5, the cross-case findings were presented for the teachers in this study. This chapter summarized the results across each research question and presented the conclusions. In this section, further implications for research and practice will be provided.

Implications for Research

The focus of this study was exploratory in nature in order to gain insight into the factors that influenced teachers as they plan and implement lessons with their students. Specifically, I wanted to gain insight into whether the teachers attempted to balance the development of procedural and conceptual knowledge. Based on the findings, it is believed there are two areas in which further research would be beneficial to the field.

Connections between concepts and procedures. As discussed in the literature review, there is little research that explores how teaching in ways that balance the development of procedural and conceptual knowledge impacts teachers. As a result of this study, a possible focus for future research could be on how teachers effectively make the connections between these two knowledge types with their students. Although the teachers in this study presented well planned lessons that were engaging, and they essentially spent an equal or balanced amount of time on developing the two knowledge types, they did not all seem to recognize the need to connect conceptual and procedural knowledge with their students. The two teachers who did make these connections, referred to this process as how they sequenced activities or how their lessons flowed. In his vignette describing Ms. Tilley, McNeill (2001) presented the struggles that this exemplary teacher had when trying to connect the students' conceptual understanding of addition to the traditional algorithm. I believe there is still much to be learned from similar research studies involving teachers struggling through the planning and implementation of cohesive units of study with their students. These lessons should focus on the students' understanding of concepts and effective ways to connect that understanding to their procedural understanding so that the students become fluent and flexible with the mathematical skills required of them.

Common core state standards initiative. I have spent some of my time as a doctoral student exploring education policy both in the United States and in other countries and this has resulted in my belief that National Standards would be beneficial for the United States. Recently, the Common Core State Standards for Mathematics have been adopted by most states. One result that should come from this adoption is that textbooks and their associated resources should begin to align with these common standards. One of the findings clearly showed the impact of the mismatch between textbooks' content and state standards on the teachers in this study. Common standards and textbooks that align with those standards should eventually make it easier for teachers to use these resources. Future studies could explore the impact these new standards and matching teaching resources have on teachers' use of curriculum materials.

Implications for Practice

One goal of this qualitative study was to speak with and observe teachers who were believed to have a participatory relationship with their curricula in order to learn about the factors that impacted them as they planned and implemented their lessons. As a result of this exploration, several implications for education practice were found. These implications are presented in the following sections.

Lesson planning. Currently, teacher education programs engage new teachers in a variety of activities that prepare them for planning units of study that typically include a week of detailed daily plans. The results of this study, though somewhat limited, indicate that none of the teachers developed detailed daily plans and their units of study were completely guided by their state's objectives and their district's pacing guide. Considering many districts dictate what teachers should be teaching and when, we need to ensure that teacher education programs focus on these rigid pacing guides and how new teachers can best work with them. In addition, teacher education programs and mentors in school districts need to assist new teachers with effective and efficient strategies for planning and implementing units of study and daily lessons that allow teachers to flexibly adjust their plans.

The SMART Board as a planning and teaching tool. One unexpected finding of this research was the use of the SMART Board and its associated software as an effective and efficient planning and teaching tool. Its daily use by two of the teachers in this study was found to positively impact their ability to stay focused on their objectives but yet flexibly adapt to their students' needs. Since returning to the classroom, I have completely embraced the daily use of the SMART Board and found it extremely efficient for me as a planning and teaching tool as well as an effective method of instructional delivery for students. Teacher education programs could embrace leveraging this technology with future teachers to guide them in the development of flexible and engaging unit and lesson plans.

Cohesive units of study. The teachers in this study created their own curricula by selecting and modifying materials in their "toolbox". Although they consistently referred to the impact that time had on them and their ability to effectively plan and teach the content with their students, they failed to recognize that resources could be developed that would assist them. One teacher, Ginger, who had participated in a graduate course on rational numbers seemed to recognize the benefits of such a resource. During the course, she worked through a unit that demonstrated how to effectively develop the conceptual understanding of fractions and connect that to the required procedural skills. By the end of the course, Ginger had developed a binder that she used as a resource when she taught operations with fractions. The field could benefit from the development of comparable, cohesive units of study that present an iterative and connected approach to the development of procedural and conceptual knowledge. Teachers could then study and engage with these materials in order to develop a deeper understanding of the mathematics and the connections between concepts and procedures.

Closing Thoughts

I can still remember when I was asked why I wanted to enter a doctoral program during my initial interview. I responded that I had been concerned since I started teaching mathematics that we were trying to teach too much, too fast to students. The results of this study clearly demonstrate the impact that time limitation had on the teachers. They repeatedly brought it up when discussing their planning of lessons, their implementation of lessons, and their justification for the resources that they selected or had to discard. Of greater concern is the role a lack of time played for some of the teachers as they tried to develop both conceptual understanding and procedural fluency. The teachers frequently mentioned running out of time to do everything they would have wanted to do and it is believed that this impacted their students' abilities to fully understand the material.

Even with common standards, textbooks that align with the standards, and cohesive units of study, if we continue to try and teach children too much, too quickly we will continue to leave students behind. I believe that as a nation, we need to begin to focus on the "big ideas" or NCTM's Curriculum Focal Points at the various grade levels in order to ensure that we have the time needed to develop deep and meaningful understanding of mathematics with children.

Appendices

Appendix A

Self-Report Survey: Elementary Teachers' Commitment to Mathematics Education Reform

TEACHER BELIEFS SURVEY

PVNC PRIME 2008-09

ATTITUDES AND PRACTICES OF TEACHING MATHEMATICS

Using the 1 to 6 point scale, indicate the extent to which you disagree or agree with each statement by filling in the appropriate bubble.

Completely fill the appropriate bubble.

1=Strongly Disagree 2=Disagree 3=Mildly Disagree 4=Mildly Agree 5=Agree 6=Strongly Agree

	1	2	3	4	5	6
1. I like to use math problems that can be solved in many different ways.	O	O	O	O	O	O
2. I regularly have my students work through real-life math problems that are of interest to them.	O	O	O	O	O	O
3. When two students solve the same math problem correctly using two different strategies I have them share the steps they went through with the class.	O	O	O	O	O	O
4. I tend to integrate multiple topics of mathematics within a single unit (i.e. geometric and algebraic concepts together).	O	O	O	O	O	O
5. I often learn from my students during math class because my students come up with ingenious ways of solving problems that I have never thought of.	O	O	O	O	O	O
6. It is not very productive for students to work together during math class.	O	O	O	O	O	O
7. Every student in my class should feel that mathematics is something he/she can do.	O	O	O	O	O	O
8. I integrate math assessment into most math activities.	O	O	O	O	O	O
9. In my classes, students learn math best when they can work together to discover mathematical ideas.	O	O	O	O	O	O
10. I encourage students to use manipulatives or technology to explain their mathematical ideas to other students.	O	O	O	O	O	O
11. When students are working on math problems, I put more emphasis on getting the correct answer rather than on the process followed.	O	O	O	O	O	O
12. Creating rubrics for math is a worthwhile assessment strategy.	O	O	O	O	O	O
13. In high school it is just as important for students to learn geometry and statistics as it is to learn algebra.	O	O	O	O	O	O
14. I don't necessarily answer students' math questions but rather let them puzzle things out for themselves.	O	O	O	O	O	O
15. A lot of things in math must simply be accepted as true and remembered.	O	O	O	O	O	O
16. I like my students to master basic mathematical procedures before they tackle complex problems.	O	O	O	O	O	O
17. I teach students how to explain and defend their mathematical ideas.	O	O	O	O	O	O
18. Using computers to solve math problems distracts students from learning basic algebraic and procedural skills.	O	O	O	O	O	O
19. If students use calculators they won't master the basic algebraic and procedural skills they need to know.	O	O	O	O	O	O
20. You have to study math for a long time before you see how useful it is.	O	O	O	O	O	O

Appendix B

2000 National survey of Science and Mathematics Education Mathematics Questionnaire

2000 National Survey of Science and Mathematics Education

Mathematics Questionnaire

A. Teacher Opinions

1. Please provide your opinion about each of the following statements. (Darken one oval on each line.)

	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
a. Students learn mathematics best in classes with students of similar abilities.	①	②	③	④	⑤
b. The testing program in my state/district dictates what mathematics content I teach.	①	②	③	④	⑤
c. I enjoy teaching mathematics.	①	②	③	④	⑤
d. I consider myself a "master" mathematics teacher.	①	②	③	④	⑤
e. I have time during the regular school week to work with my colleagues on mathematics curriculum and teaching.	①	②	③	④	⑤
f. Mathematics teachers in this school regularly observe each other teaching classes as part of sharing and improving instructional strategies.	①	②	③	④	⑤
g. Most mathematics teachers in this school contribute actively to making decisions about the mathematics curriculum.	①	②	③	④	⑤

2. How familiar are you with the NCTM *Standards*? (Darken one oval.)

- ① Not at all familiar
- ② Somewhat familiar
- ③ Fairly familiar
- ○ Very familiar

B. Teacher Background

3. Please indicate how well prepared you currently feel to do each of the following in your mathematics instruction. (Darken one oval on each line.)

	Not Adequately Prepared	Somewhat Prepared	Fairly Well Prepared	Very Well Prepared
a. Take students' prior understanding into account when planning curriculum and instruction	①	②	③	④
b. Have students work in cooperative learning groups	①	②	③	④
c. Use the textbook as a resource rather than the primary instructional tool	①	②	③	④
d. Teach groups that are heterogeneous in ability	①	②	③	④
e. Teach students who have limited English proficiency	①	②	③	④
f. Encourage participation of females in mathematics	①	②	③	④
g. Encourage participation of minorities in mathematics	①	②	③	④

4a. Do you have each of the following degrees?

Bachelors	① Yes	② No
Masters	① Yes	② No
Doctorate	① Yes	② No

4b. Please indicate the subject(s) for each of your degrees. (Darken all that apply.)

	Bachelors	Masters	Doctorate
Mathematics	①	①	①
Computer Science	②	②	②
Mathematics Education	③	③	③
Science/Science Education	④	④	④
Elementary Education	⑤	⑤	⑤
Other Education (e.g., History Education, Special Education)	⑥	⑥	⑥
Other, please specify ____________	⑦	⑦	⑦

PLEASE DO NOT WRITE IN THIS AREA

[SERIAL]

5. Which of the following college courses have you completed? Include both semester hour and quarter hour courses, whether graduate or undergraduate level. Include courses for which you received college credit, even if you took the course in high school. (Darken all that apply.)

MATHEMATICS
- ○ Mathematics for elementary school teachers
- ○ Mathematics for middle school teachers
- ○ Geometry for elementary/middle school teachers
- ○ College algebra/trigonometry/elementary functions
- ○ Calculus
- ○ Advanced calculus
- ○ Real analysis
- ○ Differential equations
- ○ Geometry
- ○ Probability and statistics
- ○ Abstract algebra
- ○ Number theory
- ○ Linear algebra
- ○ Applications of mathematics/problem solving
- ○ History of mathematics
- ○ Discrete mathematics
- ○ Other upper division mathematics

SCIENCES/COMPUTER SCIENCES
- ○ Biological sciences
- ○ Chemistry
- ○ Physics
- ○ Physical science
- ○ Earth/space science
- ○ Engineering (any)
- ○ Computer programming
- ○ Other computer science

EDUCATION
- ○ General methods of teaching
- ○ Methods of teaching mathematics
- ○ Instructional uses of computers/other technologies
- ○ Supervised student teaching in mathematics

6. For each of the following subject areas, indicate the number of college semester and quarter courses you have completed. Count each course you have taken, regardless of whether it was a graduate or undergraduate course. If your transcripts are not available, provide your best estimates.

	Semester Courses	Quarter Courses
a. Mathematics education	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
b. Calculus	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
c. Statistics	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
d. Advanced calculus	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
e. All <u>other</u> mathematics courses	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
f. Computer science	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8
g. Science	0 1 2 3 4 5 6 7 8 >8	0 1 2 3 4 5 6 7 8 >8

7. In what year did you last take a formal course for college credit in:

a. Mathematics: ________________

b. The Teaching of Mathematics: _____________

If you have never taken a course in the teaching of mathematics, darken this oval. ○

8. What is the **total** amount of time you have spent on professional development in mathematics or the teaching of mathematics in the last 12 months? in the last 3 years? (Include attendance at professional meetings, workshops, and conferences, but **do not** include formal courses for which you received college credit or time you spent **providing** professional development for other teachers.) (Darken one oval on each line.)

	Hours of In-service Education				
	None	Less than 6 hours	6-15 hours	16-35 hours	More than 35 hours
In the last 12 months	○	○	○	○	○
In the last 3 years	○	○	○	○	○

9. In the past **12 months**, have you: (Darken one oval on each line.)

a. Taught any in-service workshops in mathematics or mathematics teaching?	○ Yes	○ No
b. Mentored another teacher as part of a formal arrangement that is recognized or supported by the school or district, not including supervision of student teachers?	○ Yes	○ No
c. Received any local, state, or national grants or awards for mathematics teaching?	○ Yes	○ No
d. Served on a school or district mathematics curriculum committee?	○ Yes	○ No
e. Served on a school or district mathematics textbook selection committee?	○ Yes	○ No

10a. Do you teach in a **self-contained class**? (i.e., you teach multiple subjects to the same class of students all or most of the day.)

- ○ Yes, CONTINUE WITH QUESTIONS 10b AND 10c
- ○ No, SKIP TO QUESTION 11

10b. ***For teachers of self-contained classes*:** Many teachers feel better qualified to teach some subject areas than others. How well qualified do you feel to teach each of the following subjects **at the grade level(s) you teach**, whether or not they are currently included in your curriculum? (Darken one oval on each line.)

	Not Well Qualified	Adequately Qualified	Very Well Qualified
a. Life science	○	○	○
b. Earth science	○	○	○
c. Physical science	○	○	○
d. Mathematics	○	○	○
e. Reading/Language Arts	○	○	○
f. Social Studies	○	○	○

10c. ***For teachers of self-contained classes*:** We are interested in knowing how much time your students spend studying various subjects. In a typical week, how many days do you have lessons on each of the following subjects, and how many minutes long is an average lesson? (*Please indicate "0" if you do not teach a particular subject to this class.*)

	Days Per Week	Approximate Minutes Per Day		Days Per Week	Approximate Minutes Per Day
Mathematics	_____	_________	**Social Studies**	_____	_________
Science	_____	_________	**Reading/Language Arts**	_____	_________

NOW GO TO SECTION C, ON THE NEXT PAGE .

11. ***For teachers of non-self-contained classes*:** For each class period you are currently teaching, regardless of the subject, give *course title*, the *code-number* from the enclosed blue "List of Course Titles" that best describes the content addressed in the class, and the *number of students* in the class. **(If you teach more than one section of a course, record each section separately below. If you teach more than 6 classes per day, please provide the requested information for the additional classes on a separate sheet of paper.)**

Course Title	*Course Code*	*Number of Sudents*
______________________	________	________
______________________	________	________
______________________	________	________
______________________	________	________
______________________	________	________
______________________	________	________

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[SERIAL]

C. Your Mathematics Teaching in a Particular Class

The questions in this section are about a particular mathematics class you teach. **If you teach mathematics to more than one class per day, please consult the label on the cover letter to determine which mathematics class to use to answer these questions.**

12. Using the blue "List of Course Titles," indicate the code number that best describes this course. ________

(If "other" [Code 299], briefly describe content of course:____

____

____)

13. Please indicate the grades of the students in this class. (Darken all that apply.)

ⓚ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫

14a. What is the total number of students in this class? ________

14b. Please indicate the number of students in this class in each of the following categories. Consult the enclosed federal guidelines at the end of the course list (blue sheet) if you have any questions about how to classify particular students.

	Male	Female
American Indian or American Native	________	________
Asian	________	________
Black or African-American	________	________
Hispanic or Latino (any race)	________	________
Native Hawaiian or Other Pacific Islander	________	________
White	________	________

15. **This question applies only to teachers of non-self-contained classes. If you teach a self-contained class, please darken this oval ○ and skip to question 16.** What is the usual schedule and length (in minutes) of daily class meetings for this class? If the weekly schedule is normally the same, just complete Week 1, as in Example 1. If you are unable to describe this class in the format below, please attach a separate piece of paper with your description.

	Week 1	**Week 2**
Monday	________	________
Tuesday	________	________
Wednesday	________	________
Thursday	________	________
Friday	________	________

Examples

Example 1		**Example 2**	
Week 1	Week 2	Week 1	Week 2
45	____	90	____
45	____	____	90
45	____	90	____
45	____	____	90
45	____	90	____

16. Are students assigned to this class by level of ability? (Darken one oval.) ① Yes ○ No

17. Which of the following best describes the ability of the students in this class relative to other students in this school? (Darken one oval.)

① Fairly homogeneous and low in ability
① Fairly homogeneous and average in ability
① Fairly homogeneous and high in ability
① Heterogeneous, with a mixture of two or more ability levels

18. Indicate if any of the students in this mathematics class are **formally** classified as each of the following: (Darken all that apply.)

○ Limited English Proficiency
① Learning Disabled
① Mentally Handicapped
① Physically Handicapped, please specify handicap(s): ____________________

19. Think about your plans for this mathematics class for the entire course. How much emphasis will each of the following **student objectives** receive? (Darken one oval on each line.)

	None	Minimal Emphasis	Moderate Emphasis	Heavy Emphasis
a. Increase students' interest in mathematics	①	①	①	③
b. Learn mathematical concepts	①	①	①	①
c. Learn mathematical algorithms/procedures	①	①	①	①
d. Develop students' computational skills	①	①	①	①
e. Learn how to solve problems	①	①	①	①
f. Learn to reason mathematically	①	①	①	①
g. Learn how mathematics ideas connect with one another	①	①	①	①
h. Prepare for further study in mathematics	①	①	①	①
i. Understand the logical structure of mathematics	①	①	①	①
j. Learn about the history and nature of mathematics	①	①	①	①
k. Learn to explain ideas in mathematics effectively	①	①	①	①
l. Learn how to apply mathematics in business and industry	①	①	①	①
m. Learn to perform computations with speed and accuracy	①	①	①	①
n. Prepare for standardized tests	①	①	①	①

20. About how often do **you** do each of the following in your mathematics instruction? (Darken one oval on each line.)

	Never	Rarely (e.g., a few times a year)	Sometimes (e.g., once or twice a month)	Often (e.g., once or twice a week)	All or almost a mathemat lessons
a. Introduce content through formal presentations	①	①	①	①	⑤
b. Pose open-ended questions	①	①	①	①	①
c. Engage the whole class in discussions	①	①	①	①	①
d. Require students to explain their reasoning when giving an answer	①	①	①	①	①
e. Ask students to explain concepts to one another	①	①	①	①	①
f. Ask students to consider alternative methods for solutions	①	①	①	①	①
g. Ask students to use multiple representations (e.g., numeric, graphic, geometric, etc.)	①	①	①	①	①
h. Allow students to work at their own pace	①	①	①	①	①
i. Help students see connections between mathematics and other disciplines	①	①	①	①	①
j. Assign mathematics homework	①	①	①	①	①
k. Read and comment on the reflections students have written, e.g., in their journals	①	①	①	①	①

21. About how often do students in this **mathematics** class take part in the following types of activities? (Darken one oval on each line.)

	Never	Rarely (e.g., a few times a year)	Sometimes (e.g., once or twice a month)	Often (e.g., once or twice a week)	All or almost all mathematic lessons
a. Listen and take notes during presentation by teacher	①	②	③	④	⑤
b. Work in groups	①	②	③	④	⑤
c. Read from a mathematics textbook in class	①	②	③	④	⑤
d. Read other (non-textbook) mathematics-related materials in class	①	②	③	④	⑤
e. Engage in mathematical activities using concrete materials	①	②	③	④	⑤
f. Practice routine computations/algorithms	①	②	③	④	⑤
g. Review homework/worksheet assignments	①	②	③	④	⑤
h. Follow specific instructions in an activity or investigation	①	②	③	④	⑤
i. Design their *own* activity or investigation	①	②	③	④	⑤
j. Use mathematical concepts to interpret and solve applied problems	①	②	③	④	⑤
k. Answer textbook or worksheet questions	①	②	③	④	⑤
l. Record, represent, and/or analyze data	①	②	③	④	⑤
m. Write reflections (e.g., in a journal)	①	②	③	④	⑤
n. Make formal presentations to the rest of the class	①	②	③	④	⑤
o. Work on extended mathematics investigations or projects (a week or more in duration)	①	②	③	④	⑤
p. Use calculators or computers for learning or practicing skills	①	②	③	④	⑤
q. Use calculators or computers to develop conceptual understanding	①	②	③	④	⑤
r. Use calculators or computers as a tool (e.g., spreadsheets, data analysis)	①	②	③	④	⑤

22. About how often do students in this mathematics class use **calculators/computers** to: (Darken one oval on each line.)

	Never	Rarely (e.g., a few times a year)	Sometimes (e.g., once or twice a month)	Often (e.g., once or twice a week)	All or almost all mathematic lessons
a. Do drill and practice	①	②	③	④	⑤
b. Demonstrate mathematics principles	①	②	③	④	⑤
c. Play mathematics learning games	①	②	③	④	⑤
d. Do simulations	①	②	③	④	⑤
e. Collect data using sensors or probes	①	②	③	④	⑤
f. Retrieve or exchange data	①	②	③	④	⑤
g. Solve problems using simulations	①	②	③	④	⑤
h. Take a test or quiz	①	②	③	④	⑤

23. How much of your own money do you estimate you will spend for supplies for this mathematics class this school year (or semester or quarter if not a full-year course)? ________ If none, darken this oval: ①

24. How much of your own money do you estimate you will spend for your own professional development activities during the period Sept. 1, 2000 - Aug. 31, 2001? ________ If none, darken this oval: ①

25. How much mathematics homework do you assign to this mathematics class in a typical **week**? (Darken one oval.)

① 0-30 min ② 31-60 min ③ 61-90 min ④ 91-120 min ⑤ 2-3 hours ○ More than 3 hours

PLEASE DO NOT WRITE IN THIS AREA

[SERIAL]

26a. Are you using one or more commercially published textbooks or programs for teaching mathematics to this class? (Darken one oval.)

- ○ No, SKIP TO SECTION D
- ○ Yes, CONTINUE WITH 26b

26b. Which best describes your use of textbooks/programs in this class? (Darken one oval.)

- ○ Use one textbook or program all or most of the time
- ○ Use multiple textbooks/programs

27a. Please indicate the title, author, publisher, and publication year of the **one** textbook/program used **most often** by students in this class.

Title: ____

First Author: ____

Publisher: ____

Publication Year: __________ Edition: ____________

27b. Approximately what percentage of this textbook/program will you "cover" in this course? (Darken one oval.)

○ < 25% ○ 25-49% ○ 50-74% ○ 75-90% ○ >90%

27c. How would you rate the overall quality of this textbook/program? (Darken one oval.)

○ Very Poor ○ Poor ○ Fair ○ Good ○ Very Good ○ Excellent

D. Your Most Recent Mathematics Lesson in This Class

Questions 28-30 refer to the last time you taught mathematics to this class. Do not be concerned if this lesson was not typical of instruction in this class.

28a. How many minutes were allocated to the most recent mathematics lesson? ____________
Note: Teachers in departmentalized and other non-self-contained settings should answer for the entire length of the class period, even if there were interruptions.

28b. Of these, how many minutes were spent on the following:
(The sum of the numbers in 1.-6. below should equal your response in 28a.)

___________ 1. Daily routines, interruptions, and other non-instructional activities
___________ 2. Whole class lecture/discussions
___________ 3. Individual students reading textbooks, completing worksheets, etc.
___________ 4. Working with hands-on or manipulative materials
___________ 5. Non-manipulative small group work
___________ 6. Other

29. Which of the following activities took place during that mathematics lesson? (Darken all that apply.)

- ○ Lecture
- ○ Discussion
- ○ Students completing textbook/worksheet problems
- ○ Students doing hands-on/manipulative activities
- ○ Students reading about mathematics
- ○ Students working in small groups
- ○ Students using calculators
- ○ Students using computers
- ○ Students using other technologies
- ○ Test or quiz
- ○ None of these activities took place

30. Did that lesson take place on the most recent day you met with that class? ○ Yes ○ No

E. Demographic Information

31. Indicate your sex:

- ○ Male
- ○ Female

32. Are you: (Darken all that apply.)

- ○ American Indian or Alaskan Native
- ○ Asian
- ○ Black or African-American
- ○ Hispanic or Latino
- ○ Native Hawaiian or Other Pacific Islander
- ○ White

33. In what year were you born? ___________

34. How many years have you taught at the K-12 level prior to this school year? ___________

35. If you have an email address, please write it here: ______________________________

36. When did you complete this questionnaire? Date: ______ / ______ / ______
Month Day Year

FOR OFFICE USE ONLY
Please do not write in this area.

Please make a photocopy of this questionnaire and keep it in case the original is lost in the mail. Please return the original to:

2000 National Survey of Science and Mathematics Education
Horizon Research, Inc.
326 Cloister Court
Chapel Hill, NC 27514

THANK YOU!

PLEASE DO NOT WRITE IN THIS AREA

[SERIAL]

Appendix C

Example of Field Notes

	Field Notes - GH 3/24/09		
	Code		**Comments**
1		routine	As students enter and get settled, they notice fraction pieces sitting on the tables. BR states "Start with agenda please - fraction pieces leave those alone we'll get to those in a minute - rings leave those alone, we'll get to those in a minute" Because students start touching. BR begins to talk about homework and the bell that starts the class rings.
2			Homework is to write down what they know so far about f/d/% - gives them a choice of where: interactive notebook, some other notebook, a piece of paper. Refers to what they did yesterday and then refers to all the sticky notes from all the classes up on the walls (even taped milk carton and other items from yesterday).
3		direction	Goal for next couple of days it to look for patterns and how it "flows" from f/d/%.
4			Once they have hw in agenda - directed to put away.
5		routine	Had planned on students getting notes for interactive notebook the previous day, but did not get that far. Students are directed to get the notes and get them glued into interactive notebook once the copy their homework. Notes are in back in order - tells students to "head back there" I am impressed with how orderly (quietly as I listen once again) this occurs. Students get what they need and start gluing. All notes are cut to size, students have glue sticks in pencil boxes on their tables. There are also highlighters and scissors in these pencil boxes which students use as needed.
6			Some of the items are grids that they will be coloring in - she notices some students starting to work on them - tells them she knows it might be tempting, but she would like them to wait for her today. Just glue the items in.
7			BR says "what lesson is this" and a student responds 39 and she says "wow" They keep a table of contents for the notebook.
8		routine	Student is missing notebook - she told him to put all his work in crate so that he can glue it in tomorrow. Asks which homeroom he is in. School/ 6th grade team seems to use homeroom time to keep up with students.

Appendix D

Initial Interview Protocol

Modified from *Inside the Classroom Teacher Interview Protocol*, Horizon Research

Opening:
I appreciate you letting my observe your classes and interview you in order to learn more about the factors that influence you as you plan and implement mathematics instruction. In order to help me stay focused on our discussion and to ensure that I have an accurate record of our discussion, I would like to audio tape our interview. Would you mind?

Classroom Environment:
I'd like to know about the students in the class I will be observing. Could you tell me about the ability levels of your students and how they compare to students in the school as a whole? Do you have any students with:

- learning disabilities?
- language needs (ELL)?
- other special needs?

Is student absenteeism or mobility a problem for you in this class?

Is there anything else you would like to share with me about your students before I observe?

Learning Goals:
Could you describe the big ideas in the content that I will be observing over the next few days and how they fit into what you have recently completed and where you will go after this series of lessons?

What led you to teach the mathematics topics in these upcoming lessons? *(If necessary, use the following probes and ask about the importance of each of them in the teacher's decision to teach the topics)*

- State/District framework (SOLs)
- State Assessment
- Assigned textbook

Lesson Description and Resources Used:

I would like to go through your current plans for each of the lessons I will observe. You can tell me anything you want about the lessons and the factors that influenced you as you planned, but I would like to hear about the resources you are using and why you selected them.
(*As teachers describe lessons, probe for the following information about resources*:)

- What resources were used
- Were the resources designated for the class or teacher selected
- What features do they like about the resources/materials/activities? What do they not like?
- Was the lesson planned essentially as it was organized in the resources or was it modified in important ways? *If applicable:* Can you describe the modifications you made and your reasons for making them?

The Teacher
How do you feel about teaching the topics that I will be observing?

- Do you enjoy them?
- How well prepared do you feel to guide student learning of this content?
- What opportunities have you had to learn about this particular content area?
    - Probe for professional development opportunities. How did they become involved in it; where they required/encouraged to go by district; how helpful was it?

How comfortable do you feel about using the instructional strategies involved in teaching these lessons?

- What opportunities have you had to learn about using these strategies?
    - Probe for professional development opportunities. How did they become involved in it; where they required/encouraged to go by district; how helpful was it?

Have you taught this content before?
If yes: Have you planned anything different this time compared to how you have taught it previously?
If yes: Can you explain why you made the changes?
Is there anything about this particular group of students that led you to plan your lessons this way?

Context:
Sometimes schools and districts make it easy for teachers to teach mathematics well and sometimes they get in the way. What about your teaching situation influenced your planning of these lessons?
Probes:

- Did the facilities and available equipment and supplies have any influence on your choice of lesson and how you plan to teach it?
- Were there any problems in getting the materials you needed for this lesson?

Sometimes other people in the school and district can influence your planning of a lesson. Do you feel you were influenced by anyone on your choice of topics and how you are choosing to teach them?
Probe for: Principal, other teachers, parents/community, school board, district administrator, anyone else?

Implementation:
Do you foresee any factors that may impact your instruction of these lessons as planned? What modifications might you make as you implement these lessons and why?

Conclusion:
Is there anything else you would like to tell me about your class and your plans for instruction?

Thank you so much for taking the time to meet with me today and I look forward to observing your classes.

Appendix E

Final Interview Protocol

<u>Focus Lesson Questions:</u>

1. In general, what factors do you think influenced you when you planned the lessons that were observed? Probe for:
    a. (insert factors that came out of observation – member check)

2. Are these factors typical for most topics? Can you describe another topic where they are typical? Where they might not be typical?

3. In general, what factors do you think influenced you during the implementation of the lessons that were observed? Probe for:
    a. (insert factors that came out of observation – member check)

4. Are these factors typical for most topics? Can you describe another topic where they are typical? Where they might not be typical?

5. In general, what factors influence you when you select a resource or materials to use in your classroom? By resource, I mean just about anything including: textbook, practice pages, manipulatives, videos, games, etc.

6. Do you typically modify the resources you select? If so, why? If not, why not? Could you provide a couple of examples of resources you did and did not modify?

7. If you could go back and make changes to any of the lessons I observed, what would you change and why? (Would she change: activities, amount of time devoted to activities, homework, resource they used, modifications to resources?)

8. If time (pacing guides/SOLs) were not a factor – you had all the time you would like, what, if anything, would you have done differently with the lessons I observed and why?

9. If time (pacing guides/SOLs) were not a factor – you had all the time you would like, what, if anything, would you do differently with your teaching in general and why?

10. Do you think you did anything different over the past week due to my presence in the room? Why?

Procedural and Conceptual Knowledge Questions:

1. When planning lessons, do you believe it is important to focus on the development of procedural knowledge or conceptual knowledge? Why?

(modify questions below as needed if they mention balancing/combining the two knowledge types)

2. Do you think you focused on the development of (insert knowledge type) in the series of lessons I observed? If yes, how? In no, why not?

3. Can you describe a topic that you teach where you think you develop (insert knowledge type) particularly well and how you do this?

If it doesn't come up in discussion above:

Can you describe a time when you have attempted to balance the development of procedural and conceptual knowledge with your students?

NO:

Do you think it would be beneficial to students to balance the development of these knowledge types or do you prefer to keep them separate? Why?

YES:

Can you describe any areas that are difficult for you when you attempt to balance the development of both conceptual and procedural knowledge with your students?

Probe for: linking the two knowledge types, what knowledge type comes first, lack of teacher content knowledge, lack of guidance in resources, SOLs don't focus on both items together.

Can you think of any modifications that could be made to teacher resources that might assist you with balancing the development of procedural and conceptual knowledge with your students?

Specific Questions for Individual Teachers:

Final Question:

1 Is there anything else you think is important about how you use curriculum materials or plan for your class that I haven't already asked you about?

Thank you!

Appendix F

Daily Teacher Log

Please answer each question with as much detail as possible.

Class:

Date:

1. Thinking back on the previous day's lesson, did you modify your original plans during the implementation of the lesson? If so, how did you modify the lesson and why?

2. What is the main goal(s) of today's lesson?

3. What resources did you use to plan this lesson?

4. Did you plan this lesson essentially as it was organized in the resources or did you modify the resources in your planning of the lesson?

5. Can you describe the modifications you made and your reasons for making them?

Appendix G

Example of Completed Daily Summary Form

Date: 3/10/09
Participant: Lynn Smith
Summarize the main issues or themes that came out of today's contact below:
Source: Interview (I); Observation (O); Informal Discussion (D); Email (E); Teacher Log (L); Document (Doc)

Source	Factors Influencing Participant	Description of Event	Possible Theme
O	Time	Time was a huge factor in today's lesson. Use of manipulatives requires a lot of time. Needed to organize room in groups, pass out blocks, review names of blocks, watch video clip, demo how to do the activity, and then give students time to practice. When the bell rang at the end of class, RL said: "this is why I would like 90 minute blocks."	
O	Connections	Connected blocks again to previous use and to area – blocks are named by the areas of their faces (x by 1 = 1x; x by x = x^2)	Connection
O	Connection	To students' lives by talking about area of carpet to cover floor	Connection
O	Routines	Routines showed up again: reviewed whole process for the day (FN #5); reviewed procedures for getting some things done in the remaining time (FN #19) – worksheet for class/homework also included example section to be cut out and put in interactive notebook	Routines
O	SOL	Not sure if it is influencing her, but she mentioned the test a couple of times during the lesson when referring to the algeblocks and being able to "read" what the answer is from a picture of blocks.	

	Routine	Clip of video to introduce topic	
	Unstructured Activity	Not observed group work in this class up until now. She seemed a bit "frazzled" during the lesson (of course most of us would be). She asked me prior to beginning – "are you ready for this?"	
	Time	I think some students will be a little confused with the homework without the blocks because they have not had enough time to process everything.	

List any other interesting or important events:

- Today I did a little more than observe. Due to nature of group work with blocks, I roamed around the room to observe what students were doing. I did ask a few questions of the groups as I walked around
- Tomorrow – I will follow RL around as she talks with groups – today I was more focused on students and missed some of what she did with each group. Hard to hear her talking to different groups because the recorder is picking up the group in front.
- I think some students will be a little confused with the homework without the blocks because they have not had enough time to process everything. It will be interesting to see what happens.

What questions do you have for the participant about the events that occurred today?

- Why didn't she start with monomial time binomial? I saw those worksheets on her desk. Students seemed fine with binomial times binomial though. Maybe the other worksheets are for when they don't have blocks.
- In hindsight – is there anything she would have done differently? I am thinking area model – use 3 times 5 and fill it in to demonstrate multiplication. Then maybe have students do 3 x -5 or -3 x -5 to see how the quadrants work – see below.
- Did she mean to do area of faces when she reviewed naming the blocks? She did that with second group.
- How will she explain OR will she explain why the bottom left quadrant is positive (negative times a negative). Will she wait for the students to figure this out? Will it just be taken as fact – because that is what the mat says?
- How is this or will this visual/conceptual piece going to get connected to the skill – that is the tricky part.

Appendix H

Instructional Coordinator Letter

Dear<insert Instructional Coordinator name>,

As you know, I have received approval to conduct my dissertation research in your school district. I am interested in exploring the factors that impact middle school mathematics teachers as they plan and implement instruction. In order to gain insight into the teacher-curricula relationship, I need to purposefully select my participants. I am interested in teachers who have what Remillard (2005) calls a "participatory relationship" with their curricula. That is, teachers who seek, modify, design, or develop materials using multiple resources in order to plan and implement instruction. Of the teachers in your district who seem to have this type of relationship with their curricula, I would be interested in studying those teachers that you feel do an exemplary job in both planning and implementing mathematics instruction.

In order to assist me with participant selection, I would appreciate it if you would fill in the names of ten middle school mathematics teachers that you believe would fit the requirements of my study. Please consider the following characteristics in making your selections:

- Teacher uses a variety of teaching strategies from a variety of curriculum materials
- Teacher views curriculum materials as a resource
- Teacher has strong pedagogical content knowledge and subject matter knowledge
- Teacher selects classroom tasks based on student needs

Please complete the chart on the following page by ranking your choices from one to ten (with one being your first choice). This information will be combined with Principal recommendations and teacher survey results to select the final participants and will be kept completely confidential. After the study, this information will be destroyed.

Thank you for your time.
Sincerely,

Trish Kridler
George Mason University
540-349-8384
pkridler@gmu.edu

Appendix I

Principal Letter

Dear <insert Principal name>,

I have received permission from your Associate Superintendent of Instruction, <insert Associate Superintendent of Instruction name>, to conduct my dissertation research in your school district. I am interested in exploring the factors that impact middle school mathematics teachers as they plan and implement instruction. In order to gain insight into the teacher-curricula relationship, I need to purposefully select my participants. I am interested in teachers who have what Remillard (2005) calls a "participatory relationship" with their curricula. That is, teachers who seek, modify, design, or develop materials using multiple resources in order to plan and implement instruction. Of the teachers in your school who seem to have this type of relationship with their curricula, I would be interested in studying those teachers that you feel do an exemplary job in both planning and implementing mathematics instruction.

In order to assist me with participant selection, I would appreciate it if you could recommend two mathematics teachers at your school that you believe would fit the requirements of my study. Please consider the following characteristics in making your selections:

- Teacher uses a variety of teaching strategies from a variety of curriculum materials
- Teacher views curriculum materials as a resource
- Teacher has strong pedagogical content knowledge and subject matter knowledge
- Teacher selects classroom tasks based on student needs

If you could also include a reason for your choice and/or an example from your experiences with the teachers I would greatly appreciate it.

This information will be combined with two other sources in order to select the final participants and will be kept completely confidential. After the study, this information will be destroyed.

Thank you for your time.
Sincerely,

Trish Kridler
George Mason University
540-349-8384
pkridler@gmu.edu

Appendix J

Informed Consent Form for Teacher Survey

Factors That Influence Middle School Mathematics Teachers as They Plan and Implement Instruction

INFORMED CONSENT FORM -SURVEY

RESEARCH PROCEDURES
This research is being conducted to explore the factors that influence middle school mathematics teachers as they plan and implement instruction. If you agree to participate in this phase of the study, you will be asked to complete a short mathematics education survey. The survey should take approximately ten minutes to complete.

RISKS
There are no foreseeable risks for participating in this research.

BENEFITS
There are no benefits to you as a participant other than to further research in the area of teacher-curricula interaction.

CONFIDENTIALITY
The data in this study will be confidential. Your name will not be included on the survey. A code will be placed on the survey and, through the use of an identification key, I will be able to link the data to your identity. Only I will have access to this key.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party.

CONTACT
This research is being conducted by Patricia G. Kridler at George Mason University. She may be reached at 540-349-8384 for questions or to report a research-related problem. You may also contact her faculty advisor, Dr. Margret A. Hjalmarson, at 703-993-4818. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study.

____
Name and Signature

____
Date of Signature

Approval for the use of this document EXPIRES

FEB 0 8 2010

Revised 07/2005 1 of 1

Protocol # 6160
George Mason University

Appendix K

Ranking of Teachers for Selection

Participant Selection Form					
Teacher Number	Supervisor Recommendation (0 - 10)	Principal Recommendation (0 or 3)	Survey Score (1 - 6)	Total Score	Teacher Rank
1			4.05	4.05	
2	x	x	x	0	x
3			5.5	5.5	
4			4.95	4.95	
5			4.5	4.5	
6	8	3	4.6	15.6	
7			5.05	5.05	
8	4		4.85	8.85	
9	1		5.1	6.1	
10			5	5	
11	3		5.05	8.05	
12			4.7	4.7	
13		3	4.85	7.85	
14		3	4.85	7.85	
15			4.8	4.8	
16		3	4.15	7.15	
17			4.4	4.4	
18	5		5.4	10.4	
19			4.5	4.5	
20			4.25	4.25	
21	x	x	x	0	x
22	10	3	5.45	18.45	
23			4.85	4.85	
24			4.25	4.25	
25			3.5789474	3.57895	
26			3.85	3.85	
27			4.05	4.05	
28			4.55	4.55	
29	9	3	4.75	16.75	
30			3.85	3.85	
31	2		4.85	6.85	
32	7	3	5	15	
33	x	x	x	0	x
34	6	3	5.35	14.35	
35			4.25	4.25	
36			4.3	4.3	
37			4.6	4.6	
38			5.2	5.2	

Appendix L

Informed Consent Form for Study

Factors That Influence Middle School Mathematics Teachers as They Plan and Implement Instruction

INFORMED CONSENT FORM -SURVEY

RESEARCH PROCEDURES
This research is being conducted to explore the factors that influence middle school mathematics teachers as they plan and implement instruction. If you agree to participate in this phase of the study, you will be asked to complete a short mathematics education survey. The survey should take approximately ten minutes to complete.

RISKS
There are no foreseeable risks for participating in this research.

BENEFITS
There are no benefits to you as a participant other than to further research in the area of teacher-curricula interaction.

CONFIDENTIALITY
The data in this study will be confidential. Your name will not be included on the survey. A code will be placed on the survey and, through the use of an identification key, I will be able to link the data to your identity. Only I will have access to this key.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party.

CONTACT
This research is being conducted by Patricia G. Kridler at George Mason University. She may be reached at 540-349-8384 for questions or to report a research-related problem. You may also contact her faculty advisor, Dr. Margret A. Hjalmarson, at 703-993-4818. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study.

____
Name and Signature

____
Date of Signature

Approval for the use of this document EXPIRES

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Revised 07/2005 1 of 1

Protocol # 6160
George Mason University

Appendix M

Coding Scheme

Code	Category	Category Description
attn	Attention to Instruction	Student behavior and/or lack of attention to instruction impacting the implementation of the lesson.
blck	Block schedule	Having a longer block of time to teach mathematics
conc	Conceptual knowledge	Development of conceptual understanding
conf	Confusion	Evidence of teacher not being prepared to teach the lesson and/or the teacher being confused about the content being covered or the students reaction/response to that content
conn	connections	Making connections. Could be between mathematical concepts and the real world, other concepts/procedures, other topics they have studied or will study
c-p	Conceptual to procedural	Making a connection from conceptual to procedural understanding
diff	differentiation	Different ways of showing the same thing – assist different learners
envr	School environment	Availability of needed resources for classroom use
exp	Past experiences	Past teacher experiences with resources or activities influencing use.
flex	flexibility	Demonstrating flexibility in the planning or implementation of lessons
flow	Flow of lesson	That the lesson flows logically and smoothly and each day builds on the next.
ho	Hands-on	Engaging students with manipulatives, using a hands-on and/or visual approach to teaching mathematics
home	home	Keeping family informed; assisting students with homework
lead	Leading students	Use of questions to lead students to the answer that teacher expects; reaction of teacher when she is listening FOR an answer (as opposed to listening to student answers) to lead student in “correct” direction.
mod	modifications	Modifications to lessons and/or resources and reasons for making the modifications
ms	Math specialist background	Impact of math specialist courses/training on the teaching and learning of mathematics.
org	organization	Being prepared and well organized to teach lesson. Evidence of teacher planning.
proc	Procedural knowledge	Development of procedural knowledge – algorithms, steps
ques	questioning	Questioning strategies

Code	Category	Category Description
real	Real world	Mathematics in real world situations
rela	Relationship	Teacher – student relationship
resc	resources	Materials that are chosen and reason for selection
rev	review	Review of previous learned concepts to either assist students with moving forward or to connect new learning with previous learning
rout	routines	Classroom routines – part of student's and teacher's daily routines
see	Seeing it	"seeing" the mathematics in order to understand it. Seeing the patterns in mathematics.
sols	State Standards	SOLs and/or district pacing guides impacting planning and/or implementation
stud	students	Students impacting the planning or implementation of lessons through questions asked or demonstration of understanding/confusion over topic. This includes teacher experiences with students in other classes.
tech	Technology	Technology access impacting planning and/or implementation
text	Textbook	Use of mathematics textbook as a resource
time	time	Impact of time on planning and implementation – activities taking too much time; not enough time to get everything done; not enough time to do everything they would like.
undr	Student understanding	Teacher move in order to make sure students are aware of what they are doing and why they are doing it. Includes informal assessment.
vocab	vocabulary	Stressing the use of proper, mathematical vocabulary and/or understanding the vocabulary

Appendix N

Example of Section of a Coding Document

Teacher:					
		Code			
Source	Location	Level 1	Level 2	Level 3	Text
FI	20,15	conc	ho	undr	More time to let them work together and to look at what they're doing, if it's a manipulative-type thing, and to let them have time to play with the pieces and talk to each other about it, and try to figure out, you know, why something works or doesn't work.
FI	6,11	conc	ho	undr	I try to do a lot of hands-on stuff. I'm thinking, "Okay, weight is coming up. Got to get the scales in here, got to get some stuff into their hands." I want them to feel that it's about a paper clip, a gram is about a paper clip. Otherwise, it doesn't make any sense to them. So the more hands-on stuff I can implement, too.
II	20,1	conc	ho	undr	So, anyhow, we're going to do that all hands-on stuff, and then I want to see if they notice any pattern.
FI	27,11	conc	ho		Because I think, as time goes on -- or at least I could tell, just because of the grade levels I've taught -- we did a lot more of the -- I keep saying the hands-on stuff, because I apply that -- I put that together with the concept, I guess.
FI	27,16	conc	ho		Because I know, as they get older, it's not going to be so much of the hands-on stuff. So when they go to next year, it's less. They go to next year, it's less. And even though we talked about it in graduate classes, that you still need to bring out those pieces, I'm not really sure that the high-school people bring out the fraction pieces, even though that would be a good time to bring out the fraction pieces.

Appendix O

Matrices for Cross-Case Analysis

Matrix for Cross-Case Analysis of Factors that Influenced Teacher during Planning and Implementation

Teacher	Connections	Organized - Flexible	Time	Tool in Toolbox	Other Factors
Judy	▪ To review previously learned material especially vocabulary ▪ Link concepts to procedures ▪ Students need to “see it” – hands-on	▪ Class routines ▪ Well planned and organized patterning activity ▪ SOLs ▪ Watch her students as they interact with lesson and adjust as needed	▪ Used routines such as homework and warm-ups to focus on items her students needed to review - Possibly due to the closely approaching state test	▪ Different ways of looking at the same concept ▪ Different learning styles	
Ginger	• Linking concepts to procedures • Linking different representations together • To real world examples • To where they had been and where they were going • Questioning strategies • Review material	• Smartboard • Well planned and prepared to teach • Adjust based on student needs • Class routines • Adjust based on experiences in class • SOLs/Pacing Guide	• Limitations due to time	• Toolbox of resources – pick and choose – flow that leads to student understanding	

Teacher	Connections	Organized - Flexible	Time	Tool in Toolbox	Other Factors

Lynn	▪ Concrete (visual/hands-on) to abstract
	▪ To real world examples
	▪ To previously learned material
	▪ To elementary mathematics
		▪ Well planned out lessons
		▪ Experience with algebra content
		▪ Routines
		    ○ Homework
		    ○ interactive notebook
		    ○ student accountability – check for understanding
		▪ Student questioning for understanding and flexibly adjusting when needed based on responses
		▪ SOLs – organized around
		▪ Pacing Guide – flexible document
		▪ Smartboard – framework to guide lesson
		▪ Adjusts as day progresses based on current class experiences
			▪ Time – tried to organize around, needed to be flexible because of	▪ Students have different needs, learn differently
				▪ More than one way to do a math problem	

Teacher	Connections	Organized - Flexible	Time	Tool in Toolbox	Other Factors
Kath	▪ Different ways ▪ Review/vocabulary ▪ Student understanding	▪ Fly by the seat of her pants – easily adjusts based on student needs ▪ Reinvents the wheel ▪ Organized, structured lessons to support her students ▪ Understands the big picture of her curriculum and how the pieces fit in ▪ has goals (not fixed plans) on how to get where she wants to go	▪ Time not a factor – teacher was ahead of the pacing guide for Algebra I		Student Concerns ▪ Attention/ behavior issues ▪ Understanding of mathematics
Lea	▪ Use of manipulatives or other visuals to allow her students to see the concepts ▪ Different strategies allowing students to make connections as they learn ▪ Real world examples ▪ Made as a result of students' questions or statements	▪ Expectations of what should happen or what she wanted to happen tended to influence how she reacted to what occurred in the classroom. ▪ Reacted to what she was listen for rather than to what her students actually said	▪ Not enough time in class period to teach by using activities to help students learn ▪ End of the quarter – focused on "covering" material	▪ Experience provided her with vast supply of resources that she selected from and modified as needed based on what happened in the class	Me ▪ Influenced her students ▪ Possibly influenced/flustered teacher

Matrix for Cross-Case Analysis of Factors that Impacted the Selection & Modification of Resources

Teacher	Textbook	Different Ways	SOL	Time	Other Factors	Modifications
Lynn	▪ Resource for the parents ▪ Resource for procedural practice mainly at home, but also in class (text and supplemental resource pages)	▪ See it – make connections ▪ Manipulatives ▪ Learning styles			**Smartboard** ▪ Planning and organization tool ▪ Teaching tool ○ Procedures – games for practice **Interactive Notebook** ▪ Organizational tool for her and students ▪ Supports student learning, more accessible to all students	▪ Smartboard framework allowed her to supplement and/or modify lessons as she went based on her students' needs ▪ Based on experiences in the classroom (either with observed class or other class) ▪ Suggestions for textbook demonstrated a lack of knowledge of what the textbook had to offer

Teacher	Textbook	Different Ways	SOL	Time	Other Factors	Modifications
Kath	▪ Resource for students at home ▪ Did select procedurally based problems from the text and associated resources for class and homework ▪ Used older versions of text because she had "studied" it and liked its format	▪ Different ways to look at and present material important to her **Knowledge-type specific resources** ▪ Pulls resources from a variety of sources ▪ Text book problems for procedures ▪ CMP activities for concept development			**Lack of Technology**	▪ Purposefully selected problems to meet instructional objectives
Ginger	• Not used • If used, mainly for procedure	• Hands-on for both concepts and procedures • "cool factor" – engage students		• Limits what she can do in class • Her time to explore and find new resources is limited •	**Technology** ▪ Smartboard: planning/organization/teaching tool ▪ Websites: develop concepts and practice procedures ▪ Engaging and also provides structure for students ▪ Calculators – for calculator items on SOL test **Pick and choose** ▪ How best to show it – flow ▪ Teacher experience with resources	▪ Due to not matching SOLs ▪ Student needs ▪ Past experiences and experiences during the current lesson ▪ Flow – putting things in the right place

Teacher	Textbook	Different Ways	SOL	Time	Other Factors	Modifications
Judy	▪ Resource for use at home – look things up ▪ Workbook used for homework ▪ Does not match SOLs – need to jump around	**Manipulatives** ▪ So students can make sense of mathematics	▪ Close to time of state test – resources for review ▪ Practice with content students were missing ▪ Use of resources such as box paper for recording and formula sheet			▪ To match SOLs, especially textbook resources ▪ Created her own worksheet to match her objectives for lesson – cut and pasted from other resources and her own ideas ▪ Take existing worksheets and modify how they are used during implementat ion – again to meet her/state objectives ▪ Time

Teacher	Textbook	Different Ways	SOL	Time	Other Factors	Modifications
Lea	▪ Mentioned briefly, not observed in use during study ▪ Informal interactive notebook took the place as a resource for students.	▪ Pulls from a variety of resources ▪ Extensive teacher "tool box" from past experiences ▪ Hands on/visual activities so students "make a picture in their heads"		▪ Prevented her from using all the resources she had ▪ Prevented her from finding new resources ▪ Resulted in her adjusting her lessons due to running out of time		▪ Missing materials lead to unexpected outcome – students drawing diagonals and making assumptions about length of line ▪ Students' needs and reactions to activities ▪ Instructional goals – change directions on worksheets to focus on her goals

Matrix for Cross-Case Analysis of Balancing Procedural and Conceptual Knowledge

Teacher	Beliefs	Balance

Ginger	• Hands-on experiences first to discover relationships
	• Still need to be able to “do” the math
		• Need to develop both
		• Students need to see the big picture
		• Students need to “see” the math to understand the concepts so that they remember later on – make connections
		• Impact of students on instruction
		  ○ Questioning strategies – listening to students
		  ○ Student reactions to activities
		• Can’t just “do it” – students don’t remember

Lynn	▪ Students need to justify answers to show understanding ▪ Student need to make connections to understand ▪ Developing conceptual understanding was more influential but she recognized the need for developing procedural fluency	▪ Different ways of doing mathematics – tools in their toolbox ▪ Linking concept (visual/concrete example) to procedure ▪ Linking procedures to concepts
Judy	▪ Strong focus on the concepts ▪ Students need to see it/understand it she also referred to students “doing it” meaning physically so that they understand ▪ Review of needed procedural skills before state test	▪ Flow – concepts first then introduce them to procedures ▪ Different ways – adjusts for different learning styles; meets the needs of all students
Kath	▪ Presentation of material depends on topic/students ▪ Adjust instruction based on students’ needs ▪ DID NOT focus on connections between concepts and procedures either in discussion or during observations – different than previous 3 teachers.	▪ Equated it to order – which comes first (“the chicken or the egg”) ▪ Time – sometimes an issue. Spend all the time and the kids still don’t get it.
Lea	▪ Students were lacking in conceptual understanding ▪ Conceptual understanding first – hope it carries over when the “do” math ▪ Likes students to discover concepts - but sometimes need to just tell them	▪ Equal amounts of activities for each knowledge type ▪ Concepts during class; procedures for homework ▪ Lacked connection between the two knowledge types

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Curriculum Vitae

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