MATHEMATICS TEACHERS’ USE OF INSTRUCTIONAL MATERIALS WHILE

IMPLEMENTING A NEW CURRICULUM

by

KELLY WINNELLE EDENFIELD

(Under the Direction of Jeremy Kilpatrick)

ABSTRACT

This study examined the selection, evaluation, and implementation of instructional materials by a group of three teachers in the same high school during their first time teaching a course in Georgia’s new integrated, process standards-based curriculum. Each of the three teachers, as well as a larger group of teachers, completed a survey about the teachers’ own mathematical experiences, their beliefs about mathematics pedagogy, and their understanding of and preparation for teaching the curriculum. I observed the three participants’ classes during their instruction on three mathematics units: quadratic functions, right triangle trigonometry, and circles and spheres. The teachers also participated in individual interviews after each unit. I classified the teachers’ materials evaluation and selection and how they implemented the materials in their instruction. Although the teachers planned together, their rationales for their evaluation, selection, and implementation of materials varied. I attributed the teachers’ decisions to number of contextual and teacher factors, including their beliefs about teaching and learning and their opportunities to learn about the curriculum changes. More important than a particular textbook choice was how the teachers selected and implemented the materials to support the mathematical goals of the curriculum. The results of the study indicate that teacher educators must help practicing and prospective teachers develop their knowledge of curriculum standards and how to select and implement materials to support those standards.

INDEX WORDS: Mathematics, secondary teachers, instructional materials, curriculum standards

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DEDICATION

This dissertation is dedicated to my first teacher – my mother, Jennie Carole Hogan Edenfield. She taught me that I could accomplish anything I wanted. She inspired me to never give up, to be the best person I could be, and to believe in myself. I would not be where I am today without her. I love you, Mom!

I also dedicate this work to all of the mathematics teachers who work tirelessly, going above and beyond what the general public believes teachers do, to provide the best possible learning opportunities for our students, the leaders of tomorrow.

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BACKGROUND AND DESCRIPTION OF THE PROBLEM

My experiences as a classroom teacher, school department chair, and teacher educator led to this study. As a classroom teacher, I was often the only person teaching a particular course, which required that I search for supplemental instructional materials if I deemed the district-supplied textbook insufficient. When I joined the school leadership, I worked with other teachers to improve their teaching, often helping them find or develop activities to accomplish their goals, including making mathematics more relevant and interesting to their students.

Midway through my teaching career, I transferred to and helped start a new high school. The mission at the school—a mission espoused by the principal so often that all involved in the school could repeat it on demand—was that we would "teach every student to read, write, speak, listen, and problem solve" and we would "do it better than anyone else." The school culture was one of collaboration, within and across subject areas. Every Monday afternoon, we participated in some type of meeting—department, faculty, or interdisciplinary study group—as a way to provide protected time for collaboration. It was during those times that I began working closely with other teachers to plan lessons together. What struck me during this collaboration was that my interest in *designing* activities to support my students' learning was unique in our group; the other teachers often adapted activities, but they rarely created their own.

At the state mathematics teachers' conference one year, I presented many of my activities. After that conference and 2 years later at the same conference, teachers emailed me or approached me about my activities and said how well the activities had worked in their classrooms. These experiences led me to question how we mathematics teachers differed in our approach to developing and using activities. What accounted for one teacher's efforts to create new activities for students when others were satisfied to teach the lessons out of the textbook or to make only minor modifications? Neither choice was wrong, but what led to the decisions?

While working toward National Board Certification, I reflected on my instructional decisions—those made prior to, during, and after instruction. I began examining the cognitive demand of tasks and what made a task more or less appropriate for small group or whole class instruction. I was also forced to think about my own decisions and how I used student thinking and performance on previous activities in my planning. Although the process of writing up the National Board entries was time consuming and valuable, I did not find the process of analyzing my teaching difficult; my instructional decisions and choice of classroom tasks generally supported my learning goals.

Throughout my teaching career, I had worked with other teachers in my district to make curricular decisions, from textbook adoptions to revising the district curriculum standards. These experiences sparked an interest in curriculum issues beyond my classroom and my school. I became involved in the state of Georgia's curriculum revision process, providing feedback on draft standards and writing instructional materials for the state. I realized, however, that policy decisions and the materials I drafted might not influence the teaching that occurred in Georgia mathematics classrooms. So what *does* influence classroom teaching? What do teachers attend to when they plan and enact lessons?

My interests brought me to the University of Georgia to study teachers' instructional decision-making, at both the preservice and inservice level. While working with mathematics education majors in their final year of preparation, I discussed cognitive demand, choosing instructional tasks to meet specific learning goals associated with particular curriculum standards, and implementing worthwhile tasks. My weekly professional development meetings with the mathematics teachers in a middle school during my third year of graduate school allowed me to discuss many of these same ideas with practicing teachers. In both settings, the teachers exhibited various levels of acceptance of the ideas or methods we discussed. Again, I asked why. With the middle school teachers, I wondered why teachers with the same or similar undergraduate preparation and years of experience in the same school selected different materials and implemented the same curriculum standards in vastly different ways. All of these experiences led to the formulation of the present study.

Background

Numerous studies in the last few decades paint a disturbing picture of the mathematical abilities of American school children (American Federation of Teachers [AFT], 1997; Dossey, 1997; Gal, 1997). Emerging from these studies is the comparison of U.S. mathematics curricula with that of countries scoring higher in international studies of mathematics achievement. The U.S. mathematics curricula are criticized as being “a mile wide and an inch deep”; students in other countries spend more concentrated time studying a topic in depth and less time reviewing than students in the United States (Schmidt, McKnight, & Raizen, 1997). Additionally, the majority of exercises completed by American students can be characterized as routine, algorithmic tasks, whereas the international students who outscore their American counterparts on international assessments pursue a greater number of nonroutine problem-solving tasks (AFT, 1997). During the last quarter of the twentieth century, the National Center for Education Statistics (NCES) sponsored the National Adult Literacy Survey (NALS) and multiple administrations of the National Assessment of Educational Progress (NAEP). The results of these assessments show that U.S. students and adults lack the basic mathematics literacy needed to successfully accomplish life tasks such as determining the amount of change one is due in a restaurant (Dossey, 1997; Gal, 1997).

Beginning in the 1980s, the National Council of Teachers of Mathematics (NCTM) emerged as a major influence on both curriculum and instruction. The NCTM (2000) contends that students "need to understand and be able to use mathematics in everyday life and in the workplace" (p. 4). This observation brings with it the need for an increased focus on problem solving, reasoning, critical thinking, and mathematical communication for all students. The NCTM *Principles and Standards for School Mathematics* establishes that all students should have access to high quality, engaging mathematics. Despite the organization's call for the inclusion of more reasoning and problem solving in school mathematics, U.S. students are not actively engaged in high-level, meaningful mathematics tasks (Hiebert, 2003).

One approach to increasing the number of high-level tasks in which U.S. students might engage was the development of curricula based on the 1989 NCTM *Curriculum and Evaluation Standards.* These curricula promoted problem solving, connections, reasoning, and communication while including topics from different mathematical strands: measurement, number and operations, algebra, geometry, and statistics and probability. Each curriculum project team conducted research to determine the effectiveness of their program, with mixed results in terms of fidelity of use and student achievement (Senk & Thompson, 2003). Regardless of the curriculum project used in the classroom, whether it is considered based on the NCTM standards or more traditional,

> a school mathematics curriculum is an abstraction that can only be glimpsed through such means as examining statements of goals, analyzing mathematical and pedagogical features of materials, observing lessons, finding out how teachers understand the curriculum, and assessing what students have learned. (Kilpatrick, 2003, p. 473)

Thus, mathematics educators must not only study the features of a curriculum to evaluate its effectiveness, but they must also study teachers' implementation of the curriculum and the influences on that implementation.

Teacher-Curriculum Relationship Framework

Remillard's (2005) extensive review of research on mathematics curriculum use revealed four major conceptions of curriculum use: following or subverting, drawing on, interpreting, and participating with. From this body of research and her own work, Remillard developed the teacher-curriculum relationship framework (Figure 1). She posits that teachers bring their own experiences and contexts to the table as they read, interpret, evaluate, and adapt a curriculum. She places the participatory relationship of teachers and curriculum as the most accurate conception of curriculum but conceives of the interpreting and drawing on conceptions of curriculum use as embedded within this participatory relationship. Remillard proposes using this framework as a lens for future studies of teachers' interactions with curriculum.

The teacher-curriculum relationship framework is based on the assumptions that teaching is multifaceted and involves instructional design. Further, the framework highlights the interaction between the teacher and instructional resources. There are four major constructs in the framework: the teacher, the resource, the participatory relationship, and the planned and enacted curriculum. The emphasis on the relationships among these four constructs "allows the framework to represent the cycles of design before, during, and after classroom practice" (Remillard, 2005, p. 236). The relationships also illustrate the dynamic and iterative nature of teaching and instructional design. For instance, enacting a planned lesson may lead to in-the-moment decisions, which in turn lead to a new plan of action for the lesson, which produces a different enactment (Remillard, 1999). These types of cycles can also lead to changes in teacher characteristics such as beliefs and perceptions of students (Remillard, 2000).

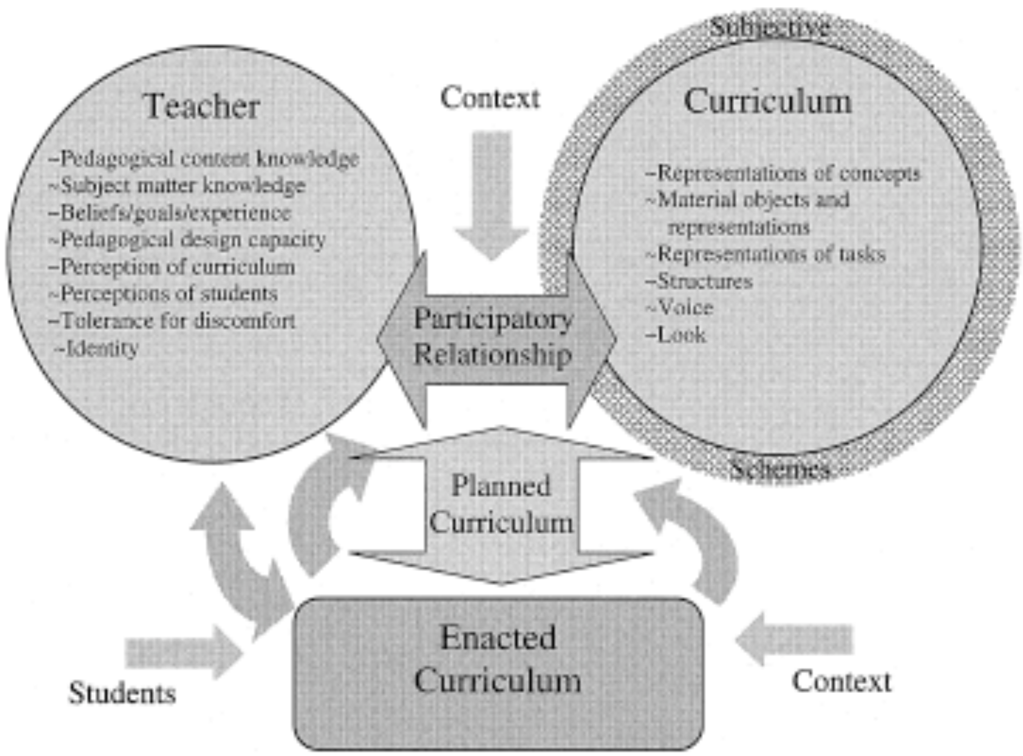

Figure 1. The teacher-curriculum relationship framework.
Note. From "Examining Key Concepts in Research on Teachers' Use of Mathematics Curricula," by J. T. Remillard, 2005, *Review of Educational Research*, *75*, p. 235. Copyright 2005 by the American Educational Research Association. Reprinted with permission.

As illustrated in Figure 1, both the teacher and the resources bring a variety of characteristics to the relationship. Remillard proposes this framework as a lens for which to conduct additional research on how each element leads to differences in materials use and the planned and enacted curriculum. And although the context is not a primary construct of the framework, Remillard suggests the relationship be studied in particular contexts, both local school and classroom contexts as well as more global policy contexts.

The State of Georgia Mathematics Curriculum

A 2001 audit of Georgia's mathematics curriculum by Phi Delta Kappa International, requested by the state board of education, revealed that the curriculum lacked rigor, provided insufficient guidance for framing high-quality instruction and ensuring high expectations for all students, and required the learning of too many topics with too little depth (Poston, 2004). In response, the Georgia Department of Education developed a new mathematics curriculum designed to be more student-centered, rigorous, and focused, with clear expectations for what is to be taught. This new curriculum included content standards based on the Japanese curriculum as well as process standards based on the National Council of Teachers of Mathematics (2000) standards—problem solving, communication, reasoning and proof, representations, and connections—throughout the K–12 grades (Georgia Department of Education [GADoE], 2004, 2005). Beginning in 2005, the new courses were gradually implemented: 6th grade in 2005; kindergarten through 2nd grades and 7th grade in 2006; 3rd through 5th grades and 8th grade in 2007; and continuing grade-by-grade in the high school (GADoE, 2004).

One major challenge to implementing the new Georgia Performance Standards (GPS) was the lack of textbooks aligned with these standards, especially at the high school level (GADoE, 2005). As a result of not having texts aligned to the GPS and a call to teach in more student-centered ways, some teachers were left feeling unsure of their own abilities to teach this new curriculum using teaching strategies that might also be new. In an effort to supplement the textbooks as well as to provide teachers with clearer expectations of what and how the content standards were to be taught, the GADoE developed *frameworks* that consisted of learning and culminating tasks for classroom use. In addition to district-provided texts and resources and the state frameworks, the teachers had access to a multitude of online and print resources from which to draw instructional activities.

Another change that accompanied the GPS was a reduction in the tracking of students in mathematics courses that had previously existed in Georgia. Under the prior curriculum, students could enroll in a college preparatory set of mathematics courses, including gifted and honors courses, or they could complete courses in the technical preparation program. These were considered different "tracks" of courses. One significant difference between the two tracks was how students could earn the state-required algebra credit. In the college preparatory track, Algebra was a 1-credit course. In the technical preparatory track, students completed two courses that combined to address most of the topics in the traditional algebra course. Despite these differences, students in both tracks were expected to take the same state end-of-course algebra test. When the GPS were implemented, the technical preparatory track was removed from the curriculum offerings; students enrolled in either the college preparatory or accelerated mathematics courses. To meet the needs of students who might need additional support to be successful in the college preparatory courses, school districts offered students additional GPS Support courses. Different districts designed their courses in a variety of ways: as a way to preview or review content for the regular course or making a one-semester GPS course into a yearlong course.

Significance of the Study

The rollout of Georgia's new mathematics curriculum, including the scarcity of appropriate and adequate textbooks (GADoE, 2005), highlighted the importance of understanding how teachers use instructional materials and how teachers could be supported to teach a new curriculum more effectively. Past research provides evidence that teachers use materials differently, often because of external and personal factors. External factors include pressure to prepare students for standardized tests, parent pressure, and pressure from colleagues. Personal factors include a teacher's preparation, teaching experience, and understanding of the materials, as well as how the instructional materials align with the teacher's philosophy of mathematics education (e.g., Collopy, 2003; Remillard, 1999, 2000).

Research on teachers' use of specific curriculum programs and differences in materials use at different points in the professional continuum has led many mathematics educators to call for additional studies to examine teachers' use of materials (e.g., Behm & Lloyd, 2009; Cooney, 2009; Remillard, 2005, 2009). The present study sought to answer that call. It contributes to understanding how personal and contextual factors mediate teachers' implementation of a process standards-based curriculum. It also provides insight into how teachers use instructional materials to teach a new curriculum, with implications for preservice and inservice education. Finally, the findings reveal teachers' concerns in selecting and evaluating materials, findings that could inform future materials development.

Research Questions

Understanding how teachers make sense of a new curriculum, how they choose the materials to use with their students, and how they implement lessons based on those materials can inform those who prepare teachers, both prospective and practicing, about ways to better prepare and support them. Also, this understanding may provide useful information for those writing materials for use with innovative curricula, so that the materials may be enhanced to better meet the needs of teachers. With these interests in mind, I used the following research questions to guide the study:

1. In implementing a new course, how do high school mathematics teachers evaluate and select instructional materials in their planning?
2. In implementing a new course, how and to what degree do high school mathematics teachers use the materials during instruction?
3. How do high school teachers’ decisions and appropriations of materials differ when teaching different mathematical topics in implementing a new course?

CHAPTER 2

MATHEMATICS TEACHERS' USE OF INSTRUCTIONAL MATERIALS WHILE IMPLEMENTING A NEW CURRICULUM

In this chapter, I review the literature about teachers' use of instructional materials that informed the theoretical framework for my study. Numerous studies have been conducted on how teachers use instructional materials and on the factors influencing that use, especially in the case of curriculum programs labeled *reform* or *Standards based*. Materials are so named because they were developed in response to the National Council of Teachers of Mathematics (NCTM, 1989) *Curriculum and Evaluation Standards for School Mathematics.* More recent research has also explored how teachers use materials at different stages in their teaching careers and at different phases of implementation of materials. Drawing on these past studies, the design capacity for enactment framework (M. W. Brown, 2009; Brown & Edelson, 2003), and the mathematical tasks framework (Stein, Smith, Henningsen, & Silver, 2000), I developed the theoretical framework for my study.

Defining Instructional Materials

For the purpose of this study, *instructional materials* refer to resources available to, and used by, a teacher for instructional purposes. This definition includes materials describing the intended curriculum: what the teacher is expected to teach and the resources provided to achieve that goal. Instructional materials also refer to resources obtained online, supplemental textbooks and activity books, and materials provided by colleagues or from other sources. In contrast, *curriculum materials,* or *curricular programs,* refer to a particular set of materials developed by a single organization to be used together. For example, the Connected Mathematics Project curriculum materials support the curricular program of the project (Lappan, Phillips, & Fey, 2007).

Each district or school in Georgia adopts a set of textbooks and the associated resources, but schools must also abide by any state-, district-, or school-provided curriculum guides. Districts may emphasize different areas of the curriculum or topics not included in the textbooks, requiring their curriculum coordinators to mix and match units from different courses of a textbook series to fit their curriculum guides, as is currently the case in Georgia with *Connected Mathematics 2* (*CMP 2*; Lappan et al., 2007) for middle school and *Core-Plus Mathematics* (Fey & Hirsch, 2007) for high school. For example, with *CMP 2*, much of the content is aligned with the Georgia Performance Standards (GPS) curriculum for middle school; however, some units from the seventh-grade *CMP 2* are more aligned with the sixth-grade GPS.

Teachers implement curriculum guidelines through the tasks they employ with their students. They must evaluate the affordances and constraints of their instructional materials to select those tasks that are most appropriate for their students (Howson, Keitel, & Kilpatrick, 1981). Classroom *tasks* are defined as the activities and problems teachers select for instruction. Once tasks are selected, a teacher must choose how to use them. Clarke (2008) referred to this process as “the *implemented* curriculum—the ways in which a teacher takes a syllabus or curriculum guidelines or standards and enacts them in the classroom” (p. 134). The tasks provided to students may have been created by the teacher or may originate directly from the instructional materials as a suggested activity; the teacher may have modified the task from its original form; or the teacher may have found and modified a task from a source outside of those provided by the school. Remillard (1999) described those tasks taken directly from materials as *appropriated* tasks and those tasks created by teachers based on ideas in the text as *invented* tasks. A teacher needs the ability to invent and to modify tasks in line with his or her learning goals: "By analyzing and adapting a problem, anticipating the mathematical ideas that can be brought out by working on the problem, and anticipating students' questions, teachers can decide if particular problems will help to further their mathematical goals for the class" (NCTM, 2000, p. 53).

From a sociocultural perspective on mathematics education (Forman, 2003), the teacher must consider not only the instructional materials available but also his or her students' backgrounds, mathematical knowledge, special needs, and culture in implementing a particular curriculum. Regardless of the materials provided by the school, the teacher is the ultimate decision-maker and curriculum developer in the classroom.

> Teachers don't merely deliver the curriculum. They develop, define it and reinterpret it too. It is what teachers think, what teachers believe and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get. (Hargreaves, 1994, p. ix)

Although teachers *implement* a curriculum, they *use* particular materials. The materials they choose to use and how they use those materials to implement the curriculum influence their students' learning opportunities.

Factors in Teachers' Use of Instructional Materials

The relationship between the curricular materials provided to a teacher and the tasks used in the classroom depends on the teacher's past experiences; contextual factors; the teacher's interpretation of the texts; the teachers' knowledge and beliefs about mathematics, pedagogy, and students; and how well the provided materials meet the teacher's needs and beliefs (Collopy, 2003; Drake & Sherin, 2009; Lloyd, 2008; Remillard, 1999, 2000, 2005; Remillard & Bryans, 2004).

Teacher Identities and Experiences

Teacher identities. Teacher identities form through teachers' own educational experiences, their experiences as teachers, and their self-efficacy as teachers and with mathematics, mediating how teachers embrace change, including reform ideas and instructional materials. Some researchers view teaching as a cultural activity (e.g., Stigler & Hiebert, 1999) that "is learned through informal participation over long periods of time" (p. 86), contributing to a shared cultural understanding of how classrooms look and how the participants behave. When NCTM (1989, 1991, 2000, 2007) called for reform in mathematics education in the 1980s and subsequently published standards for curriculum, assessment, and professional development, the reform ideas challenged the commonly held view of "teaching as telling," as well as the traditional roles of teachers and students in the classroom. Consequently, reform may challenge teachers' self-efficacy, their mathematical knowledge, and how they think about student thinking (Philipp, 2007).

Current mathematics teachers have not necessarily experienced teaching and learning that reflects the ideas of the NCTM (2000) standards. After the early 1980s, the median age of a typical U.S. secondary teacher increased by 10 years (National Center for Education Statistics, 2008); even if they were aware of the reform movement, these teachers were likely already inculturated into a traditional teaching style. Newer mathematics teachers, although possibly educated during the post-NCTM standards era, may not have learning experiences consistent with the ideals of NCTM. Additionally, researchers have failed to find evidence of reform-minded teaching, including teaching by teachers who professed belief in and teaching strategies consistent with the NCTM reforms (Cohen, 1990; Stigler & Hiebert, 1999). When teachers have so much experience learning and teaching mathematics in a traditional IRE (teacher initiationbrief student reply-teacher evaluation) style (Mehan, 1979), the introduction of reform ideas or instructional materials, even if one agrees with them, may not be able to overcome the images one has of teaching. Teachers who do try to implement reforms often assimilate new ideas—the use of new materials, class organization, and activities—into their more familiar, traditional pedagogy (Cohen, 1990; Cohen & Hill, 2000; Lloyd, 2008), possibly as a way to maintain self-efficacy. This assimilation can lead to positive changes in teachers' identities; Remillard (2005) reported that teachers willing to interact with innovative materials improved their self-efficacy as teachers, as users of curriculum, and as authorities in the classroom.

Teaching experience. Teachers use curriculum materials differently at different stages in their careers. Lack of experience may motivate teachers to use new materials willingly (Behm & Lloyd, 2009; Christou, Menon, & Philippou, 2009; Remillard & Bryans, 2004), whereas those teachers with a great deal of experience with specific types of curricula may resist using tasks from a newer, standards-based curriculum (Collopy, 2003). Teaching experience and an extensive understanding of pedagogy may improve one's ability to plan lessons that use a variety of materials and better meet the needs of one's students (Anhalt, 2006; Behm & Lloyd, 2009; D. S. Brown, 1993, 1996).

Behm and Lloyd's (2009) study of three elementary student teachers' use of mathematics curriculum materials revealed five possible factors influencing how they interacted with the materials: the materials themselves, the degree to which the teacher education coursework focused on standards-based ideas and instructional materials, the teacher's content knowledge, the teaching context, and the cooperating teacher's guidance. For example, one participant, Heather, was not confident in her own mathematics ability, had taken one mathematics course for teachers, completed a single pedagogy class that extensively employed the materials she used during student teaching, and had the least amount of education directly related to the NCTM standards. Perhaps because of her familiarity with and trust in the materials, Heather relied more heavily on the book than the other student teachers did, using the scripted lessons as her primary lesson plan and following the lessons closely during class. She adapted the materials to account for managerial issues (e.g., related to class time) but not to accomplish her mathematical learning goals.

The case of Heather (Behm & Lloyd, 2009) echoes the findings of Remillard and Bryans (2004) and Christou, Menon, and Philippou (2009). Remillard and Bryans found that beginning teachers "tended to read and use all parts of the curriculum guides. … They sought to follow all the lessons as suggested in the guide, studying, and sometimes struggling with, all or most of the information provided for the teacher" (p. 377). In contrast, experienced teachers paired the tasks from the materials with their own approaches and teaching strategies. In Cyprus, curricular reform accompanied adopting a new textbook, a text that was easily accepted by novice teachers:

> The findings suggest that beginning teachers accepted the decision to proceed with the change in mathematics curriculum materials and did not seem to have high self-concerns about the innovation. Beginning teachers were not concerned about their abilities in relation to the new mathematics textbooks and, on the contrary, felt capable of meeting the demands of the innovation. (Christou et al., p. 240)

Christou et al. explained the lack of self-concerns associated with using the new textbook with the learning opportunities provided to the younger generation of teachers; "most of their courses [emphasized] the philosophy and the practices needed for the successful implementation of the new mathematics curriculum materials" (p. 241). Therefore, Christou et al. concluded that more important than teaching experience was the professional training experienced by the teachers. This conclusion seems consistent with the finding of Behm and Lloyd; those teachers with more substantial reform-based training were more comfortable using the materials as guides to their instruction than as scripted lessons dictating what they should do in their classrooms. Similarly, teachers who are supported in their use of reform ideas may exhibit standards-based teaching as they progress in their careers, whereas others with less support but, instead, pressure to have their students achieve on standardized tests, may not retain reform-based practices learned during their early teacher development (Cady, Meier, & Lubinski, 2006).

Experience with the materials. In addition to number of years teaching, how teachers use instructional materials is influenced by the teachers' experiences with the materials. Much research has focused on the selection and first years of implementation of standards-based curriculum programs with little attention given to the long-term implementation and use of the materials (Silver, Ghousseini, Charalambous, & Mills, 2009). Lloyd's (2008) experienced teacher used his materials as suggested during his first year of implementation but reverted to his traditional style of whole class instruction with primarily teacher-to-student discourse rather than student-to-student discourse in his second year using the materials; Lloyd attributed this change to her participant's discomfort with the demands of the curriculum materials.

This interpretation is consistent with Silver et al.'s (2009) assertions about the *curriculum implementation plateau*, the point at which successful, thoughtful implementation of curricular innovations ceases. During the first wave of professional development meant to support implementation of a new curriculum, teachers may use the materials with integrity. However, as the novelty of the innovative materials diminishes, how teachers implement those materials may change, with the teachers attending less to the importance of their role and of the pedagogy needed for teaching the materials:

> First, the curriculum implementation plateau appears to be associated with teachers having an underdeveloped understanding of their role as active agents in mediating the interaction of students and content through curriculum materials. Second, the curriculum implementation plateau appears to be associated with teachers having an underdeveloped

> repertoire of instructional strategies to use in effectively mediating the interaction of students and mathematics content through curriculum materials. (p. 251)

After working with a group of teachers in their fourth year implementing a standards-based curriculum, Silver et al. determined that the teachers needed additional support in understanding the instructional issues inherit in using standards-based materials: the teachers' roles as facilitators of student learning and the need to continue developing and maintaining effective instructional strategies. The strategies specifically cited include anticipating student responses, purposefully selecting solutions, sequencing solutions to present to the class, and asking follow-up questions to support and challenge student thinking about the mathematical ideas in the task.

In contrast to Lloyd's (2008) secondary mathematics teacher, Drake and Sherin (2009) found that as the elementary mathematics teachers in their study gained experience with a particular curriculum program over 2 years, they embraced the aims of the curriculum more fully. These teachers shifted from a concern over teacher-centered aspects of teaching the curriculum (e.g., transitioning between tasks and their own understanding of the materials) to focusing on the broad overviews provided in the materials and what their students would learn while using the materials. Instead of worrying about how to introduce a topic, they thought about how the particular topic contributed to the long-term mathematical goals of the curriculum. As such, during the first year of implementation, the teachers decided to supplement or omit tasks from the curriculum "in order to support their ongoing practices or prior beliefs about students' needs" (p. 332). In the second year, in contrast, they replaced tasks "that met the needs of particular students while still maintaining the conceptual and pedagogical goals of the curriculum program" (p. 333). The teachers focused on the overall mathematical goals of the curriculum—without reducing the cognitive demand of the curriculum, something they previously did to ensure that all students could be successful. Lloyd's teacher, however, focused more on his perception of his students' expectations of a mathematics class than on the mathematical goals designed into the curriculum materials.

Drake and Sherin (2009) used the curriculum strategies they developed to understand how their participants read, evaluated, and adapted materials to study the ideas of curriculum vision and curriculum trust: "Teachers must first develop their ideas about where the curriculum program is going mathematically (curriculum vision) before deciding whether the curriculum materials will help them reach that mathematical goal (curriculum trust)" (p. 325). So their participants had to move beyond the managerial concerns of implementing the curriculum before they could develop the curriculum vision; in turn, because the teachers now possessed the vision, they would be able to trust the materials. However, vision is not necessary for the development of curriculum trust, especially in the case of less experienced teachers. Novice teachers may exhibit curriculum trust before they develop curriculum vision (e.g., Behm & Lloyd, 2009; Remillard & Bryans, 2004). A key component in developing curriculum vision and trust seems to be the transparency of the mathematical intentions in the materials; teachers who are unable to determine the purpose of the lesson may experience difficulty with facilitating student thinking through the use of those materials (Stein & Kim, 2009). Their findings were promising: Additional experience with instructional materials can lead to teaching based on student thinking rather than on determining how to use the materials. Drake and Sherin believe, however, that it is possible to help teachers "understand that one of their objectives is to understand the long-term goals of a new curriculum program, [and thus help them] find ways to focus both on the details of activities as well as on the broad purposes of the lesson" (p. 335).

Contextual Factors

External factors may support or inhibit teachers' use of particular materials. Teachers who are provided professional development and administrative support for using materials may be more inclined to embrace and use those materials than teachers without such advantages. Regardless of the support provided, if teachers feel pressure for their students to excel on procedure-based tests, they may discard standards-based ideas and return to using procedurally-based texts to prepare their students for those tests. Similarly, pressure from community members, including parents, to teach children as they were taught may inhibit a teacher's use of specific materials (Cady et al., 2006; Collopy, 2003; Davis & Krajcik, 2005; Remillard, 2000). When evaluating instructional materials, teachers often think of how they might use those materials with their students. Although that is an appropriate consideration, Remillard (2005) found that "teachers' perceptions of students' deficits figure significantly in their negative responses to *Standards*-based curricula" (p. 229). If teachers do not hold high expectations for their students, they may be less likely to use standards-based materials. However, if they persevere, it is possible, as was the case in Drake and Sherin's study (2009), for the use of reform-based materials could lead to higher expectations for students. Related to expectations is classroom discipline; Eisenmann and Even (2009) reported that student discipline problems also influenced why a single teacher provided two different classes with different learning opportunities when using the same curriculum matierals in both classes.

Mathematical Knowledge

A teacher's knowledge often influences how he or she uses particular materials. The teacher's mathematical knowledge and ability to transfer knowledge from her or his preparation courses to the classroom may influence her or his use of instructional materials (Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992; Manoucherhri & Goodman, 2000). Those teachers with greater mathematical knowledge may be more able than other teachers to transfer their understanding from one context to another and to adapt materials to their own needs. Teachers whose knowledge allows them to see the "big mathematical picture" and to understand their students' learning trajectories may also be more willing to diverge from teachers' guides (Behm & Lloyd, 2009), build lessons on student discussions, and make more significant mathematical connections than teachers with less knowledge (Manoucherhri & Goodman, 2000).

Teachers' Beliefs

One of the most important factors contributing to a teacher's use of curriculum materials is the degree to which a particular curricular program fits the teacher's beliefs about mathematics, pedagogy, and student learning. Teachers who view mathematics as a web of interconnected ideas and who see mathematics as a human activity will seek to use and learn from materials that share that view (Remillard, 1999). Likewise, if teachers view their primary teaching role as that of a conveyer of facts and procedures, they may reject the pedagogical approach taken in standards-based materials. They may view students as consumers of knowledge, not creators who should engage in problem solving, conjecturing, and justification (Collopy, 2003). As Remillard (2000) showed, however, if teachers are willing to try innovative materials, even when the materials are inconsistent with their beliefs, they may learn from their experiences and change those beliefs.

Additionally, how teachers view textbooks contributes to their use of instructional materials. Teachers often view textbooks as authoritative, inflexible, or associated with traditional mathematics teaching (Remillard, 2005). Remillard and Bryans (2004) found that how teachers perceived the materials and their place as resources influenced how the teachers used standards-based materials more than how well the materials reflected the teachers' beliefs about mathematics. In discussing beliefs, mathematics educators must be careful not to ascribe specific beliefs to teachers just because they are assigned to use specific instructional materials. Chval, Chávez, Reys, and Tarr (2009) showed that teachers who were provided standards-based curriculum materials did not necessarily use standards-based instructional strategies. Similarly, teachers who were assigned to teach using skill-based textbooks sometimes exhibited pedagogy that was more aligned with the standards. The textbook was not as important as the teachers' pedagogical beliefs in determining how they taught.

Teachers' Philosophies of Education

A teacher's pedagogical beliefs, beliefs about teaching, beliefs about mathematics, or beliefs about students do not work in isolation from one another (Philipp, 2007). How teachers use instructional materials is influenced by their overall educational philosophies. Ernest (1991) outlined five educational ideologies, including the theory of educational resources held by each group (see Table 1 for a summary). If teachers' practices and ways of talking about their jobs as teachers reflect a specific ideology, that may provide additional insight into why specific materials were chosen or used as they were by the teacher.

Teachers who follow Ernest's (1991) industrial trainer ideology view mathematics as a set of truths that is learned through hard work and practice; ability is fixed and inherited. The teacher is the authority in the classroom and needs only "chalk and talk" instructional methods; learning is not based on irrelevant resource materials. Also espousing fixed ability, the teacher who is a technological pragmatist values mathematics as an unquestioned body of knowledge and the acquisition of skills needed for one's chosen occupation. Education is motivated by relevance, and the materials necessary to realize that relevance must be available to and used by the students.

Table 1
Summary of the Mathematical Elements of Ernest's Educational Ideologies

	Industrial trainer	Technological pragmatist	Old humanist	Progressive educator	Public educator
Theory of ability	Fixed	Inherited but needs training	Inherited; need tracking	Different "readiness" levels	Social construction
Mathematical aims	Acquisition of basic facts	Equip students for their future employment	Transmit pure mathematics	Overall development of child	Citizenship through critical thinking
Theory of learning	Learner engages in drill and practice	Learner acquires skills through practical experience	Learner receives and internalizes	Learner investigates, plays, discovers	Learner actively engages with mathematics
Theory of teaching mathematics	Teacher is authoritarian and disciplinarian	Teacher motivates through work relevance	Teacher lectures and explains	Teacher facilitates and manages environment	Teacher facilitates discussion, questioning, projects
Theory of resources	Teachers more important than resources	Resources necessary to prepare students for future employment	Textbooks and traditional tools alone	Ample resources for discovery	Authentic and socially relevant materials

Note. Ernest's (1991) five educational ideologies are described in depth in *The Philosophy of Mathematics Education*. Additional elements of the ideologies are included in his text; the table summarizes only the mathematical aspects of the ideologies.

Old humanists embrace the purity of mathematics for study by the elite. Although the mathematical aims are to transmit knowledge, that knowledge should include conceptual understanding of the mathematics and an appreciation for the structure and rigor of mathematics. Referring to supplemental instructional materials, Ernest (1991) stated that old humanists believe "the 'hands-on' exploration of resources by students is practical work, inappropriate to pure mathematics, and is thus reserved for low attainers, who are not studying 'real' mathematics, anyway" (p. 177). Progressive educators find meaning in experiences and seek to provide children with opportunities for investigation and discovery. This child-centered view of education values creativity, play, and self-confidence. The teacher should facilitate exploration and build the students' confidence in their mathematical abilities. Teaching mathematics, in a progressive educator's classroom,

> will involve the use of teacher or school constructed mathematics curriculum, offering a 'circus' of different mathematical activities. … The role of the teacher is seen to be that of a manager of the learning environment and learning resources, facilitator of learning, with non-intrusive guidance and shielding from conflict, threat and sources of negative feelings. (p. 192)

The teacher is instrumental in evaluating, selecting, and using instructional materials that offer students a variety of experiences for learning mathematics in a positive, supportive environment.

Finally, the public educator views mathematics and mathematical ability as social constructions. The aim of education is "the development of democratic citizenship through critical thinking in mathematics" (Ernest, 1991, p. 207). Students are encouraged to engage in the mathematical work of problem solving, questioning, and negotiating; teachers, likewise, should engage students in teacher-student and student-student discussions. Diversity should be embraced and utilized in mathematics education, including the use of socially relevant instructional resources and assessments that reflect the diverse history of mathematics.

Theoretical Framework

The present study was informed by Remillard's (2005) framework of the interactions within the teacher-curriculum relationship (see Figure 1, chapter 1, p. 6). The design, however, used two other operational frameworks. I used M. W. Brown's (2009) design capacity for enactment framework to focus on how teachers use instructional materials. In addition to using Brown's construct of materials appropriation, I examined teachers' decisions about materials implementation through a cognitive demand lens, using the mathematical tasks framework (Stein et al., 2000). This lens was particularly useful because of the call in the GPS for more rigor, student-centered activities, and attention to the process standards (Georgia Department of Education, 2005).

Design Capacity for Enactment Framework

In positioning the assumptions of her framework and the importance of the participatory relationship between teacher and curriculum, Remillard (2005, 2009) often referred to M. W. Brown's (2009) design capacity for enactment framework. Brown conceptualized teaching as "a process of design in which teachers use curriculum materials in unique ways as they craft instructional episodes" (p. 18). He proposed his framework as a nonevaluative tool for studying how teachers use materials and how designers can create materials that influence teaching practice. Central to this framework is the belief that how teachers engage with materials—selecting, interpreting, and reconciling personal goals with those in the materials; making contextual accommodations; and modifying materials—is influenced both by teacher characteristics and by the design of the materials. Also, this relationship is cyclical, with the curriculum influencing teachers and how they, through their unique lens, interpret and use the materials.

Types of materials use. To analyze how teachers use resources, M. W. Brown (2009) developed a scale for the ways and degrees of materials appropriation: *offloading, adapting,* and *improvising*. The scale focuses on the level of shared authority between the teacher and the instructional materials. Brown specifically stated that none of the three types of materials use is necessarily negative. Any decision to use curricular materials in a specific way must be viewed in terms of the teacher's goals and the value of the particular resources. Also, because of the dynamic nature of teaching, it is possible to engage in offloading, adapting, and improvising within a single class period. The value of Brown's framework as a tool is in characterizing "the nature of a teacher's interaction with a given resource, but it does not evaluate the outcomes of this interaction" (p. 25).

"Offloads are shifts of curriculum design responsibility to the materials" (Brown & Edelson, 2003, p. 6). This type of materials use is common when teachers are unfamiliar with the content or pedagogy called for in the materials or when they are unfamiliar with the materials themselves. Examples of offloading include logistical pedagogical decisions such as using ready-made materials with one group of students while others use learning stations in the classroom. Additionally, teachers may offload materials that they perceive as well written and aligned with their own beliefs, curriculum standards, and the needs of their students.

In the middle of the scale is the use of curriculum adaptation, a more equal sharing of the responsibility of curriculum design between the teacher and the materials. Adaptation occurs when teachers use certain elements of the materials but also contribute their own design elements. This type of materials appropriation is used to account for contextual factors such as student needs and classroom constraints as well as to better align instructional materials with learning goals. Teachers may also adapt materials to engage students in student-centered rather than teacher-centered instruction, or vice versa (M. W. Brown, 2009; Brown & Edelson, 2003).

At the opposite end of the continuum from offloading is improvisation. In this form of appropriation, the teacher is the primary designer of the learning activity. That is, he or she may take an idea from a published resource, but the resulting instruction and class activities, while supporting the overall goals of the resource, may represent a complete departure from the written materials themselves. Often resulting from an opportunity for learning that is beyond the written materials, an improvisation is often deliberate (M. W. Brown, 2009; Brown & Edelson, 2003) and can be either planned before instruction or occur during instruction, as part of the dynamic relationship between the planned and enacted curriculum. Improvised activities are analogous to Remillard's (1999) *invented* tasks.

Pedagogical design capacity. M. W. Brown (2009) claimed that the design capacity for enactment could be used in a nonevaluative manner to describe how teachers interact with instructional materials. He also claimed, however, that studying how teachers use materials might highlight an evaluative aspect of their work: pedagogical design capacity.

> Although the [design capacity for enactment] framework accounts for the resources contributed by the teacher and the curriculum materials—the nouns of the interaction, as it were—it does not fully account for the actions involved in their mobilization—the verbs of the interaction. … [The teacher] possesses a skill in perceiving the affordances of the materials and making decisions about how to use them to craft instructional episodes that achieve her goals. (p. 29)

Pedagogical design capacity takes into account not only how teachers evaluate materials but also how they balance mathematics and pedagogy and devise strategies to accomplish their specific instructional goals. It focuses on teachers' abilities to mobilize their knowledge and their ability to act and with their knowledge to design appropriate learning experiences.

Beliefs and experience contribute to a teachers' pedagogical design capacity (M. W. Brown, 2009). Because teachers' beliefs about students, mathematics, and teaching contribute to their selection of appropriate materials and teaching strategies, those beliefs and goals are important considerations in understanding how teachers evaluate, select, and use instructional materials. Additionally, because pedagogical design capacity may develop over time, greater familiarity with specific materials and the instructional strategies employed in those materials may also result in an improved ability to use those materials to meet one's instructional goals.

Mathematical Tasks Framework

"What students learn is fundamentally connected with *HOW* they learn it. Students' opportunities to learn mathematics are a function of the setting and the kinds of task and discourse in which they participate" (NCTM, 1991, p. 21). To learn mathematics at a conceptual level, students should engage in authentic problem-solving-based mathematical work. This engagement can be accomplished through the use of worthwhile tasks. *Worthwhile mathematical tasks* are defined as those that promote student understanding of mathematical concepts and procedures, encourage problem solving and reasoning, may have multiple pathways to solution, and may have multiple solutions (NCTM, 1991, 2000). That is, worthwhile mathematical tasks require students to engage the process standards of communication, connections, reasoning and proof, representations, and problem solving.

Task selection. One lens for examining teachers' selection and use of instructional materials is the mathematical tasks framework (Stein et al., 2000). Stein et al., in the development of their framework, focused on the cognitive demand level of mathematical tasks posed in middle school classrooms. "By cognitive demand, we mean the kind and level of thinking required of students in order to successfully engage with and solve the task" (p. 11).

This framework classifies mathematical tasks into four categories—memorization, procedures without connections, procedures with connections, and doing mathematics tasks—depending on the level to which students are required to engage in and think about the task, from simple recall of facts to analyzing a situation, exploring possible solution paths, and using self-monitoring behavior. Stein et al. refer to *memorization* and *procedures without connections* tasks as having lower-level cognitive demand and *procedures with connections* and *doing mathematics* tasks as having higher-level cognitive demand. Higher-level tasks require students to attend to the mathematical concepts underlying the problem. Students should make connections among mathematical ideas, use appropriate representations, and engage in strategic reasoning.

Task implementation. The cognitive demand of a task can change at different stages in the teaching process; therefore, the mathematical tasks framework "provides a fluid representation of how tasks unfold during classroom instruction" (Stein et al., 2000, p. 4). This unfolding includes examining tasks—as they appear in the instructional materials, as set up by the teachers, and as implemented by the students—and ending with student learning. The NCTM (2000) agrees with this stance:

> Worthwhile tasks alone are not sufficient for effective teaching. Teachers must also decide what aspects of a task to highlight, how to organize and orchestrate the work of the students, what questions to ask to challenge those with varied levels of expertise, and how to support students without taking over the process of thinking for them and thus eliminating the challenge. (p. 19)

Just as teachers who exhibit high levels of pedagogical design capacity (M. W. Brown, 2009) choose materials and strategies that serve their instructional goals, implementing worthwhile tasks requires a teacher to keep her or his student learning goals in view and to support those goals through instructional interactions and class norms.

Stein et al. (2000) provided evidence that teachers can identify and choose to use high-level tasks in their classrooms; however, in only one third of the high-level tasks was the demand level maintained throughout implementation. Cognitively demanding tasks are also, according to Stein, Grover, and Henningsen (1996), challenging for teachers to implement. Conceptually demanding mathematics may pose a challenge for those teachers who learned mathematics procedurally. These tasks are also more open-ended than lower-level tasks, requiring additional skill by the teacher to orchestrate the class activities—understanding student thinking, managing time, and managing behavior. Accordingly, Stein et al. (2000) identified a number of sources for the decline in task level that arose from class norms that were part of the established learning environment: Students were not held accountable for their work on high-level tasks, classroom management issues overshadowed the task and made maintaining the demand difficult, and students were not required to justify their conjectures and solutions. Other sources for the decline in task level were connected with poor lesson and task planning: inappropriate time provided for engaging with the task, inappropriate tasks because of insufficient prior knowledge or interest by students, and unclear expectations for what the students were to do with the tasks. In a productive learning environment with well-planned and appropriate tasks, cognitive demand can still decline if the teacher reduces a challenging problem to a routine one, shifts the emphasis to skills or procedures, or takes over the explanations.

The factors cited by Stein et al. (2000) for the decline in cognitive demand level are consistent with other research findings concerning intent versus implementation. Schmidt, McKnight, and Raizen (1997), in their analysis of data from the Trends in International Mathematics and Science Study, found that U.S. mathematics and science teachers actually practiced few of the complex teaching strategies they claimed to be aware of and believe in. In general, teachers may choose not to use high-level mathematics tasks because they do not think their textbooks or other instructional resources supply good examples of such tasks. This idea could be supported by the lack of extended attention to important topics in U.S. textbooks, as reported by Schmidt et al. U.S. teachers also complained of having too many topics to teach, thereby having insufficient time to engage students in mathematically meaningful activities. Schmidt et al. stated that teacher beliefs indicated that instruction might be organized differently and more effectively if teachers were less concerned with covering lots of topics.

Relevance to the Present Study

In the present study, I sought to understand how teachers evaluate, select, and implement instructional materials while teaching a curriculum for the first time. The design capacity for enactment framework (M. Brown, 2009; Brown & Edelson, 2003) focuses on the participatory relationship between the teacher and the resources she or he uses. This framework is primarily concerned with the design that happens before instruction, that is, the planned instruction. However, the framework does allow for the influence of the enacted curriculum affecting future curriculum planning. This framework provided me with a terminology for describing the teachers' planning decisions as well as how the teachers chose to use their available materials—through offloading, adapting, or improvising. It also facilitated my ability to search for patterns in the teachers' evaluation, selection, and use of specific instructional materials and to respond to Cooney's (2009) call for additional research that aims "to develop understandings of the knowledge and skills that teachers, at different points on the professional continuum, draw upon and develop as they use mathematics curriculum materials" (p. 272).

I applied the mathematical tasks framework (Stein et al., 2000) in two ways in this study: to the selection and evaluation of materials and to the implementation of tasks based on the instructional materials. Because this framework is first concerned with task selection, the classification criteria of the framework were used to help me understand the reasons for teachers' evaluation and selection of specific materials and tasks, thus contributing to understanding the relationship between teacher characteristics and characteristics of the instructional materials. The second consideration of the framework concerns implementation of tasks based on instructional materials. In the present study, I was less interested in how the enacted instruction reflected the planned instruction than in the reasons for the integrity or lack of integrity with respect to the materials or plans. For example, if the teachers evidenced a decline in cognitive demand in their implementation of tasks, were the factors similar to those found by Stein et al. (2000) for the decline of cognitive demand? If the teachers selected materials for a task because specific aspects of the task made it highly demanding, did their implementation support those aspects, or did other factors override the teachers' original purposes in using the task? Were the factors more related to teacher characteristics or to characteristics of the materials employed with the students? Because of the inherent place of the process standards in highly demanding tasks, how did the teachers attend to those process standards as they implemented their tasks? Did their attention to the process standards reduce, maintain, or raise the cognitive demand of the task as written? The lens of the mathematical tasks framework helped me explore these questions in my analysis.

CHAPTER 3

METHODOLOGY

The design of the study, participants, data collection methods, and data analysis techniques are discussed in this chapter. Data collection took place during the summer and fall of 2009. The summer data collection included surveying 21 high school teachers who were working together writing lessons for teaching the Georgia Performance Standards (GPS) courses. The fall data collection consisted of surveying, interviewing, and observing three teachers in the same high school implementing the first year of a GPS course.

Design of the Study

This was a qualitative case study of how the teachers in a high school mathematics department met the challenge of implementing a course from a new state curriculum for the first time. Although the study included a survey yielding quantitative data, those data were not intended for statistical analysis but as a way to help the participants reveal their thinking about aspects of their experiences, teaching, and beliefs. I used the survey data to support and contribute to inferences made through a close examination of the three teachers, providing "elaboration, enhancement, illustrations, clarification of the results" (Greene, Caracelli, & Graham, 1989, p. 259). These measures were also included to allow comparison of the focus participants with a larger set of teachers.

Data were collected to answer the following research questions:

1. In implementing a new course, how do high school mathematics teachers evaluate and select instructional materials in their planning?

2. In implementing a new course, how and to what degree do high school mathematics teachers use the materials during instruction?

3. How do high school teachers' decisions and appropriations of materials differ when teaching different mathematical topics in implementing a new course?

Participants

The search for a research site began in December of 2008. I contacted five Georgia high schools within a 60-mile radius of the university about participating in a study of the implementation of the first year of a GPS course. If the study were to be conducted in the spring of 2009, I would study the implementation of Math 1; if it were to be conducted in the fall of 2009, I would focus on Math 2. After meeting with teachers and submitting research proposals to boards of education, I found only one site that agreed to participate. Reasons the other schools or districts gave for not wanting to participate included the pressure the teachers felt from their administration to implement the new curriculum, a concern over upcoming teacher turnover, the discomfort expressed by less-experienced teachers about participating in research on their teaching, and one district's assertion that their district offered "a less distinctive venue for studying the interactions of curriculum change and instructional choices than would be available in many other Georgia school systems." By the time a site was chosen, it was too late in the school year to study implementation of Math 1; therefore, I studied the implementation of Math 2 during the fall of 2009.[1]

Park Valley City School District[2] contained one high school, Park Valley High School of approximately 1200 students, one middle school, and five elementary schools. It also contained

[1] The Mathematics 2 standards taught at the time of the study were from the July 2006 version of the GPS for mathematics.
[2] The names of the district, school, county, and teachers are pseudonyms.

an alternative high school and had plans to open a nontraditional high school in the near future. Park Valley High had a lower percentage of White and African American students than was average for the state of Georgia, but its Hispanic population was more than four times the state average. The percentage of students who were labeled “limited English proficient” was almost three times the state average, and more than half the students were eligible for free or reduced lunch. Despite these statistics, which some might use as excuses for low achievement, Park Valley High School consistently made Adequately Yearly Progress in accordance with the No Child Left Behind Act of 2001 (NCLB, 2002). The school also posted a higher percentage of students passing the mathematics graduation test than the overall state percentage, particularly the White and Hispanic students.

Park Valley High School operated on a 4 × 4 block schedule. On a 4 × 4 block schedule, students have the opportunity to earn 8 credits in a school year, 4 in the fall and 4 in the spring; typically, students took mathematics one semester each year. Park Valley High School provided its students with a variety of support systems to help them be successful in the new curriculum (see Table 2). For Math 1, students could enroll in Math 1 Part 1 and Math 1 Part 2 during fall and spring, respectively. To receive additional support in Math 2, students could enroll in Math 2 and Math 2 Support concurrently. The extended Math 1 course and Math 2 Support course were intended to provide students with additional time to master the ideas and skills in Math 1 and Math 2, providing a stronger foundation for future mathematics courses.

Park Valley is the county seat of Shaw County, which has its own school district. Park Valley has approximately 30,000 residents, making up one-sixth of the county’s population. Shaw County is home to a number of food-processing plants, with these plants comprising the majority of the major industries in the area. The other major employers are school districts, governments, and health industries. Three institutions of higher education are located in the county, but only 20% of the population holds at least a bachelor's degree.

Table 2
Park Valley High School GPS Mathematics Courses

Grade	Accelerated	Typical	Extra support
9th grade	Accelerated Mathematics 1	Mathematics 1 (one-semester course)	Mathematics 1 Part 1 & Mathematics 1 Part 2 (enrolled in mathematics all year)
10th grade	Accelerated Mathematics 2	Mathematics 2 (one semester course)	Mathematics 2 & Mathematics 2 Support (enrolled in both courses during the same semester)

All three participants from Park Valley High School lived in Shaw County. They brought a variety of experience to their teaching. Each teacher was assigned to teach at least one section of Math 2 in the fall of 2009, and they were the only teachers at the school teaching Math 2 that semester. All three had also taught either Math 1 Part 1 or all of Math 1 the previous year.

Helen Bradley. Although Helen Bradley had obtained her initial undergraduate preparation in mathematics education approximately 30 years before, she was just beginning her eighth year teaching. She taught for 3 years after receiving her initial certification and then earned a master's degree in industrial engineering, with a focus on computer science. She used that degree in her approximately 20 years working for International Business Machines Corporation (IBM) and American Telephone & Telegraph (AT&T). Helen returned to teaching and was in her fifth year at Park Valley High School during the study.

During the 2008–2009 school year, Helen had taught one section of Math 1 Part 1. She then taught two sections of Math 2 and one section of Math 2 Support during the fall of 2009. Students who had struggled in Math 1, had successfully completed both semesters of the yearlong Math 1 sequence, or were recommended for additional help enrolled in the Support class. All students who needed extra assistance took Math 2 Support during the fourth block with Helen. These students spent approximately 180 minutes a day in a mathematics course, 90 minutes in their Math 2 course during first or second block and 90 minutes in Math 2 Support.

Kasey Turner. Kasey Turner was beginning her second year of teaching, both in her career and at Park Valley High School. In her first year, she had taught the typical semester-long Math 1 course as well as one part of the yearlong Math 1 sequence. During fall 2009, Kasey taught two sections of Math 2 and one section of Math 1 Part 2.

Kasey had done her student teaching at Park Valley under the direction of another participant, Eva Sailors, and earned a bachelors of science degree in mathematics education from the University of Georgia (UGA). I served as a teaching assistant for the senior methods course that Kasey took the semester before she student taught. Although I did not observe her teach during that time, I had ample opportunities to assess her thinking about teaching. Initially, she expressed some hesitation with having her teaching studied; however, after we discussed the research project, she readily agreed to participate. Although she did express some discomfort, at times, during the observations, she was very candid and open in our interviews. She often asked for my thoughts on her teaching and how she could improve as a teacher.

Eva Sailors. In addition to being a mathematics teacher, Eva Sailors was the chair of the mathematics department at Park Valley High. She had a total of 20 years teaching experience, with some of that experience as a university professor and as an instructional coach for the Park Valley City School District. In the fall of 2009, Eva was in her third year back as a full-time teacher at Park Valley. Like Kasey and Helen, Eva's initial teacher preparation had occurred during her undergraduate program. She went on to complete a Ph.D. at UGA. Because of her affiliation with the university, Eva and I had socialized on a number of occasions over the previous 15 years. Eva also participated in a research conference in which I was a research assistant. It seemed that our similar backgrounds and interests made our interviews and our interactions very comfortable.

As an instructional coach for the school district, Eva helped oversee and support the teachers in the rollout of the middle school GPS courses. She was then hired as department chair at the high school to oversee the rollout of Math 1 to Math 4. Eva taught Math 1, both the typical course and Part 1 of the yearlong sequence, in 2008–2009. During the fall of 2009, she taught only one section of Math 2 and two sections of Precalculus. She was planning to teach Accelerated Math 2 the following semester.

Eva hosted an intern teacher, Matt Wood, during the 2009–2010 school year. Matt spent part of each day at Park Valley but also attended classes at his university some afternoons. His internship program was a year long. He worked primarily with Eva's Math 2 class and also with a Math 1 Part 1 class with another teacher in the afternoon. Although Matt was often present during observations and sometimes did the instruction, most of the decisions about instructional materials were Eva's. Also, because his attendance in the Math 2 class was sporadic, I chose not to include Matt as a participant.

Regional teachers. One criticism of qualitative research is its narrow focus and lack of generalizability. Because this study addressed factors that influence how teachers select instructional materials for implementing the same curriculum standards, it is useful to estimate how well the three teachers at Park Valley High School represented other Georgia teachers. I asked a separate group of teachers (n = 21) to complete the beliefs and implementation survey (see the section on instruments below) completed by the Park Valley teachers. This group was chosen because they were (1) in the same geographic part of the state as Park Valley, (2) already convened through a regional professional development agency, and (3) working together to write tasks and assessments to improve the implementation of Math 1 and Math 2.

Instructional Materials

The Park Valley teachers used a variety of instructional materials to teach Math 2. Their primary textbook was the second edition of *Georgia Mathematics 2 Student Text* (Carnegie Learning Development Team, 2009b). They also used the supplemental book, *Georgia Mathematics 2 Assignments and Skills Practice* (Carnegie Learning Development Team, 2009a). Additionally, they referenced and used activities from the state produced instructional units, called *frameworks* (Georgia Department of Education [GADoE], 2008a, 2008b, 2009). Other materials included traditional, strand-based textbooks previously used by the teachers, worksheet creation software, a Math 2 textbook from McDougal Littell (*Georgia High School Mathematics 2*, 2008), and classroom activity books.

State frameworks. As a way to support teachers' implementation of the high school GPS, given the scarcity of textbooks that adequately addressed the content and process aspects of the new standards, the state produced units of instructional materials to help guide instruction. Each unit consisted of an overview, the key standards addressed, vocabulary and formulas, lessons or activities for students, solutions to the activities, and commentary for the teachers. Teachers, graduate students, and university professors from around the state were employed to write the units. Unlike the NSF-funded reform texts, these units did not undergo a piloting and revision process (Hirsch, 2007); however, they often were revised by mathematics specialists in the state department of education.

Textbooks. Few publishers presented books to the state of Georgia for adoption. A representative of a well-respected publisher informed me that they were not sure how to approach the GPS or what the state would approve; therefore, they chose not to develop or revise texts for Georgia. Another publisher chose to rearrange its strand-based texts to address the mathematical content in each of Math 1 to 4 and presented those books for adoption. Kasey and Eva used this Math 2 textbook, *Georgia High School Mathematics 2* (2008), which is henceforth referred to as the McDougal Littell textbook, as a supplement to their other materials. The McDougal Littell book is a more traditionally designed text than the primary (Carnegie) book. I refer to the McDougal Littell textbook as traditionally designed because each section lists a particular standard, provides any needed theorems or formulas, illustrates how to do a small number of examples, and then provides opportunities for students to complete similar exercises of varying difficulty levels.

Carnegie Learning, however, chose to write a set of textbooks that could be updated from year to year. Each student received a paperback student textbook and a paperback assignment-and-skills-practice book with removable pages. Lessons and assignment pages provided students space to write their answers and comments directly in the books. The publishers sought feedback from teachers, parents, and students and revised the book each summer to reflect the feedback. Kasey stated that she did not like the Carnegie Math 1 book that she had used during 2008–2009; however, after the revisions, she thought the 2009–2010 version was much better. Carnegie Learning employed Georgia teachers and mathematics specialists who helped with the development of the GPS and with some of the frameworks units to help write the texts and deliver the publisher's professional development workshops.

The general approach taken in the tasks in the Carnegie textbook was consistent with the mathematical tasks framework's *procedures with connections* (Stein, Smith, Henningsen, & Silver, 2000). Although some problem sets consisted of review exercises, others led students through investigations that would lead to a mathematical conclusion. For example, students might be asked to graph a series of quadratic functions and then make conjectures about how different parameters affected the graph. They were asked to explain relationships as well as the reasoning behind their conjectures. There was a constant push to attend to the process standards of communication, representations, connections, and reasoning and proof that are included in the GPS. Formulas were typically not provided in the text but rather were developed by the students through a set of exercises. For example, the formula for the *x*-coordinate of the vertex of a parabola was to be derived by the students at the end of Section 1.5; there was no "boxed off" area that gave the formula, as is common in many textbooks.

Data Collection

I used a survey, observation cycles, and interviews to answer the research questions. I used a version of the survey and the interview protocol in a pilot study, later revising both. This section describes the instruments, the modifications I made based on the pilot work, and how I implemented the study.

Instruments

Survey. The Mathematics Georgia Performance Standards Knowledge Survey (Appendix A) comprises both Likert-type and open-response items. Part 1 asks teachers for information about their education and experience. A later section of Part I asks about their backgrounds as mathematics learners. This section was an adaptation of the last section of the Integrating Mathematics and Pedagogy Beliefs Survey for elementary teachers (Integrating Mathematics and

Pedagogy, 2003). Part 2 addresses teachers' general beliefs about mathematics education and their agreement with NCTM (2000) standards-based statements about instructional activities and mathematical tasks. Seven of these questions were adapted from a survey designed and validated to measure elementary teachers' implementation of standards-based mathematics teaching (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003). These questions primarily address Ross et al.'s (2003) reform dimensions having to do with student tasks and implementation of tasks. I wrote the remaining three questions to capture the participants' views of the process standards, the teacher's role in relation to developing tasks, and their text use. Part 3 asks teachers to explain their understanding of the GPS, the challenges and benefits of this new curriculum, and the resources available to them to support GPS instruction.

Observation protocol. I used an observation protocol (Appendix B) to organize the teachers' materials use and curriculum implementation. I adapted this tool from the University of Missouri's Middle School Mathematics Study; they had revised the protocol from the University of Wisconsin's Longitudinal Study of Mathematics Project (Chávez-López, 2003). The first part of the tool provides background on the day's lesson, the materials being used, and the standards addressed. Next is a sketch of the lesson, including the activities of the lesson and how much time is spent on each activity. The remainder of the protocol consists of questions about the teacher's instructional focus and use of instructional materials. These questions include categorizing the cognitive demand of the lesson tasks (Stein et al., 2000) and the teachers' attention to the process standards.

Field notes. In addition to completing the observation protocol to summarize each observed lesson, I took detailed field notes during all classes. These notes consisted of a running account of each class, including work written on the board or overhead projector. I specifically noted when teachers made comments—before, in, or after class—about their materials selection or evaluation, their understanding of the materials they were using, or their thoughts about using specific materials in the future. Additionally, when the teachers discussed their thoughts and decisions about planning with each other and with me before school, between classes, or during lunch, I recorded those notes in that day's field notes.

Interview protocols. The teachers completed three individual interviews, one at the conclusion of each instructional unit. Each interview followed up on survey questions, planning and implementation of the specific unit, and comments from prior interviews (Appendix C). The first interview included questions asking each teacher to elaborate on her mathematical abilities in high school and at present, questions about the mathematics in the quadratics unit, and questions about the teachers' planning. The next interview focused on instructional decisions in the right triangle trigonometry unit and on survey follow-up questions about pedagogy. In the final interview, I asked the teachers additional questions about the GPS, how their instructional materials supported the GPS, and their views of proof and reasoning in GPS courses.

Pilot Study

During the fall of 2008, I conducted a pilot study to examine three novice teachers' decision-making and the influences on their choices of mathematics tasks during student teaching. These teachers had completed their student teaching the prior spring but were not teaching at the time of the study; they were either completing a master's degree in mathematics education or completing requirements for a bachelor's of science degree in mathematics at UGA. They were chosen because of their willingness to participate in the study and their differing teacher preparation experiences. One participant had completed a bachelor's of science degree in mathematics at a different university in Georgia and learned about the GPS in his master's teacher preparation program. Another completed her undergraduate teacher preparation in a mid-western state but planned to teach in Georgia; she also learned about the GPS in graduate school. The last participant grew up in Georgia and attended UGA for her undergraduate preparation. Because I did not know who my final study participants would be, I felt it important to involve a variety of teacher preparation backgrounds in my pilot study. I had attended UGA for my teacher preparation and was involved in teacher preparation at UGA; therefore, I had a specialized knowledge of UGA's teacher preparation program. Using pilot study participants with varied backgrounds helped me ensure that my instruments were understandable and adaptable for use with participants from different preparation programs.

An earlier version of the Mathematics Georgia Performance Standards Knowledge Survey was administered to the three novice teachers, and they each participated in an hour-long semi-structured interview focused on their beliefs about mathematics, teaching, and specific lessons taught during student teaching. These interviews also asked about the mathematical tasks framework (Stein et al., 2000) and the process standards. Work on the pilot study led to changes to the survey, including changing questions to make them less biased. For example, one of my participants stated that she felt she had to agree with some of the statements; otherwise, she would feel that she was completely rejecting the NCTM standards, which she did not. I searched for existing surveys about standards-based teaching that could be adapted for the main study and that might provide questions to replace the biased questions. During this search, I located Ross et al.'s (2003) survey of elementary school teachers' standards-based teaching, which informed the revisions of the Mathematics Georgia Performance Standards Knowledge Survey. The participants' comments about the influences on their materials decisions during student teaching made me realize that school-wide collaboration might influence teachers' decisions, something I needed to be aware of in the main study. That was one reason I chose to work in a single school for the main study: If the teaching context was basically the same, I might be able to distinguish contextual factors from personal factors that influenced teachers' materials selection, evaluation, and implementation.

Survey of Regional Teachers

During the spring of 2009, I contacted the regional professional development agency about finding additional participants for the study. The mathematics specialist at the agency sent me the list of workshop offerings focused on implementation of the GPS: one on initial GPS training, two on specific content, and one that would allow teachers to work together developing lesson plans and assessments for the first 2 years of high school GPS. I chose teachers in this last workshop to complete the Mathematics Georgia Performance Standards Knowledge Survey because their prior GPS experiences and interests were likely to be the most similar to those of the three teachers at Park Valley High School. All of the teachers working on lesson plans and assignments should have previously completed the initial GPS training, as the Park Valley teachers had, and all were planning lessons for Math 1, Accelerated Math 1, Math 2, or Accelerated Math 2: the courses the Park Valley teachers were teaching or had taught. Although Eva indicated, during our conversations in May of 2009, that the Park Valley High School teachers would likely attend the workshop, none of them actually participated in this professional development activity.

On the first day of the workshop, the mathematics specialist discussed the GPS, including the reasons for the change in Georgia's curriculum, and how to interpret standards and develop a content map. During the remainder of the week, groups of three or four teachers worked on lesson plans and assessment questions for specific units. I met with each group on the third day of the workshop to explain my research, distribute an information letter, and ask for participation in the survey. I answered their questions and sent electronic copies of the survey to those who requested them. I returned the next morning to collect the surveys that had been completed. Only one teacher submitted her survey response via email. A total of 21 surveys were submitted from the group of 30 teachers.

Observations Cycles at Park Valley High School

In mid-August 2009, I began visiting the Math 2 classes of Kasey, Helen, and Eva. I was introduced to each class and provided the students with information letters to take to their parents to explain the research I was conducting. Additionally, I asked for and received verbal assent to participate from the students in all five classes. I met informally with Kasey, Helen, Eva, and Matt to explain my research and obtain written consent. Each teacher was given a copy of the Mathematics Georgia Performance Standards Knowledge Survey to complete at her or his convenience; I also emailed the survey to the teachers, if requested. Helen, Kasey, and Eva submitted their completed surveys, either in hard copy or via email, before the first set of individual interviews; Matt did not submit his survey. In addition to situating the teaching context, the survey served as a source of additional interview questions and for triangulation of data.

The first three instructional units for Math 2, as determined by the state curriculum map, were the focus of the three observation cycles. Quadratic functions were covered in Unit 1; Unit 2 addressed right triangle trigonometry; and Unit 3 focused on circles and spheres. The observation cycles included primarily informal conversations about the participants' planning decisions, observations of at least 4 days of the unit, and a postobservation interview. Although the participants did not participate in formal preobservation interviews, the observation cycle mimicked the teaching cycle of planning a lesson, enacting a lesson, and reflecting on the lesson (Smith, 2001). I completed the observations and interviews over a 2-month period.

Because the teachers made many of their instructional decisions in collaborative planning meetings, I had planned to observe their planning meetings. However, I attended only one formal planning meeting with the teachers because of the nature of their work: Planning meetings were often impromptu or irregularly scheduled. Most days I was in the school only until lunchtime, so I was not able to attend impromptu meetings that occurred during Helen and Kasey's planning time or after school. I provided the participants with a digital recorder and asked them to record their formal planning meetings; however, such recording did not occur.

On one occasion, just before the first classroom observations, I was able to observe, videorecord, and audiorecord an after-school planning meeting. Other planning occurred informally either during lunch, during Kasey and Helen's shared planning time, or in informal meetings before or after school. I engaged in many informal conversations with the teachers before school, between classes, and during lunch. These conversations provided valuable information about the teachers' instructional materials and decisions about strategies; such information was recorded in the field notes for that day.

During the established observations, I observed the teachers' classes, audiorecorded them, and made field notes. Following each observation, I completed the observation protocol. Each instructional unit was allotted a different number of weeks, so rather than observe every day of instruction, I tried to observe at least 4 days of instruction of each unit by each teacher. For Eva, this goal meant observing her first period Math 2 class four times. For Helen and Kasey, I attempted to observe a selection of each of their first and second block classes. My initial plan was to observe at least 2 consecutive days of each teacher's instruction. I also attempted to observe lessons on similar content in the teachers' classes. Even though the teachers planned together and hoped to stay together, in an effort to help the Math 2 Support students remain on the same topic, one teacher would get ahead or behind the others. Sometimes this variation in pacing resulted in shifts in my planned observation schedule. Also, because Unit 2 was very short, I observed only 3 days of Unit 2 instruction by Kasey and Helen. For Unit 3, I made additional observations because Eva was absent for several days and because I wanted to obtain additional observations of her teaching. I also chose to observe Helen's class an additional time during Unit 3; one of my initial observation days coincided with behavior problems in her classroom, so I decided to observe an additional day to get a better picture of Helen's implementation of the circles unit.

After completing the scheduled observations for the first unit, reviewing the data on the observation protocol for each teacher, and reviewing the teachers' responses to Part 1 of the survey about their own mathematical experiences, I scheduled an individual interview time of approximately 45 minutes with each teacher. For the first unit, I interviewed Helen and Eva during their respective planning periods. Because Kasey and Helen shared a planning time but also had to conduct lunch duty, I interviewed Kasey during her lunch duty. At the conclusion of the observations for Units 2 and 3, I repeated this process, but reviewed the survey responses for Part 2 with Interview 2 and for Part 3 with Interview 3. Because Eva was often pulled away for administrative duties during her planning period and Kasey and I decided not to conduct any additional interviews during lunch duty, the interviews after Units 2 and 3 were conducted on different days. All interviews were audiorecorded.

Data Analysis

Throughout the data collection and analysis, I characterized patterns in the teachers' materials use and searched for confirming and disconfirming evidence, sometimes altering my characterizations. I examined the transcripts of the interviews and planning meeting on factoring for emerging themes for instructional decisions, including reasons the teachers gave for using specific instructional materials or tasks and how the materials were appropriated.

Classroom Observations

I combined data from the observation protocol for each teacher's implementation of each unit into a single spreadsheet to help me search for patterns (see Figures 2 and 3 for examples). I then coded these data using the categorizations on the observation protocol: the cognitive demand categories of the mathematical tasks framework (Stein et al., 2000), the process standards, and the use of specific instructional materials. I then recoded the use of instructional materials according to the appropriation taxonomy of the design capacity for enactment framework: offloading, adapting, and improvising materials (M. W. Brown, 2009; Brown & Edelson, 2003).

KT (Unit 3)	**Day 1**	**Day 3**	**Day 6**	**Day 7**
	Circle vocabulary MM2G3ab	**Understand properties of circles - chords MM2G3a**	**Angles formed by segments in circles MM2G3ab**	**Arc length MM2G3c**
Memorization	Learning definitions		Learning theorems for finding angles and arcs	
Procedures without connections			Practicing procedures - generally algorithmic; some required algebra and the finding of additional information	
Procedures with connections		Pathways to the conjectures were provided, but students had to make the cognitive "leap"		Students developed finding the arc length from circumference and fractions of a circle
Doing mathematics				

Figure 2. Organizing classroom data according to the mathematical tasks framework.

KT (Unit 3)	Day 1	Day 3	Day 6	Day 7
	Circle vocabulary MM2G3ab	**Understand prop of circles - chords MM2G3a**	**Angles formed by segments in circles MM2G3ab**	**Arc length MM2G3c**
Problem solving				Built new knowledge through PS (as designed by the book)
Connections		Through the Patty Paper Investigations, students made connections between different parts of a circle.	Recognized and used connections among mathematical ideas - sometimes had to find missing info	Connected to torque (as the book does); connected arc measure and arc length; connected arc length to circumference
Reasoning and proof		Through the Patty Paper Investigations, students made conjectures about circles		
Representations	Pictures drawn to represent each term	Used representations to model situations about circles	Used representations to model the theorem under discussion	
Communication	Used proper mathematical language to express ideas; students answer "why" questions	Used language of math to express ideas precisely; evaluated mathematical thinking of others in the group		Text asked the students to write sentences. Students discussed in their groups

Figure 3. Organizing classroom data according to the process standards.

Interviews and Planning Meeting

In addition to trying to understand how the teachers made their instructional materials decisions, I also searched for why they made specific decisions and how those decisions differed from those of the other teachers. My work as a high school teacher, department chair, researcher, and graduate student had convinced me that many teachers' decisions are based on their views of education, mathematics, curriculum, and students. The teachers' own mathematical knowledge and comfort in the classroom also contribute to instructional decisions. This view is reflected in Remillard's (2005) teacher-curriculum relationship framework (see Figure 1 in chapter 1, p. 6), which argues that teacher characteristics and curriculum material characteristics are engaged in a participatory relationship. The pilot study also validated my belief that teachers' views of the students, teaching, and mathematics influenced their decisions. Therefore, I examined the data for emerging themes that characterized and differentiated how the participants viewed their job as a mathematics teacher, their understanding of the GPS, and their beliefs about mathematics. I also analyzed the data for consistencies and irregularities in the teachers' survey responses, interview questions, and classroom observations. As I transcribed the interviews, I noted trends and statements that would inform the research questions; for example, I took a teacher's use of mathematical activities that stressed the value of multiple representations as evidence for how her beliefs regarding the process standards were revealed in her practice.

Before beginning a formal analysis, I created a list of codes for beliefs about what is important in teaching and student learning, understanding of the GPS, and rationale for using or not using mathematically rich tasks in the classroom. This list was developed from themes that emerged in the pilot study and themes from the literature about the purposes of mathematics tasks (Edenfield, 2010). I then read each transcript and highlighted excerpts that might inform the research questions. I assigned codes, based on the early coding scheme, to these highlighted excerpts. As I read the transcripts and reviewed the surveys and observation tools, I refined the codes. For example, the original first coding category addressed what the teachers saw as important in teaching mathematics, and the second addressed the purposes of learning mathematics. As I coded the data, I had difficulty distinguishing between the two based on the teachers' comments; therefore, I altered the first category to capture general ideas about teaching and the second to focus on the mathematical aspects of teaching and learning. Table 3 provides the final coding scheme.

Table 3
Final Coding Scheme for Data Analysis

1. What is important in teaching?	**2. What do the teachers want their students to learn about mathematics?**	**3. Rationale for using or not using of specific materials**	**4. Understanding of the GPS for mathematics**
a. Good relationships with students b. Keeping students engaged and on task c. Using student-centered pedagogy d. Prepare for tests and later courses e. Prepare for life	a. Skills and procedures b. Conceptual understanding, including applications c. Higher order thinking skills d. Appreciation of mathematics	a. Student motivation and behavior b. Student knowledge c. Materials d. Collaboration e. Other contextual factors f. Testing g. Planning time h. Instructional time i. GPS j. Teaching experience	a. Content standards b. Process standards c. Integrated curriculum d. Goals and rationale for the change e. Materials produced for GPS

After my initial analysis, I wrote narratives describing the teachers' planning and implementation of the three Math 2 units. The planning narratives described the group decisions made in formal and informal planning meetings with respect to the materials appropriations decisions and rationales for those decisions. I included any additional information the teachers provided about their planning during our interviews. These narratives provided me with an overview of the teachers' planning concerns and enabled me to identify patterns in their materials selection and evaluation. The implementation narratives formed the basis for chapter 5; these enabled me to identify trends in the teachers' implementation of the chosen instructional materials, specifically their attention to the process standards and the cognitive demand of the tasks. The two sets of narratives also facilitated my comparison of the teachers' planning and implementation over time and across different mathematical topics, the third research question.

I used the survey of the 21 regional teachers as a means of comparing the three Park Valley teachers' views of the GPS and its challenges with those of similar teachers. I compared the survey responses of the two groups, searching for similarities and differences and possible reasons for those responses. For example, the Park Valley High teachers discussed a variety of positive and negative attributes of the GPS. I used the survey of the larger group of teachers to support or contradict the views of the Park Valley teachers.

As a researcher, I realize that my beliefs about standards-based teaching and my involvement with the development of the mathematics GPS influenced the design of the study, particularly the data collection instruments. Reflecting on my early teaching experiences, I realized that I had concluded that all students can learn much more meaningful mathematics if they are engaged in solving quality mathematics problems that require them to think critically about the mathematics, to make connections, to use representations, and to communicate with others about mathematics. I was also involved in public feedback on early versions of the GPS and have written units for the Georgia Department of Education, stressing not only the integrated nature of the curriculum but also teaching by using the process standards. However, I realize that few teachers have had the experiences I have had and that few of them are likely to feel as strongly as I do about the NCTM (2000) *Principles and Standards for School Mathematics*. This realization presented a challenge and required me to be careful not to judge a teacher or overgeneralize from a single statement or occurrence. My biases forced me to search for multiple sources of evidence for my conclusions about the teachers' decisions.

The findings are presented in three chapters. Chapter 4 describes the three Park Valley High School teachers' planning, specifically their evaluation and selection of materials (Research Question 1) and how those decisions differed across the three units (Research Question 3). Chapter 5 classifies the teachers' implementation of those materials (Research Question 2) and, again, how these decisions compared across the three units (Research Question 3). Finally, chapter 6 provides a summary of the teachers' planning and implementation decisions and teacher factors that might contribute to those decisions.

CHAPTER 4

PLANNING FOR MATH 2

This chapter describes the Park Valley High School teachers' planning decisions, focusing on their evaluation of the materials available to them, their selection of specific materials to use with their students, and the rationale they gave for those decisions. I also the teachers' decisions with respect to each of the units observed. Finally, similarities and differences across the three units studied are discussed.

General Planning Decisions

During the interviews, I asked the teachers how they prepared to teach a new unit. In one case, I asked specifically about Unit 2 of the Georgia Performance Standards (GPS) for mathematics, and in another case, I asked the general question of how they used the different materials available to them to support the new state mathematics curriculum. All three teachers reported that they referred to the state standards and frameworks units to guide their decisions about which materials to use. Their other reasons for choosing materials varied.

Helen Bradley

In discussing her evaluation and selection of materials, Helen referred to external pressures, her prior teaching experience, and her perception of her students' abilities.

Contextual external pressures. Instructional pacing and standardized tests drove many of Helen's planning decisions. The three teachers had spent more time than they had planned on the first unit, leading to a decision to use the Carnegie Learning textbook (Carnegie Learning Development Team, 2009b) exclusively for Unit 2. Helen said, "We were also trying to get that finished, and we were calendar driven to get that done before the posttest" (Interview 2). Helen believed that it helped "for pacing better to have, like, the structure that Carnegie Learning has over just pure frameworks" (Interview 3). Sticking to the pace they had set at the beginning of the year would enable the teachers to prepare the students for the state end-of-course test. When teaching geometry in previous years, Helen and her colleagues based their instructional decisions on what they believed was going to be assessed on the test:

> We decided [that] since there are almost no proofs on the end-of-course test, and we have to cover so much material in a semester, we skipped proofs. … So, we, um, kind of went through our textbook, and we eliminated any and everything that we thought that there were very—. That there were no questions we felt like or just one question on the end of course test, we skipped it. (Interview 3)

Helen admitted that her focus on getting through the required content often led to one of her weaknesses as a teacher: "Sometimes I do overlook students. … I think I'm oblivious sometimes, you know. I have my overall goal of what I'm trying to do, [and] I overlook those [students] that are very, very quiet" (Interview 2).

Teaching experience. Although Helen had not taught for very many years, she had taught both geometry and second-year algebra courses. She drew on these experiences and the materials she used in those courses to aid her planning, including adding variety to the Math 2 lessons. To prepare to teach the geometry units, Helen specifically stated that she would read what the textbook provided, but that she also had a number of activities that she liked to use, including using constructions to develop the relationships in the special right triangles:

> But see, those are all activities that I'm pulling out of my geometry book, which has—. The resource books for that have a lot of different variety to pick from. Every section has a real-life application, an activity starter, like some of those were. That's what Carnegie just needs to work on, I think, to add some variety. (Interview 2)

This notion of variety was a common theme in Helen's conversations about her use of materials. She believed that her classes were repetitive and she needed more variety in the activities but the

Carnegie textbook did not support this goal of adding variety, so she returned to the textbooks she had used in the past. Helen recognized her own difficulty, however, in integrating new activities into instruction with a specific textbook: “It takes a lot of time to do that. And, especially with this new book, trying to figure out how to add stuff to it when I’m just learning how to do it the first time” (Interview 1). She believed that her prior teaching materials had better mathematical explanations than the Carnegie textbook did, which resulted in her choice to use those textbooks as reference materials.

Perception of her students. Some of Helen’s materials selections were based on her perception of her students, their motivation, and their abilities. When asked about her ideal mathematics class, Helen stated, “Mainly just kids willing to try” (Interview 2), continuing by saying that if she had a class of highly motivated students, she “would probably want to bring in more real-life examples that are complex, that can’t be done just necessarily in one day, but that take maybe a week or so to work on” (Interview 2). Helen believed, however, that her present students did not have sufficient basic skills and were not motivated enough for such activities:

> They are all so weak on multiplication. … They just give up. That’s a common trait I’ve seen with these students: that when things take a little bit of digging because they are a little bit hard, [the students] just stop. So it takes a lot of encouragement for them to just keep on working on these harder problems. (Interview 1)

A number of the regional teachers surveyed also expressed concern over the lack of motivation, confidence, and prerequisite skills the students seemed to exhibit. (Selected responses to the survey from the regional teachers and the Park Valley teachers are included in Appendix D.) Possibly because she viewed the policy decision to eliminate the lowest track of classes as lowering “the bar for academic excellence” and because she believed “students should pass if they can just demonstrate a basic understanding of what we’re talking about” (Interview 3), Helen designed additional materials to summarize ideas that had been discussed in class, such as information about quadratic functions and conjectures about circles, rather than requiring the students to create those summaries themselves.

Overall evaluation and selection of specific materials. Helen primarily used the Carnegie textbook, supplemental materials from prior years, and the state frameworks tasks (Georgia Department of Education [GADoE], 2008a, 2008b, 2009) for instruction in her classes. She was critical, however, of both the Carnegie book and the frameworks tasks. When preparing for a new unit, she said, "We do like using some of the frameworks, like especially the culminating tasks because it kind of helps us to make sure, between the two [frameworks units and Carnegie textbook], that we've covered everything that we're supposed to do" (Interview 3). Although she liked the ability to pace the course using the Carnegie textbook, Helen did not view the student text as an actual textbook but as a guiding workbook:

> Except for vocabulary words in a, just a few paragraphs, there is no way [the students] can look up how to do anything [in the Carnegie textbook]. And I think that's a problem, and parents have a big problem with that. But, I mean, there's very few examples that you can just go look at that show you how to do something. Now, the [traditionally designed Math 2] book has that. And so that's a good thing. But, uh, if a student couldn't remember how to find the vertex of an equation, quadratic equation, they really can't look it up in the index and go find an example of how to do it unless they had correctly copied down the examples themselves. But there is no index to go find it. I think that's something that we need to work on, um, whether it's like a reteach section or something that takes them step-by-step how to find something. And that's what parents find very frustrating. Especially parents who are able to help with math and find they can't because they don't have anything to refresh their memory. (Interview 3)

Like other teachers surveyed, Helen struggled with "finding a good balance of skills practice, tasks, and applications" (survey response from a regional teacher). Helen reported that if it seemed that Carnegie was "going too deep or they've made it too complicated, the way they are drawing it out. [So we teachers] put something together on our own to meet the same goals" (Interview 1).

Kasey Turner

Kasey Turner's reasons for selecting instructional materials centered on the curriculum itself, a desire to integrate new ways of thinking about mathematical content with how she had learned the content, issues of reading comprehension, and ways to motivate her students.

Curriculum. Kasey's materials evaluation and selection were influenced by the curriculum she was teaching. She admitted that the curriculum she was expected to teach was more rigorous than she had experienced: "I think if I would've had Math 1 and Math 2 and all that, I would not have been as successful as I was" (Interview 1). It does seem, though, that Kasey was excited to teach such a different curriculum: "It's more interesting for me, because I get to relearn how to do this and do something more activity based or task based than how I did it" (Interview 2). She saw planning and preparing this new curriculum, however, as placing additional demands on teachers:

> This GPS is all about expanding on, instead of just learning the basics, going and diving into it more and learning more about it. And there's really not a way to do that traditionally, just fact based. You know, this and this, and you can do this, and this would be your result. How is that, you know? I just like [the GPS] a lot better. I mean, I don't know why. I think this is clearly, like if everything worked out, like on paper, this is the ideal way to teach this material for the kids to know more. … So, yeah, I think this is, of course, this is better than teaching the traditional way. I don't know why anyone disagrees. I'm sure that's what the traditional people think too. It's just—. It's harder to teach this way. And I think that is probably why a lot of teachers are more against it: because it's harder. It's more planning, and you have to have more of a relationship with your students, which I think is really hard for some people. Like, when I was student teaching, planning those lessons [was] so much easier because we were doing QCCs [Quality Core Curriculum objectives]: Algebra One. I have Section 10.1 in my book. I have my notes right there. I have my practice right there, and my homework right there. Everything was done for me. (Interview 2)

The idea of needing additional planning time to make judicious materials selections was echoed by many of the teachers surveyed; one teacher even stated, "If I can't finish [a Math 2 task] in 30 minutes, I don't use it," indicating both a concern with planning time and the amount of time the task would take to complete with his students.

Materials and mathematics. In addition to stressing the importance of conceptual understanding of mathematics, Kasey wanted to understand the intent of the activities she used with her students so that she could integrate those activities into her existing knowledge of how to teach the content. She stated, "And if I just don't understand the reasoning for them doing something, I'm not going to teach it to my class. If I know a better way, then I'm going to use my better way" (Interview 1). When choosing activities, Kasey said that she would

> look at the frameworks and look at the book and see what topics are necessary to cover and see the best way—how I learned it, how they want them to learn it, and pretty much mesh those together. Because I'm going to teach it at least somewhat in some way close to how I learned it, using what they've given me also. But I can't—. It's hard for me to go completely separate from how I learned something and then teach it in a one hundred percent opposite way. (Interview 1)

Although she realized that the way she learned mathematics was different from how she was expected to teach, she was not able to separate her learning experiences from her thoughts on how to teach a topic.

Reading comprehension. Kasey frequently commented on her desire to reduce the level of reading comprehension necessary to complete the learning tasks. She attributed this desire to the fact that many of her students spoke English as a second language, but she also had experienced reading comprehension difficulties when she was a student. Kasey criticized the state tasks as having "so much unnecessary reading detail and stuff, that it's just too much. … [The students] don't care if Johnny throws the [energy bar] off the cliff. You know, they don't care when it hits his hand" (Interview 1). She thought the complexity of the context provided in the tasks slowed her students down and that reducing the contextual information would help her students identify the mathematics and be more successful: "I have one student that is an amazing mathematician; she can do it all, but she cannot read English very well" (Interview 2). Although critical of the amount of reading required in the contextual problems, Kasey valued the use of contexts in instructional tasks and believed that her students might remember more mathematics than she and her high school classmates had because her students were learning mathematics through a variety of contexts, for example, the path of a golf ball or other projectile.

Student motivation. A common theme in Kasey's conversations about teaching was the need she felt to make mathematics interesting for her students. She expressed disappointment with the state materials that were provided for teaching the GPS and the impact the GPS seemed to have had on student attitudes towards mathematics:

> One of my biggest things with this stuff is, I guess, how I was told about it in college and from everything that—. I guess I just thought it was going to be so different from what it is. … Everything is supposed to be connected, and it's going to be like—. "Activity based" is what everyone kept saying: activity based. And these [frameworks tasks] are not activities; these are worksheets. It's a packet. … So I've been trying to think what kind of project or activity—. Can we go outside and measure anything? Is there anything we can do? And I'm just drawing a blank everywhere. … I'm just thinking about how can I cover this, and how can I make it interesting? Desperately, how can I make it interesting? So. Because I feel like my kids—people don't like math anymore. I think I've told you that before. They just don't like it anymore, and it makes me sad. (Interview 3)

In addition to the state frameworks tasks not meeting her expectations, Kasey realized that her students were not motivated by their textbook or the fact that they could write in their textbook. So, instead of having the students work in their books, Kasey would occasionally opt to lead a whole class discussion, working through the book and having the students take notes on their own paper, believing that "they are more inclined to do something when it's not in a book" (Interview 2). If she did not think the activities in her regular materials were sufficient, she would use the Internet to find something more interesting. Once, she found a video about crop circles and chords of circles to show her students, relating mathematics to the world outside of school.

Overall evaluation and selection of specific materials. Kasey cited the state frameworks units, the Carnegie textbook, the McDougal Littell textbook (*Georgia High School Mathematics 2*, 2008), and the Internet as reference sources she used when preparing to teach a new unit. She reported that, first, she used the state frameworks units and the culminating task provided in the unit to determine what content she needed to teach. During the unit, she highlighted the key terms and theorems listed in the unit, as she taught them, to ensure that she addressed all of the content: "I want to cover everything in here because I am using other things, and this is what everything is based on" (Interview 3). Kasey liked some features of the Carnegie text—the common student errors and warm-up exercises in the teacher's edition as well as the way the students were required to investigate mathematical ideas—and tried to use those in her classes. She particularly liked "the warm-ups because they get the basic ideas. Like before we did arc length, we just did some circumference problems, things like that. They were good preview prerequisite-skill-type stuff" (Interview 3). Although the Carnegie textbook was accompanied by the assignment-and-skills-practice book (Carnegie Learning Development Team, 2009a), Kasey preferred using McDougal Littell Math 2 textbook to reinforce basic skills, to apply newly learned theorems, and to better integrate algebraic ideas with the geometric ideas in the circles unit.

Eva Sailors

Eva Sailors referred to her views of mathematics and of teaching mathematics, which were influenced by her teaching and graduate school experiences, when discussing why she chose to use specific instructional materials. Additionally, her collaboration with her student teacher and with Kasey and Helen led to her specific planning and selection of materials.

Views of mathematics and teaching mathematics. Eva often talked about the beauty and connectedness of mathematics and the importance of helping her students appreciate mathematics. The GPS were designed to be more student centered than the previous mathematics curriculum, but, for Eva, the only difference was that "there are many more materials accessible to me now that are published. You know, we have books that we send home now that are task based. ... Nothing really else about my classroom has changed" (Interview 3). Eva described this curriculum as "a dream come true" for her; she was expected to teach her students to think about mathematics and use multiple representations to make connections. In her eyes, all teachers were now required to teach in ways consistent with how she believed mathematics should be taught and with how she had taught for years.

Eva stated that although her ability to see how mathematical topics in the curriculum connect to each other was one of her mathematical strengths, it often caused her to change planning decisions in the middle of a class. Instead of staying on the agreed-on pacing, she would venture out onto tangents, coming back to the original topics a few days later. Because she was able to see how mathematical topics in a particular unit connect to other topics in the curriculum, Eva was able to orchestrate classroom discussions to investigate, in depth, the mathematical ideas in the unit. She also wanted her students to be able to make these types of connections:

> That's important to me. I think it should be important to everyone. I mean, I really believe that about kids, that if they can do that, then they really have it. … So I try to make that happen in the classroom. … I'd rather much more [give] the big picture. (Interview 1)

> And knowing that the most effective instruction is when you can get kids to engage in their own investigations and make their own generalizations, their own connections. (Interview 2)

Eva's focus on mathematical connections contrasted with her understanding of her student teacher's emphasis, which she believed was skill development. In discussing her mentoring of Matt, Eva stated, "I don't think he sees all the connections, so he's not pushing to make them. And when he and I had conversations about it, I would expect something to happen in the lesson that didn't happen" (Interview 1). Because of this difference in their approach to teaching mathematics, much of Eva's instruction during the observation cycles reviewed content Matt had taught, but at a deeper, more conceptual level, incorporating multiple representations and student explanations of the connections between the mathematical topics in the lesson. Eva's general teaching style and the confounding presence of Matt's teaching resulted in Eva teaching a large number of improvised lessons.

Eva saw two main reasons to teach mathematics—its utility and its beauty—and she wanted her students to appreciate that beauty and applicability:

> I mean, there is mathematics that we need to know. We need to be able to make sense of the world around us numerically and geometrically. And we engage in problems that do that. And I also think that we study it because it's beautiful and fascinating. And I think kids need to be able to see patterns and be able to generalize and see relationships between different representations of math. And I think it's a very powerful thing to be able to do. To be able to think deductively and inductively, both are really powerful skills. … And be able to make your own generalizations and verify things for yourself. So, I think those are equal parts of mathematics; it's for application and its use. Maybe not equal. I think maybe more so for what it gives us in our ability to think creatively and analytically. (Interview 2)

To accomplish her teaching goals, Eva tried to foster a supportive environment and positive relationships with her students so that they could engage in conversations about mathematics. These conversations allowed Eva to determine student misconceptions and direct the content in the necessary direction to correct those misconceptions, even if it was an unplanned direction.

With these ideas in mind, Eva looked for classroom activities that supported her view of what it means to understand mathematics and that would enable her to understand what her students understood about mathematics.

Experience. Eva referred to her teacher preparation program, teaching experience, and graduate study as major influences on how she approached teaching. For example, she believed that her preparation program had trained her to “look at a problem and look at multiple representations” (Interview 1), but she did not believe that one of the other participants in the study had experienced such a program. Also, as the most experienced of the three teachers, Eva had used a variety of teaching activities in her career and stated that, when looking for materials to use with her students, she often searched “for things similar to tasks I’ve already created or ways I’ve seen it taught. So sometimes I probably don’t give materials all the attention that I should” (Interview 3). The regional teacher with the most teaching experience (33 years), who had previously earned a doctorate in education, expressed a similar idea: “I may also look at a few other sources such as [regional professional development agencies] and NCTM Illuminations as well as others I have collected over the years and have stored in my head.”

An additional aspect of Eva’s experience was her doctoral study, which included reading and discussing research on problem solving and learning theories:

> The research that I have studied, the things that I have learned, and the things that I have read—all influence what I choose. I mean, they’re a part of who I am, you know. … One of the most influential things that I’ve ever read is Polya’s work. … But I absolutely know what he believes is a good task, a good open-ended investigation. Um, and I also, um, I’ve really been influenced by constructivist work and learning trajectories. And just, where is a student? Where do I want them to go? How do I put in front of them the materials that they need? (Interview 3)

Eva's theoretical and experiential knowledge of how students learn provided her with the confidence to diverge from her plans in order to build on her students' mathematical knowledge and help them make connections among the ideas they were studying.

Collaboration. Although she was excited about the GPS, Eva felt constrained in her teaching of the curriculum. Reflecting on her experiences with Math 1 and Math 2, she said:

> I really feel stifled the last couple of years. Yeah, I've really thought about that, why this magic curriculum that I would have died for makes me feel less creative or more constrained. And I think it might be because I'm working with other teachers and trying to get all of us on the same page—doing the same investigations—that I don't necessarily feel like I have the flexibility to just take it and run with it. Like the day when you were here, and we were doing tangent. We were doing slope, and it just turned into tangent when really we were going to do distance formula. And that's just how I would go at it, usually. I would just know where we're ending. But after that happened, I was immediately like, "Oh, no. I have to back up and get back on task with the other two teachers." And I think that's probably been it. In Math One last year, it's my job. I mean, I've been told to lead this rollout. And I guess, yeah, when other people are doing the same thing as you—. Maybe that's it. I don't, I don't really know. Or maybe it's because there are things to choose from now, instead of me writing my own. I don't feel as creative, because I'm using somebody else's tasks. Um, even though they're great tasks. Maybe that's it. Yeah, I have really felt, yeah—. Or 'cause there's a book we use. (Interview 3)

Rather than collaboration being a valuable activity, Eva found it to be a hindrance to her teaching. In her role as a leader, she felt pressured to oversee a successful implementation of the curriculum and to guide others in their implementation. She also felt constrained to use the same tasks and stay at the place in the curriculum as the other Math 2 teachers.

In addition to working with her student teacher, Eva tried to plan with Helen and Kasey; because she did not share their common planning time, however, that was not always possible. Eva was concerned about keeping pace with the other teachers because students from all three teachers' classes attended the same Math 2 Support class every afternoon. She claimed that she "probably stuck to the order that the textbook did things more than if I was alone. But you know, it was our first unit together, so it felt like an important decision" (Interview 1). The three teachers also gave common tests. Just as Eva's teaching focus differed from Matt's, Eva also believed her focus was different from that of Helen and Kasey:

> And they would say, "Well, it doesn't matter what method [the students] use, and we don't care." And, I said, "When I give an assessment, I want them to show me the method and tell me why they're using it and when is it the most efficient method and when is it not." And they said, "When we write assessments, we don't care how they do it. And we've agreed to give common assessments." So that was a little—. Like, how much do you say, "Well, we're doing it my way"? Because that's not really being a part of the team. But I really think my way is the best way. I feel like Helen and I are on very opposite ends of how we view this, and Kasey is kind of stuck in the middle. But she's planning more with Helen. I don't have their planning time. (Interview 1)

Because she believed her view was different from the others but that they needed to stay together and give the same tests, Eva believed it was important for the three teachers to discuss the "really, really big picture of what [they] were trying to accomplish" (Interview 1), but she did not think that such an understanding was developed at their planning meetings.

Overall evaluation and selection of specific materials. Eva valued having a task-based textbook such as the Carnegie text, and she liked the guidance of the state frameworks units, but, again, she felt stifled by the abundance of such resources. Similarly, many of the regional teachers felt overwhelmed by the number of resources available, although none aligned well with the curriculum. Because the primary materials Park Valley High School had adopted for teaching the GPS were written specifically for the state of Georgia, Eva wanted to try the materials without modification the first time she used them. Like Helen and Kasey, Eva referenced the state frameworks, including the culminating task, to get the "big picture" of what was addressed in the unit. She also liked that the culminating tasks were often complex application problems, something she deemed missing in the Carnegie textbook. One criticism she made of both of her primary instructional materials was that their tasks were not open-ended enough, that the tasks led the students too much in their investigations. Her second criticism of the frameworks units was the excessively complex contextual situations used in the *instructional tasks*. When discussing a particular task from the state frameworks unit on right triangle trigonometry that she did not use, Eva said:

> I never can decide whether those sort of investigations, whether it helps to have the context … [or if] looking for the relationships is the better idea. … Sometimes … I think the context makes it so difficult to get the mathematics out of it. (Interview 2)

Like Kasey, Eva found that her students were more engaged in the class when she did not use the Carnegie textbook but instead gave notes or problems from the board. Although not phrased as a criticism of the textbook, Eva noted that it could be used in the service of making mathematical connections or in the teaching of skills; if the intent was to make connections, a teacher must "use the material with that goal in mind" (Interview 1).

Most of Eva's desired learning outcomes reflected the idea of developing conceptual understanding; however, she also wanted her students to learn to apply the mathematics to procedural exercises. She liked using the warm-up problems from the Carnegie textbook to review the prerequisite skills needed for particular lessons, but she preferred using the McDougal Littell Math 2 textbook for problems in the circles and spheres unit. The exercises in this text required the students to use algebraic ideas to solve circle theorem application problems. Supporting her earlier statement about using materials with a specific purpose in mind, Eva showed the ability to critique and select materials based on the learning emphases in her classroom.

Planning in Units 1–3

In this section, I provide an overview of the teachers' planning decisions, including how and why they chose their materials in Units 1–3. To adequately explain their decisions, I provide the content and structure of some of the lessons in the Carnegie textbook. Also, I explain details about the mathematics in each unit. After I discuss the planning decisions in each unit, focusing primarily on Unit 1, I address how their decisions differed according to the unit. As the teachers planned their lessons, both collectively and individually, they provided additional evidence of their general planning thoughts as well as information about their choices on how to use their materials.

Unit 1: Quadratic Functions

Unit 1 in Math 2 began by building on the work the students had done the previous year with quadratic functions by introducing quadratic functions with leading coefficients other than 1. The GPS included in Unit 1 and relevant to this study are listed here.

> MM2A3. Students will analyze quadratic functions in the forms $f(x) = ax^2 + bx + c$ and $f(x) = a(x - h)^2 + k$.
> a. Convert between standard and vertex form.
> b. Graph quadratic functions as transformations of the function $f(x) = x^2$.
> c. Investigate and explain characteristics of quadratic functions, including domain, range, vertex, axis of symmetry, zeros, intercepts, extrema, intervals of increase and decrease, and rates of change.
>
> MM2A4. Students will solve quadratic equations and inequalities in one variable.
> a. Solve equations graphically using appropriate technology.
> b. Find real and complex solutions of equations by factoring, taking square roots, and applying the quadratic formula.
>
> (GADoE, 2008c)

The scheduled observations, and therefore the focus of the follow-up interviews, coincided with the instruction on solving quadratic equations and analyzing quadratic functions in both standard and vertex forms.

As part of their summer planning for Unit 1, the Park Valley teachers worked through Unit 1 of the state frameworks. The teachers also reported that they reviewed the Carnegie text to make certain that the book adequately addressed the GPS for the unit as determined by their examination of the state frameworks unit (GADoE, 2008a). They deemed the book to be appropriate and adequate; the teachers also planned, however, to use a selection of adapted problems from the culminating task at the end of the state frameworks unit. Below is an example of the application problems provided in the culminating task:

> Gary is on the baseball team. During a crucial game, the bases were loaded, and Gary was at bat with a full count of 3 balls and 2 strikes when he connected with the next pitch. The ball was 3 feet above the ground when it left Gary's bat, and it reached its greatest height of 28 feet when it was above the head of the center fielder, who was 200 feet from home plate at the time.
>
> a. The outfield fence is 8 feet high and at center field is 375 feet from home plate. If the ball cleared the fence and went out of the baseball field, Gary had a grand slam home run. Was Gary's hit a home run? Justify your answer algebraically and use a graphing utility to verify it graphically.
>
> b. The height of the ball is a function of its distance, *x*, from home plate. Denote this function by *H*, sketch the graph based on the given information, and then describe how to the graph *H* using transformations of the graph of the function $f(x) = x^2$.
>
> c. Write the formula for *H*(*x*) in standard form.
>
> (GADoE, 2008a)

The content for Unit 1 was addressed in chapters 1 and 2 of the Carnegie text, but the first three sections of chapter 1 were primarily a review of Math 1. Therefore, Unit 1 began with Section 1.4 of the text. The day before the teachers taught began this unit, I observed their planning meeting.

Sections 1.4 and 1.5 were the primary foci of the planning meeting. The objectives for Section 1.4 were to solve quadratic equations by factoring and extracting square roots. Problem Set 1 included six exercises that asked students to calculate the roots or zeros of quadratic equations or functions, respectively, with a leading coefficient of 1. The second problem set reviewed using the distributive property, multiplication tables, and area models to multiply two binomials. The next problem set used area models to help students develop an understanding of the relationship between the coefficients of a general quadratic equation and the coefficients of the binomial factors in service of developing the students' proficiency with factoring quadratics with a leading coefficient other than 1. The final problem set consisted of four exercises for practicing solving quadratic equations by extracting roots; however, those exercises often required students to simplify expressions before they could apply a procedure, for example, $x(x-5)=144-5x$ (Carnegie Learning Development Team, 2009b, p. 62).

The learning objectives, as stated in the textbook, for Section 1.5 were to determine the vertex of a parabola given the equation of the quadratic function and to determine the vertex for the standard form of a quadratic function. The first problem set focused on quadratics of the form $y = ax^2 + c$. Here, students were to investigate the relationship between the vertex and axis of symmetry and between the leading coefficient and the type of extrema present. The next set focused on different ways to find the axis of symmetry. Finally, Problem Set 3 led students to the formulas for the coordinates of the vertex of a parabola by finding the midpoint of the segment joining the y-intercept and the point on the parabola symmetric to the y-intercept. In the final exercise in this set, students were to derive the formulas for the coordinates of the vertex of a parabola, that is, $\left(-\frac{b}{2a}, \frac{-b^2+4ac}{4a}\right)$.

Despite previously stating that the text sufficiently addressed the GPS for Unit 1, the teachers often made statements during the planning meeting indicating they had not thoroughly examined the teaching methods or sequencing of the text:

> Helen: When I looked at Section 4, I don't understand why we didn't do this near the beginning of the chapter. … It just seems that a good part of this should have already been done first.
> Eva: What's the point of that section? … It just seems like that whole section is what we already did.
> Helen: So then, right now, we're going to skip one five.

Kasey: I say, skip one five. On Monday, we'll do completing the square.
Eva: That is *not* how they derive the quadratic formula.
Kasey: What do they do?
Eva: Look at page 106.
Kasey: The title of the—.
Eva: Yeah, but they don't derive it from standard form. They don't solve it from standard form using completing the square. They derive it from the vertex [form].[3]

Although the three teachers thought they knew what content was included in the unit and in the text, none had studied the materials very closely. For example, the above excerpt indicates that they thought completing the square was part of Unit 1, when in fact, that topic is not in Math 2 at all.

During the planning meeting, the teachers discussed the two book sections, the parts they wanted to use, and other materials they wanted to use to teach the content. The group decision for Section 1.4, solving quadratic equations, was to improvise the lesson, using the main ideas from the book but using their own materials to accomplish the same goals. This decision was informed by the realization that the first two problem sets reviewed Math 1, so the teachers believed they could accomplish the same outcomes with fewer, different problems in less time than if they had used the textbook's lesson. Eva suggested reviewing factoring as the warm-up for the day instead of completing Problem Set 1. Kasey and Helen agreed, and Kasey volunteered to write up a set of basic factoring problems, including some that required factoring out a greatest common factor, a weakness for her students. Eva then pointed out that these warm-up problems should be "factor-to-solve [problems] because that's the point of this chapter," a comment that indicated her awareness of the overarching ideas of the unit.

For the second problem set of Section 1.4, multiplication of binomials, Kasey and Eva agreed to use the distributive property and the area models, but not the multiplication table

[3] This alternative method for deriving the quadratic formula is explained in chapter 5.

method. They thought that the area models would be easy for the students because they had used those in Math 1, but that the multiplication table method would confuse the students. (See Figure 4 for examples of the three methods). Accordingly, these two stated that they would use only the area model method in their classes; Helen did not weigh in on that decision. Because of the similarity of the area models problems in the textbook to a task from Math 1 called Planning for the Prom, Eva volunteered to make a scaled-down version of the task to reintroduce the students to area models. This task began by describing the size of a square dance floor and asking the students to determine the area of the dance floor if it was increased in increments of 5 feet (i.e., 5x feet). The teachers decided that they would then assign the multiplication practice problems in Problem Set 2.

Distributive Property: $\mathbf{(2x+3)(3x+5)} = 6x^2 + 10x + 9x + 15 = 6x^2 + 19x + 15$

Multiplication Table:

•	**3*x***	**5**
2*x*	$6x^2$	$10x$
3	$9x$	15

Area Model:

	3*x*	**5**
2*x*	$6x^2$	$10x$
3	$9x$	15

Figure 4. Three methods for multiplying two binomials.

The primary new content in Section 1.4 was factoring quadratic equations with a leading coefficient other than 1. Helen suggested a factoring procedure, Bob's method, that had worked well with her previous classes.

> Helen: Now, on factoring when *a* is not equal to 1, I like to use something different from what they use in the book. But I'm open to—. Basically, this [in the book] is guess and check.
> Kasey: Yeah.
> (Eva nods.)

Helen: And the method that Bob showed me, I like to teach. My students liked that.
Kasey: What is it? I don't know that.
Helen: Um, it's where you take *a,* and you set it to the side. And you rewrite your trinomial but you multiply the constant by *a*. It—. I just have to show you on the board. Yeah. Give me one. Just give me one from the book.
Eva: Ten *x* squared plus nineteen *x* plus six [$10x^2 + 19x + 6$]
Helen: And I've got this typed up—the rules of how you go through it—that I give them. So you take *a,* and you set it over here, and you rewrite without *a*. But I'm going to multiply this by *a*. (Multiplies 10 and 6, and rewrites the trinomial as $x^2 + 19x + 60$.)
Kasey: Just that one [*c*]?
Helen: Umhmm. So I took the *a* and put it over here, but when I rewrote this [the trinomial] without *a*, I multiplied this [*c*] by 10. Now I can factor this with my regular rules. Factors of 60 that add up to 19. Um. …Yeah, 15 and 4. Okay. So that will be plus 15 and plus 4. Okay. Now you've got to put ten back in and it goes in front of every binomial. So that's 10*x* plus 15 and 10*x* plus 4 [$(10x + 15)(10x + 4)$]. So now, you factor out any common factor, and you discard it. … So you've got to do them separately. So five and this will be two *x* plus three. I can take a two out of here, so it will be five *x* plus two [$\cancel{5}(2x + 3)\cancel{2}(5x + 2) \rightarrow (2x + 3)(5x + 2)$].
Kasey: I've never seen that before.
Helen: Well, Bob showed it to me the first year I was here, and it just beats guess and check.
Eva: That is so cool.
Kasey: That is so cool! I have never seen that before. But we just don't know how it works, why it works. I don't really care.
Helen: I think if we all sit down and eventually work on it, we could figure out how it works.

The teachers agreed to use this procedure. Eva's agreement to use Bob's method seemed incongruous with her focus on conceptual understanding;[4] I suggest a possible reason for this decision in the implementation chapter (see chapter 5). The teachers also decided to use simple problems for practicing the procedure; they wanted the focus to be on using the steps. As Kasey stated, "I don't want them to have to mess up anywhere else." Because the problems in the Carnegie assignment-and-skills-practice book required simplification before factoring could be done, for example, $3(x+1)^2 = 6(x+1)$ (Carnegie Learning Development Team, 2009a, Skills

[4] The procedure is mathematically valid for solving quadratic equations; however, the strategy requires multiplying the entire equation by *a* and using variable substitution with $u = ax$.

Practice, p. 40), the teachers decided to use worksheet software to generate a list of problems, including equations whose solutions were fractions.

As they moved on from Section 1.4, Eva proposed skipping Section 1.5, finding the vertex of quadratic functions in standard form. Her rationale was that they had already taught finding the vertex when their students were determining characteristics of parabolas using the graphing calculator and when the students determined the vertex by averaging the zeros of the quadratic function. Kasey and Helen agreed that the content in the section had been taught or would be addressed in a later section on transformations of graphs. Helen, however, while examining the text, pointed out that the section proposed a new method for finding the axis of symmetry, and therefore, the vertex of a parabola. Eva again stated that she believed the content had been taught, so the three agreed to skip the section.

> Eva: Unhuh. But it says determine the vertex of the standard form of a quadratic function. I guess in 1.5, they just want you to—.
> Kasey: I did everything in 1.5.
> Helen: I think it's just focusing in on, you know, using the axis of symmetry, finding symmetric points, and averaging them to get the *x*.
> Eva: I guess I feel like we've already done—. Like we don't have to.
> Helen: Yeah.
> Kasey: So 1.6.
> Helen: Do you think we could just skip this chapter? This section?
> Kasey: Yeah.
> Eva: I really do. Okay.
> Helen: Yeah, I think we did probably pull all this information out.
> (Unit 1 Planning Meeting)

Eva then realized that the last exercise in Section 1.5 helped students derive the formulas for the coordinates of the vertex of a parabola using this alternative method for finding the vertex. As Helen pointed out, these formulas would then be used in Section 1.6 to convert from standard form to vertex form of a quadratic. From previous study, the students knew about graphical transformations, so if they encountered a quadratic equation in vertex form, the students would be able to determine the vertex. Because all three teachers had previously taught completing the square—Eva in numerous classes, Helen in second year algebra, and Kasey during her student teaching—they considered replacing the book's method for finding the vertex by completing the square, a Math 3 topic. They reached a consensus to teach only one method. But again, Eva realized that the text did not use the learning trajectory she was expecting; instead of completing the square to derive the quadratic formula, the text used the formulas derived in Section 1.5, vertex form, and extracting roots to derive the quadratic formula in chapter 2. So by the end of the meeting, the teachers agreed to teach Section 1.5, although they did not discuss which parts of the section they would use. Although the teachers drew on their experiences in their planning discussions, they decided to offload instructional authority to their text for Section 1.5 to ensure that their students learned the appropriate mathematical methods needed for future instruction—instruction that would be either offloaded to or adapted from the Carnegie text.

Unit 2: Right Triangle Trigonometry

Similar to how they taught Unit 1, the Park Valley teachers chose to use the Carnegie Learning textbook as their primarily source of instructional materials for Unit 2. The topics included the relationship between the Pythagorean theorem and distance formula, special right triangles, and the sine, cosine, and tangent ratios. The GPS included in Unit 2 are as follows:

> MM2G1. Students will identify and use special right triangles.
> a. Determine the lengths of sides of 30°-60°-90° triangles.
> b. Determine the lengths of sides of 45°-45°-90° triangles.
>
> MM2G2. Students will define and apply sine, cosine, and tangent ratios to right triangles.
> a. Discover the relationship of the trigonometric ratios for similar triangles.
> b. Explain the relationship between the trigonometric ratios of complementary angles.
> c. Solve application problems using the trigonometric ratios.
>
> (GADoE, 2008c)

Because this unit was allotted only 2 weeks in the course outline, the scheduled observations, and, therefore, the focus of the follow-up interviews, spanned the entire unit; the small window of time, however, meant that I was not able to observe each teacher's instruction on each topic.

To prepare to teach this unit, all three teachers stated that they would read the text, review the frameworks tasks, and possibly refer to other resources for their instructional materials. I was unable to attend their planning meetings for this unit but was informed by each teacher individually that they had agreed that the conceptual approach taken by the Carnegie text was very good; and therefore, that they should follow the book as written, that is, offload instructional authority to the materials. However, they also agreed that the trigonometric ratios should be taught in a single day, together, instead of three different lessons as presented in the text. One rationale for this agreement was a belief that students need to be able to make strategic decisions about which ratio to use in which situation. Helen, particularly, did not like the way the Carnegie text separated the trigonometric ratios into three separate sections, so she chose to use problems from a book she had previously used.

Eva provided a second reason for adhering to the Carnegie text, based on the text's connection between the tangent ratio and the slope of the hypotenuse:

> I think this is just such a cool way to start thinking about trig ratios. I had never presented it that way, so when we sat down to plan, that was the thing I was most excited about. It's cool, and we can talk about how the angle changes and slope. So I knew that we were all going to emphasize that. (Interview 2)

Kasey added three other reasons—personal boredom, an additional mathematical connection, and time:

> And I cannot spend an entire day on just tang—. I mean, I could, but not for the limited stuff we were doing. … I would have been bored out of my mind because I would be bored just doing one. And I like doing all three, doing the sine and then the cosine and then the tangent and then dividing sine by cosine and seeing it's tangent and saying, "Why is that?" And I like comparing them and seeing that we can use all of these things

> in this triangle, and it will give us the same answer. So, it just made more sense to do it all in one day. And we had time to do it. So, one day, because it didn't take that long. (Interview 2)

All three teachers also knew they were behind their pacing because of the amount of extra time they had spent on Unit 1 and so were feeling pressure to complete the unit before an upcoming benchmark test. They agreed that using the textbook would help them move through the content quickly without sacrificing conceptual understanding.

During instruction on this unit, Helen and Kasey met to make additional planning decisions. After following the Carnegie text's lesson on 45-45-90 triangles and being unhappy with the nonintuitive fill-in-the-blanks exercises in the lesson, they decided to use a construction activity from the book Helen had previously used in her geometry classes. Eva did not attend these meetings but instead made decisions about planning and materials use based on her understanding of the mathematical "big picture" ideas that her students needed to learned during the unit.

Unit 3: Circles and Spheres

The Park Valley High teachers took a different approach to materials use in Unit 3. The topics in the unit included the angle and segment relationships in circles as well as basic ideas about spheres. The Unit 3 GPS relevant to the study are as follows:

> MM2G3. Students will understand the properties of circles.
> a. Understand and use properties of chords, tangents, and secants as an application of triangle similarity.
> b. Understand and use properties of central, inscribed, and related angles.
> c. Use the properties of circles to solve problems involving the length of an arc and the area of a sector.
> d. Justify measurements and relationships in circles using geometric and algebraic properties.
>
> (GADoE, 2008c)

Because of the limited time available for observations and because the teachers were off their original course pacing, in the scheduled observations, and therefore the focus of the follow-up interviews, I addressed only planning and instruction on circles.

Eva developed the plan for instruction on Unit 3. She knew that *Patty Paper Geometry* (Serra, 1994) included a unit on developing conjectures about circle relationships through paper folding. She also thought the tasks provided by the frameworks unit (GADoE, 2009) were appropriate for the Park Valley High School students and would be a nice follow-up to the investigations. So, the plan was to spend a day on circle vocabulary; to use the paper-folding investigations to develop conjectures about arc, angle, and segment relationships in circles; and finally to work through the state frameworks tasks to prove and apply the conjectures. Kasey agreed to follow this plan. Helen was absent the day Eva and Kasey discussed the Unit 3 plan and indicated that she might have made different planning decisions:

> I got the impression that we were just kind of going to skip these sections [in the Carnegie textbook] but cover them all with the patty paper stuff. And I like these sections, and I felt like we needed them. And I've ended up going back and doing just about all of them because we needed to have problems to go with them. (Interview 3)

In fact, all three teachers, upon reflecting on the unit, stated that they would change the order of the activities used. They agreed that, in the future, they would alternate between the investigations and skills; they would use the paper-folding investigations to develop conjectures and then provide their students with opportunities to apply the theorems (the informally proved conjectures). Helen believed that this approach would help the students connect the investigations and skills together more effectively, and Eva thought the alternating approach would provide the students a sense of efficacy with the new ideas.

During instruction on the unit, each teacher altered the plan in her own way. In addition to the paper-folding investigations (Serra, 1994) and state frameworks tasks (GADoE, 2009), Eva used the McDougal Littell Math 2 textbook for exercises on which to apply the theorems. Kasey quickly abandoned the state frameworks tasks in favor of the Carnegie Learning text and the traditionally designed text with the rationale that “the frameworks ... just didn’t work well with my classes” (Interview 3). Helen also abandoned the frameworks tasks and used the Carnegie books as her primary instructional materials.

Comparison of Materials Selection in Planning Across the Three Units

The three teachers, collectively and individually, engaged in the three different types of materials use: improvising, adapting, and offloading (M. W. Brown, 2009; Brown & Edelson, 2003). When Kasey, Helen, and Eva planned as a group, they discussed the mathematics of the lessons, their students’ prior knowledge and experiences, and how they previously taught similar lessons in order to determine which materials they should use. Because I observed only one planning meeting, what happened in that meeting may not have been representative of their other meetings. Considering that Kasey and Helen deferred to Eva’s guidance in the planning meeting and in her choice of tasks for Unit 3, however, it is reasonable to assume that, at least in initial materials selection, they trusted her experience and knowledge to guide their group decisions. Their trust in Eva’s choices carried over into their implementation; when an activity was developed by Eva (the Planning for the Prom task) or selected by Eva (the Unit 3 state frameworks tasks and paper-folding investigations), Helen and Kasey did not necessarily prepare to implement the task. The day they began the Unit 3 tasks, Matt, Helen, and Kasey told me that they had not worked through the tasks. Although the lesson was *planned*, the teachers had not *prepared* to teach the lessons. In each of these activities, the plan was to offload instructional authority to the materials chosen or developed by Eva. Implementation of the activities, however, did not always follow what was outlined in the materials (see chapter 5).

The group often chose to offload instructional authority to the Carnegie Learning textbook, particularly when they (1) believed the students would need to follow the learning trajectory developed in the text, (2) agreed on the approach taken by the book, and (3) thought the book would help them accomplish their goals in minimal time. In discussing why the other teachers might choose the Carnegie textbook over other materials, Eva said, “We’ve talked a lot about how Carnegie has really developed some good materials. So it would make sense that she [Helen] would trust those materials” (Interview 1), possibly shedding light on Helen’s materials appropriations. Helen chose to offload authority to the Carnegie text rather than improvise or adapt in her planning because she was learning the approach in the book and believed it would be difficult to make changes before she had worked through the book. Similarly, when Eva had instructional command in her classroom, she intended to offload authority to the materials during her first experience with them, although this did not usually occur in implementation; she stated she would be more apt to make adaptations in subsequent uses. She expressed this in both the survey and in Interview 3: “I should try [an activity] out before I pass judgment on it.” Kasey’s decision to offload to the Carnegie text, however, often coincided with her feeling ill and believing that teaching directly from the text would be the easiest instructional strategy on those days.

Kasey also offloaded authority to supplemental texts, but she adapted and improvised lessons as well. Other than the days when she did not feel well, Kasey adapted or improvised every lesson I observed in Units 1 and 2, the quadratics unit and the right triangle trigonometry unit. In at least two of these instances, her decisions increased the level of mathematical student thinking required and, in her view, would increase her students’ mathematical self-efficacy. Although Unit 2 addressed geometry topics, Kasey associated the unit with trigonometry, a course she had taught during her student teaching. Geometry was not a course she had taught or was comfortable teaching; she stated, “Geometry was really hard for me” (Interview 1). She called it her “worst math subject” (Interview 3). Therefore, it is not surprising that every observed lesson in the circles and spheres unit, with the exception of a vocabulary lesson improvised by all three teachers, was an offload to the paper-folding investigations, the McDougal Littell text, or the Carnegie Learning text. Additional information on her implementation of these materials can be found in chapter 5.

In addition to the group decisions previously discussed, Helen generally chose to adapt lessons or offload authority for the instructional activities to existing materials, primarily the Carnegie Learning textbook. She often planned to use a book section from start to finish or to use a particular activity, as written, from a book she previously used. She ended up adapting a number of her lessons during implementation, however, because of insufficient class time, student behavior, or not understanding the intent of the task (see chapter 5). Helen respected the group planning decisions and attempted to see them through even when she did not agree with the decision, for example, in Unit 3. She did, though, add her own instructional materials such as teacher-made summarizing handouts and supplemented with book lessons not in the original group plan. Unlike Kasey, Helen’s materials appropriations did not appear linked to the mathematics strand. Rather, she generally seemed to rely on the district-provided Carnegie Learning textbook and the materials chosen by the teachers for the majority of her instruction.

Eva’s teaching style of using student responses to guide instruction, coupled with the teaching of her student teacher, resulted in the majority of her lessons I observed being improvisations of the lessons in the materials. In the first unit, Eva retaught her classes the content previously taught by Matt, using her own mathematical knowledge to develop problems and class activities on the spot. She rarely used specific materials for any purpose other than for homework problems. Although she taught Unit 2 without Matt, Eva allowed instruction to follow a trajectory different from what was in the Carnegie text, the materials the group had agreed to use. Subsequent lessons were thus built from the new trajectory, resulting in Eva using the text very little for her initial instruction. She did offload one lesson in this unit because she did not believe the topic to be essential for the students during Math 2. Although she was absent during the majority of the Unit 3 observations, Eva intended for Matt to offload authority to her chosen materials: the paper-folding investigations and state frameworks tasks. When she returned, Eva continued using these materials but chose to combine them with problems from the traditionally designed Math 2 textbook. Rather than use the paper folding, then the frameworks tasks, and then the problems, she thoroughly addressed a specific topic—such as segment relationships when two tangents meet outside a circle—with all three materials before moving to a new topic, which would also be addressed using all three sets of materials. (See chapter 5 for a discussion of Eva's implementation.) Throughout the units, Eva seemed guided by her understanding of the mathematical big picture in each unit, what she wanted her students to learn, and how to move students forward in their mathematical understanding.

CHAPTER 5

IMPLEMENTING MATH 2

This chapter describes each teacher's implementation of the three observed units in the Math 2 course. The implementation is discussed in terms of the teachers' changes in planned materials use, her attention to the process standards, and the cognitive demand of the tasks as set up and implemented by the teacher. To adequately discuss these ideas, I provide some minimal information about what occurred during the observed lessons. What happens in a teacher's classroom can be vastly different from that in another teacher's classroom, even if they choose to use the same materials. Therefore, each teacher's implementation of all three units, along with possible explanations for their implementation decisions, is discussed before moving to the next teacher. This approach allowed me to more easily observe similarities and differences in each teacher's instruction of the topics in Math 2.

Helen Bradley

Helen's planning decisions were influenced by time and standardized tests, her prior teaching experience, and her perceptions of her students. As discussed in chapter 4, she tended to rely heavily on group planning decisions for her materials selection but also cited books she had previously used in her teaching. This section describes how she implemented her instructional materials with her students.

Unit 1: Quadratic Functions

The primary topics taught during my observations were factoring, converting between the standard and vertex forms of quadratic equations, and the quadratic formula. Helen's first day of instruction on solving quadratic equations included reviewing factoring with a leading coefficient of 1 and Eva's adaptation of the Planning for the Prom task. Helen seemed unsure of the students' prior knowledge, stopping in the middle of the factoring warm-up to ask me, as someone knowledgeable about the GPS, if the students had previously learned how to factor a difference of two squares, for example, $x^2 - 9$. She was also unsure of the goal of the Planning for the Prom task, stating that she was unclear what the questions were asking or how the students were expected to answer the questions. After sitting down to work on the task during class, Helen led the students through the task from the front of the room. For both of the student activities used on Day 1, Helen offloaded mathematical authority to the tasks (as discussed in chapter 4), adapting only the ways in which they were implemented, that is, walking the students through the tasks rather than requiring them to make sense of the mathematics in the tasks themselves.

The factoring procedure, Bob's method, discussed during the planning meeting, was the focus of the next day. After pointing out the general factoring guidelines in the text (Carnegie Learning Development Team, 2009b), Helen reviewed the three methods for multiplying binomials provided in the book: using the distributive property, area models, and multiplication tables. She drew attention to the similarities between the Planning for the Prom task and the distributive property. The students then completed binomial multiplication problems using all three methods, including the multiplication method, a method Kasey and Eva had stated they would not use with their students because, as Eva stated in the Unit 1 planning meeting, "I think these boxes [multiplication table] are going to confuse them [the students]." Upon reflection, Helen stated, "I think the kids seemed to prefer the area model. Probably next time when I teach this, I won't even do the multiplication table" (Interview 1). Finally, with the statement, "Instead of using what's in the book, which is more of a trial and error by looking at all the possible factors, I'm going to teach you a process to factor the quadratics when *a* does not equal 1," Helen showed her students Bob's method (described in chapter 4) and then led the students in practicing the procedure. After class, Helen expressed the need for better resources for factoring problems; she did not think the Carnegie text and the worksheet software problems were adequate for good introductory factoring problems.

The next lesson in the text was designed to help the students derive the formulas for the coordinates of the vertex of quadratic function. In class, Helen stated, "This book is based on—. We don't want to just give you the formulas. We want you to understand where they come from." Because of time constraints, however, Helen chose to give her students the formulas, offering extra credit to students who wanted to show the derivation of the formulas. The students then practiced using the formulas. The next class day, Helen gave the students a summary sheet that listed the characteristics of quadratics—vertex, *y*-intercept, symmetric point to *y*-intercept, axis of symmetry—in standard form, standard form when $b = 0$, and vertex form. The summary sheet also included how to convert from one form to another and directions for different methods of finding the vertex. In terms of materials use, Helen used the practice problems as written and moved through the text, opting to skip only the derivation of the formulas for the coordinates of the vertex.

On the last instructional day I observed, Helen taught the students the quadratic formula and reviewed factoring. As was the general pattern in the Carnegie text, the first few problem sets in the section built up the need for new method for solving a problem, in this case, a method for finding *x*-intercepts other than factoring or graphing. During the third problem set, the students were to derive the quadratic formula by using the vertex form of a quadratic function with the vertex $\left(-\frac{b}{2a}, \frac{-b^2+4ac}{4a}\right)$ and solving the quadratic by extracting roots. The text then provided practice problems. Instead of using this approach, Helen asked her students to write the quadratic formula in their book, illustrated how to use the formula, and then assigned practice problems. In this case, Helen adapted the lesson, using the idea from the book, but teaching the lesson based on how she taught the content in the past, including using practice problems from an old algebra text.

When I asked about her student-learning goals for the quadratics unit, Helen replied,

> Well, what's outlined in the [state] standards—which was being able to look at all the characteristics of the quadratic and being able to identify the vertex, the line of symmetry, the zeros, and come at it from several different angles. ... You know, trying to make all those connections. And the skills needed to manipulate those were needed. I think that really kind of sums up what we've done. (Interview 1)

Helen focused on skills and procedures, although she did occasionally engage her students in conceptual understanding activities (e.g., connecting the distributive property with factoring and connecting quadratics to application problems in the culminating activity). This is not a surprising finding; Helen gave a neutral response on her survey that students needed to master basic skills before tackling complex problems. However, her reliance on Bob's method and using formulas without deriving them shows a primary concern with developing procedures and skills in service of finding correct answers, a finding contrary to what Helen believed about her own teaching.

Helen's material use during the observed classes from Unit 1 can generally be classified as offloads (see chapter 4). The one exception was the quadratic formula section, which was the lesson Helen adapted to be procedural. Although Helen did attend to connections between procedures, applications, and terminology, the process standards did not appear to be primary concerns in Helen's instruction. This claim is supported by her reduction of the cognitive demand of tasks as presented in the materials (Stein, Smith, Henningsen, & Silver, 2000). For example, the Planning for the Prom task, as written, would be classified as a *doing mathematics* task; however, it was reduced to *procedures with connections* by her decision to walk the students through the task after they asked questions about it. Also, despite stating that students should understand the rationale behind formulas, an understanding developed through problem sets in the text, on two occasions, Helen provided the students with the formulas, focusing more on *memorization* than on *connections*.

The reasons Helen's gave for using memorization tasks, instructing students to use decimals instead of fractions, and for not focusing on more conceptual mathematics often concerned student lack of knowledge, student lack of motivation, and insufficient instructional time. For example, she preferred Bob's method to strategic trial-and-error because she did not think her students would persevere with the trial-and-error. Alternately, her reason for not deriving the formulas for the coordinates of the vertex of a quadratic function was that she "ran out of time and didn't want to carry that over to the next day" (Interview 1).

Unit 2: Right Triangle Trigonometry

I observed Helen's initial instruction in Unit 2 for 3 days. On the first day, Helen reviewed homework problems and engaged the students in warm-up problems that would refresh the needed skills for the day's lesson, the distance and midpoint formulas. She stated that it was important for each student to work the problems rather than to merely watch, that the students would "remember so much better if [they] work it." While going over the solution to $\frac{x+6}{2}=7$, Helen stressed a procedural approach to solving the problem and dismissed a student's way of thinking through the problem as guess-and-check, possibly indicating a preference for using established procedures over relying on student sense-making of the mathematics. She did, however, stress the importance of pictorial representations to aid students' reasoning in solving application problems.

According to the textbook, the primary topic for the first observation day was supposed to be the relationship between the Pythagorean theorem and the distance formula; the title of the section in the book was "The Pythagorean Theorem Disguised as the Distance Formula!" (Carnegie Learning Development Team, 2009b, p. 181). Because of insufficient class time, however, Helen chose to skip the first two problem sets that culminated in the derivation of the distance formula. Instead, she provided the students with the distance formula and led them through solving exercises from the book, including an exercise in which the students were to find a missing coordinate when given the distance between two points. The text provided only the positive solution for the coordinate, and Helen agreed with it that there was only one solution because it was a distance formula problem.[5] This lesson was improvised: The book's intention was to see the connection between the distance formula and the Pythagorean theorem. Instead, the students were taught the distance formula in isolation from the Pythagorean theorem. Also, Helen chose to use parts of two of the seven problem sets—those exercises that were procedural.

I observed Helen's class again during instruction on the 30-60-90 special right triangles. This lesson was an offload, although authority was offloaded to a *different* text, her previous geometry textbook (Larson, Boswell, & Stiff, 2001). Because Helen believed that her former geometry text did a better job than the Carnegie text of teaching the 30-60-90 side length ratios, she used the construction activity from that text (p. 550). After the students had constructed different equilateral triangles, the class created a table of side lengths and made conjectures about the relationships between the sides. Helen then pointed to the relationships already written

[5] There are two solutions to the problem. The coordinate could have been either positive or negative.

on the board and instructed the students to write the rules in their *Georgia Mathematics 2 Assignments and Skills Practice* (Carnegie Learning Development Team, 2009a) book. The teacher and class then completed exercises from this supplemental text together before the students worked on their own. For some of the later problems, such as to find the area of a right trapezoid (Assignments, p. 85; Figure 5), Helen provided the students with the area formula for a trapezoid and instructed them to use that particular formula to solve the problem.

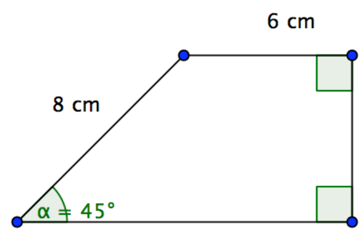

Figure 5. A special right triangle problem in Helen's class.

The last instructional day I observed on Unit 2 was a review of similar and congruent figures. This review was provided by the text authors to set up the study of the trigonometric ratios in the following lesson. Helen stated that when she tried to teach the tangent ratio in first block, she realized that her students needed additional work with ratios and similarity, so she decided to return to a skipped book section to practice setting up ratios. This last-minute decision led to Helen's offloading instruction to the text: She following the section problem for problem until class time ran out and then assigned problems from the assignments-and-skills-practice book.

Helen stated that her learning goals for her students were "that they understand the Pythagorean theorem, that they can identify special right triangles, and that they can understand really what the trig ratios are" (Interview 2). These goals indicated a mix of procedural and conceptual understanding. Helen also repeatedly stressed that these ideas could be easily applied and that, unlike her former geometry book, the Carnegie text did not have enough open-ended application problems for the students. Helen’s focus on connections in Unit 2 centered on connections of mathematics with situations outside mathematics rather than with connections within mathematics, for example, the relationship between the Pythagorean theorem and the distance formula. She showed an increased attention to representations for solving application problems and leading to conjectures. Classroom conjectures were generated based on tables of values determined from student constructions and measurements and led to the rules for the relationships between the lengths of the legs of special right triangles, linking the process standards of representations with reasoning and proof. I could not determine if the students understood these relationships or merely recited the rules for right triangles that had been written on the board before class began. So, although some of the process standards were evident in Helen’s implementation of Unit 2, her primary goal appeared to be the development of procedures and skills.

According to the mathematical tasks framework (Stein et al., 2000), Helen’s use of the tasks as set up and implemented with her students was primarily *memorization* and *procedures without connections*; however, her use of the construction activity would be a *procedures with connections* task. Rather than derive the distance formula, she provided it for her students and asked them to practice exercises. Also, her unquestioning acceptance of only the positive solution for the missing coordinate when using the distance formula shows a failure to connect what was being asked to the concepts underlying the problem.

Unit 3: Circles and Spheres

I observed Helen’s classes five times during Unit 3 instruction. As suggested by Eva, Helen spent the first day of the new unit reviewing vocabulary about circles. To accomplish this review, Helen gave the students a set of five words to look up in their glossary and then went over the definitions as a class. She repeated this process until the students had written the definitions of the terms in the unit. In some cases, she provided her own definitions because she did not like the ones given in the text. When students asked if they needed to draw pictures to correspond with the definitions, Helen responded, "If it would help illustrate for you what the definition means." Class ended with students completing exercises from their assignment-and-skills-practice book, illustrating the new terms. This lesson was an improvisation; although all the terms were in the first section of the Carnegie text, Helen chose a different approach for teaching the vocabulary.

The next 3 days, only 2 of which I observed, were meant to engage students in the paper-folding investigations (Serra, 1994) and part of the state frameworks tasks (Georgia Department of Education [GADoE], 2009). For the first two days, Helen's students completed the investigations, filling in the conjectures on the worksheets as they went along. In these investigations, Helen emphasized the investigations rather than the proofs of the conjectures, comparing what they were doing with what she believed is usually important in geometry: "Normally, in geometry, we would like to *prove* that a theorem is true, but that's not really what we're after. We're just trying to make some observations." Contrary to this statement, Helen, in Interview 3, said that proofs were not taught in the traditional geometry course, primarily because it was not assessed on the state end-of-course test. Helen stated that after the students completed the paper-folding investigations, she would provide them with a spreadsheet that summarized the investigations. This lesson was an offload; other than providing her students with circular objects to trace rather than requiring them to use compasses for creating their circles, Helen allowed her students to work through the investigations with no alterations in the activities.

When the students began the state tasks, Helen also planned to use practice problems from the text to allow them to apply what they were learning in the task. She was worried about the redundancy between the paper folding and frameworks activities. As the class went through the task together—about half of the class chose not to work on the task at all when Helen asked them to work in pairs—Helen drew pictures on the board to illustrate the class's conjectures and provided the students with a way to approach future problems: "We're going to often be trying to form a right triangle, so that we can use information and our knowledge of how to find lengths of sides and angles of a right triangle to work a problem." Because of continuing student misbehavior (e.g., students talking across the room, turning around talking to other students about nonmathematical topics, and getting up to walk around the room), Helen stopped working through the task and assigned the students to work practice problems, from the book, on the angle relationships. Because they had not yet discovered those relationships through the task, as intended, Helen listed the three "rules," with illustrations on the board (Figure 6). Although Helen had intended to use an offload to the frameworks task, allowing the students to work through task on their own, and then add in practice problems for homework, she ended up adapting the lesson. She used part of the frameworks, and then, rather than have the students discover the relationships among the angles and arcs, she provided the formulas. Student behavior was the primary factor affecting this decision.

On the next observation day, Helen's class continued working practice exercises using the rules in Figure 6. They reviewed the rules, and Helen added that the measure of a central angle is the same as the measure of its intercepted arc. After the review and warm-up problems, Helen assigned 26 additional problems for practice from the assignments-and-skills-practice book. Because I could not determine the origin of the lesson or of the first exercises, I classified this lesson as improvised.

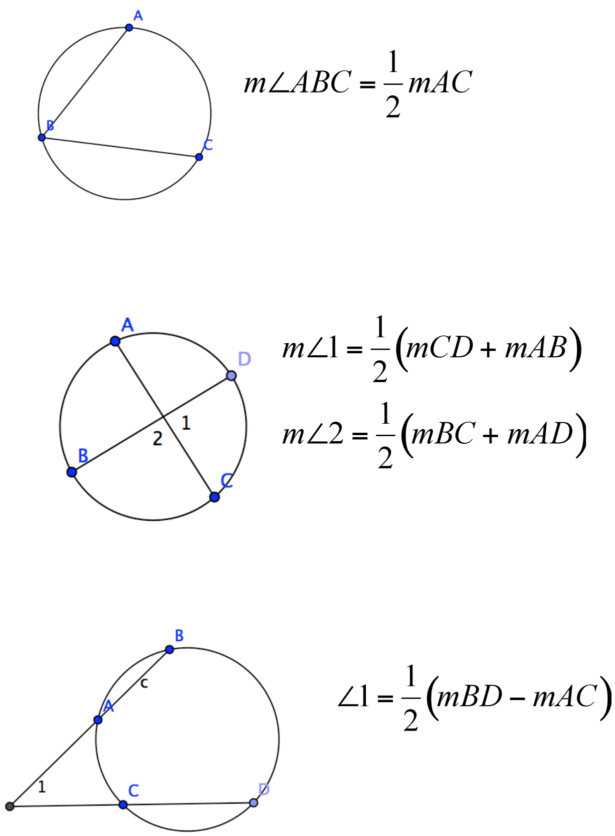

Figure 6. Circle angle and arc rules in Helen's class.

My last observation day coincided with instruction on arc length. For this topic, Helen offloaded her lesson to the Carnegie textbook. The warm-up for the day reviewed finding the circumference of a circle. During this activity, Helen stressed the difference between linear measure and angle measure as well as the importance of leaving π in their answers, both ideas emphasized in the text. Her stated rationale for not using the decimal approximation for π was that many standardized tests left π in the answers. The students had completed Problem Set 1 from the text for homework the night before, so they went over those problems after their warm-up. The students worked through the text on their own, coming together in the middle of their work to go over what they had done thus far. At the end of the lesson, Helen instructed the students to "put a star or highlight" by the formula for the arc length that was developed in the textbook investigation.

Helen attended to the process standards when they were included in the activity being used. For example, the investigations in the Carnegie textbook asked the students to write out explanations in complete sentences, and Helen expected her students to follow those instructions. She also consistently stressed the need for correct terminology and notation, even when that was not mentioned in the text. The connections between mathematical ideas and the outside world were evident in the paper-folding investigations, frameworks tasks, and arc length section of the Carnegie text; Helen did not bring in other connections, and by disregarding the frameworks tasks in favor of practicing problems with the formulas, she reduced the number of connections her students might make, as well as their opportunities to reason through why the relationships existed.

In terms of the mathematical tasks framework (Stein et al., 2000), the tasks, as implemented, by Helen in the circles portion of Unit 3 would primarily fall within the *memorization* and *procedures without connections* categories. However, the occasions in which she offloaded her instruction to the materials—use of the paper-folding investigations, frameworks tasks, and arc length section of the text—provided evidence of using *procedures with connections*. The lessons that were adapted and improvised were *memorization* activities—vocabulary and learning formulas—and *procedures without connections* activities—using the formulas.

Comparison of Implementation Across Three Units

Over the three units, Helen's materials appropriation was generally either offloaded or adapted. As Eva hypothesized while comparing her materials decisions with Helen's, Helen may have decided to engage in offloading because she had been told by Eva how good the Carnegie materials were. A number of instances in which Helen intended to offload to the Carnegie materials or the state tasks became instances of adaptations because of either lack of time, poor student behavior, or lack of preparation. The decision to offload or adapt (by not deriving formulas) may have also been a result of a lack of teaching experience or lack of confidence in teaching complex algebraic manipulations.

I classified the cognitive demand, as Helen implemented the tasks, primarily as *procedures without connections* or as *memorization* tasks (Stein et al., 2000). An exception occurred when Helen used, and supported the connections in, the Carnegie textbook or state frameworks tasks *as written,* in which case I labeled the task implementation as *procedures with connections*. Her attention to the process standards was minimal. Although she stressed correct notation and terminology, Helen did not focus on the connections across the topics or the reasoning behind the mathematics. In Units 2 and 3, she increased her use of representations, possibly because of her greater comfort with the content, geometry. If she felt more confident with the geometry content, that would also explain why she appeared to bring in more applications and critical thinking in the latter two units but focused more explicitly on skills and procedures in the first unit, quadratic functions.

Helen's implementation style might be explained by her classroom management problems and by her belief that, by reducing the tracking system, the state was "diluting our diploma." She stated that she felt "like students should pass if they can just demonstrate a basic understanding of what we're talking about," so she searched for differentiation strategies to use in both the Math 2 Support and the regular Math 2 courses. One strategy she used was to sit with students and help them take their tests; if she did not help them with their assessments, "There's no way they would ever pass. And we can't have half of our students not passing" (Interview 3). She might have viewed focusing on procedural understanding as a way to ensure that her students could demonstrate the basic understanding of the content in the Math 2 course. Helen's lack of teaching experience and focus on passing tests may explain her incongruent statements about using exact answers versus decimal approximations. In the circles unit, she advocated using exact values because that was how the answers would appear on tests, such as the geometry end-of-course test with which she was familiar. However, in the other two units, she encouraged her students to convert fractions and radicals to decimals, possibly highlighting her inexperience with end-of-course or other standardized tests that assessed algebraic topics.

Kasey Turner

Kasey's planning decisions were influenced by the new state curriculum, her understanding of the materials, and issues of reading comprehension and student motivation. She tended to offload instructional authority to the materials when she felt ill, but otherwise, she adapted and improvised lessons. This section describes her implementation of the available instructional materials.

Unit 1: Quadratic Functions

I observed Kasey's classes four times during Unit 1 instruction. Unlike Helen, who required 2 days to teach factoring quadratic expressions, Kasey both reviewed factoring quadratics with a leading coefficient of 1 and taught Bob's method in one day. During the factoring exercises, Kasey repeatedly stated that factoring was a process of undoing the distributive property and the distributive property was her favorite thing in math. Although she used the Planning for the Prom task in her first block class, she chose not to use it in her second block class; she did not think it was a helpful activity in the first class. Instead, after the second block students wrote their solutions to the warm-up problems on the board and discussed those solutions, Kasey moved directly to the area models for representing binomial multiplication. She reminded the students of the Planning for the Prom task from Math 1 and completed area models with the students, drawing attention to both the resulting factored and expanded forms of the quadratic. For example, Kasey gave her students an area model to fill in and asked the students to give the factored and expanded forms of the quadratic expression (see Figure 7).

	2*x*	**4**
6*x*		
3		

Figure 7. An example of an area model used in Kasey's class.

After the students completed the model and wrote out the factored and expanded forms of the quadratic expression, $(2x+4)(6x+3)$ and $12x^2+30x+12$, respectively, Kasey motivated the need for additional methods of factoring. She asked the students if they had ever factored a quadratic like this, to which the students said no, because the leading coefficient was not 1. Kasey then pointed out that such factorization was possible, as they could see from their area model. She spent the next portion of class on an activity she devised, in which she gave her students the inside of the area model and asked them to come up with the outside of the model—the binomial factors of the quadratic expression. I termed this activity the Inside-Out Game. In many of these problems, students were using the models to factor quadratic expressions with a leading coefficient other than 1, a fact Kasey pointed out to the students. For example, Kasey gave the students an area model (Figure 8) and asked them to find the factored and expanded forms of the quadratic expression. These problems came both from her own knowledge, as she created them during class, as well as from modifications of problems in the text.

$10x^2$	$15x$
$4x$	6

Expanded: $10x^2 + 15x + 4x + 6 = 10x^2 + 19x + 6$
Factored: $(2x + 3)(5x + 2)$

Figure 8. Determining factors of a quadratic expression, given an area model.

Like Helen, Kasey transitioned into Bob's method after working with the area models. She wrote the steps on the board and led the students through a few examples. In one problem (see Figure 9), taken from problems provided by Eva, a student completed a step incorrectly, but Kasey did not know whether the student's work would lead to a correct solution. The left column of Figure 9 illustrates the correct steps of the procedure. The second column represents the student's attempt at applying the procedure. Instead of removing the respective greatest common factors of 5 and 2 from each binomial, the student removed a greatest common factor of 10. Kasey did not know how to proceed at that point; she turned to me for advice on how to aid her student. I responded that, first, we did not know why the procedure was valid, but it might be possible to use a simple correction to the student's work if we did. Second, when applying the procedure, the student factored over the rational numbers rather than over the integers in her last step. Kasey pointed out this latter fact to the student, at which point the student completed the problem again, correctly applying the procedure.

$10v^2 + 53v + 36$	$10v^2 + 53v + 36$
$v^2 + 53v + 360$	$v^2 + 53v + 360$
$(v + 45)(v + 8)$	$(v + 45)(v + 8)$
$(10v + 45)(10v + 8)$	$(10v + 45)(10v + 8)$
$\cancel{5}(2v + 9)\cancel{2}(5v + 4)$	$\cancel{10}(v + 4.5)(10v + 8)$
$(2v + 9)(5v + 4)$	

Figure 9. Use of Bob's method in Kasey's class.

The next two observation days coincided with Kasey's instruction on determining the vertex of a quadratic function. The students completed the problems in the section, including developing a method for finding the vertex by using the *y*-intercept and the point symmetric to the *y*-intercept to first find the axis of symmetry; the equation for the axis was then used as the *x*-coordinate of the vertex and substituted into the equation to find the *y*-coordinate. The students would later use this form of the vertex substituted into the vertex form of the quadratic function to derive the quadratic formula. Throughout the exercises for determining the vertex, Kasey used graphical representations to help her students see the relationships among the characteristics of the quadratic functions. For the derivation of the formulas for the vertex of $y = ax^2 + bx + c$, Kasey led the students through the process they had practiced, concluding with a summary of their findings:

y-intercept: $(0, c)$ symmetric point: $\left(-\frac{b}{2a}, c\right)$

axis of symmetry: $x = -\frac{b}{2a}$ vertex: $\left(-\frac{b}{2a}, \frac{-b^2 + 4ac}{4a}\right)$.

When her students asked when they were going to use these formulas, Kasey directed them back to a warm-up problem in which the students had determined the characteristics of a quadratic function using other algebraic methods. She illustrated that by knowing these formulas, students could determine the characteristics of the quadratic could be determined much quicker than by using the method they had originally used. After this illustration, the students agreed that the formulas were cool; they were glad they had them. One student asked, "So that thing is universal? You can use it on any problem?" Kasey replied, "As long as it's in the form of $y = ax^2 + bx + c$." The students spent the remainder of the class practicing using the formulas to determine the characteristics of the quadratic functions.

On the final instructional day I observed, Kasey taught the vertex form of a quadratic function and transformations of functions. Although she did not ask the students to follow along in the book, she used problems from the text and used graphing calculators to illustrate that standard form and vertex form graph the same parabola. She reminded the students of their knowledge of vertex form from Math 1; this basic form had been used in the study of quadratic and cubic functions with leading coefficients of 1 and with absolute value functions. Kasey also gave her students lecture notes about the effects of changes in the parameters in each form of the quadratic on the graph of the function. The students then practiced converting between forms.

When I asked about her student learning goals, Kasey said, she "wanted them to be able to look at a quadratic in either standard form or vertex form and be able to tell me everything about the graph. And the vertical motion problems ... to make connections with what's going on" (Interview 1). These goals were evident in her classes, as she often used graphs to help students answer questions about the characteristics of a quadratic function. For instance, during a warm-up problem in which the students were to use the midpoint formula to find the equation of the axis of symmetry given two symmetric points on the parabola, Kasey drew a parabola and a horizontal line connecting the two symmetric points to illustrate that the midpoint of the horizontal line determines the equation of the axis. Kasey also stressed correct mathematical language to describe processes. She rejected the acronym FOIL (First-Outside-Inside-Last), preferring instead to focus on using the term *distribute* to describe how to multiply binomial expressions. Her rational was that FOIL was confusing for students: "It only works for binomials, but that's not what you're always going to have. You can just learn the distributive property, and it works for everything" (Interview 1).

Despite her general focus on understanding mathematical processes and making connections between graphs, equations, and applications, Kasey's desired student outcomes seemed procedurally driven. Although she built up the idea of factoring quadratics with a leading coefficient other than 1 through the use of area models, she taught factoring in a procedural manner. As she stated, "I can't think of a way to do it nontraditionally" (Interview 1); I interpreted this statement to mean that she taught factoring using a procedural, rather than a conceptual, approach. This interpretation is supported by Kasey's reflection on her prior implementation of Math 1; she stated, "I also taught factoring in a more traditional way because I was unclear about how the students would learn how from the task" (Survey response). Teaching factoring procedurally seems a reasonable action for Kasey, given that she indicated, on the survey, a belief that students needed to master basic skills before tackling complex problems. This belief was shared by 16 of the 21 regional teachers surveyed. She also walked her students through the derivation of the formulas for the coordinates of a vertex, but stated that once her students had these formulas, they did not need to remember the conceptual ways of calculating the vertex.

Kasey's materials use during the observed classes from Unit 1 was primarily offloading and improvising. However, during offloading occurrences, the intended implementation called for small group interactions instead of the whole class method used by Kasey. Although she often went through the exercises with the students, Kasey continued to ask her students to explain why the answers were correct and how to calculate the answers. Rather than adapt the suggested activities in the text or the Planning for the Prom task, Kasey chose to take the ideas from those activities and create her own activities. Because she did not believe Planning for the Prom to be helpful, she, on-the-spot, developed a new activity for a similar purpose. However, for the section on transformations of functions, Kasey may have improvised because the text suggested using the quadratic formula to complete a number of exercises, but the quadratic formula had not been presented yet. On a related note, she may not have understood the rationale for the text's presentation.

Kasey attended to the representations, connections, and reasoning and proof process standards. She focused on students' understanding where formulas came from and how those formulas and processes are related to the graphs of quadratic functions. Once these ideas had been addressed in instruction, however, she did not necessarily expect them to be used during student practice. The one exception was in completing the culminating task, in which students were required to explain how their answers related to the graphs and contexts presented in the problems. Upon reflection, Kasey recognized a need to increase her focus on students making connections: "I don't think that they made all the connections that they should have. I would focus more on the connections than on the work" (Interview 1).

Because the Carnegie text developed mathematical procedures through the process standards, when Kasey offloaded materials use to the text, I considered her instructional tasks as *procedures with connections* (Stein et al., 2000). Similarly, when she offloaded authority to Bob's method, I classified her instructional tasks as *memorization* because learning that procedure was a memorization activity. Having taught factoring in a second-year algebra course using a guess-and-check method, she thought that the procedure was much easier and would reduce student frustration.

I did not discern a clear picture of how Kasey chose to improvise her lessons. Instead of using the Planning for the Prom task, a *doing mathematics* task, she opted for her Inside-Out Game, potentially a *procedures with connections* task. She believed the game would be more fun than using what was in the text. Her “point in [using] the game was since they had never done factoring with a coefficient greater than one before, and they see, hey, it can actually be done, and this is what it looks like” (Interview 1). However, because she used Bob’s method, she did not know if her students really made the link between the game and factoring; therefore, it may have been reduced to a *procedures without connections* task.

Unit 2: Right Triangle Trigonometry

I observed Kasey’s second block class three times during Unit 2. Instruction on the first observation day began with the Well Problem, from the previous section on the Pythagorean theorem, written on the board.

> 1. Calculate the depth of the water in a ground well using the following clues.
>
> Clue 1: You place a stick vertically into the well, resting against the inner well wall and perpendicular to the ground. The stick touches the bottom of the well with an 8-inch portion of the stick above the water.
>
> Clue 2: Without moving the bottom of the stick, you rest the top of the stick against the opposite wall. The top of the stick is even with the surface of the water.
>
> Clue 3: The diameter of the well is 36 inches.
>
> (Adapted from *Georgia Mathematics 2 Student Text*, 2nd ed., Carnegie Learning Development Team, 2009b, p. 179)

Rather than direct the students to the textbook problem, which provided a picture of the situation, Kasey increased the cognitive demand of the task in her implementation: She engaged the students in a discussion about the terms in the problem, how to draw an accurate picture, what they needed to do to solve the problem, and then how to solve the problem using algebra. She provided the students with a similar, teacher-made problem for them to do on their own. The class continued by connecting the Pythagorean theorem to the distance formula, as directed in the text; however, they did not review the midpoint formula as directed because Kasey believed her students already knew that content. The students then worked distance and midpoint formula problems from their assignments-and-skills-practice book.

The next day, Kasey was not feeling well and had already planned to use the book for her instruction on 45-45-90 right triangles. She began by answering questions about the homework from her students, which were primarily questions about how to determine the coordinate of one of the points when given a distance or midpoint between two points. Like Helen, Kasey dismissed the possible negative value of the coordinate when using the distance formula because it was a distance problem and distance is positive. She then proceeded to follow the textbook section completely, offloading instruction to the text.

On the final instructional day, Kasey used the textbook to teach the tangent, sine, and cosine ratios but required her students to take notes in their notebooks. During the tangent section, the class made the connection between the slope of the hypotenuse of a right triangle and the tangent ratio. Kasey stated that the students had "three fun things to learn" that day before providing them with the formal statement of the definition of *tangent* and continuing with application problems. The students took notes on the definitions of the sine and cosine ratios, followed with practice problems from the text. Although she combined three sections into one day's lesson, Kasey's material use could be classified as adaptation. The only parts skipped in these sections were the introduction problems in the sine and cosine sections; she retained the conceptual understanding, connections, and application problems, often infusing context into the problems as a way to make them more relevant to her students.

Kasey's materials use in Unit 2 was primarily adaptation. The adaptations were a result of a lack of instructional time, a fear of boredom for both her and her students, and her desire to increase her students' critical thinking skills. Adapting text problems to require students to understand the problem in order to draw the picture showed a focus on critical thinking skills and a desire to improve her students' ability to understand application problems. However, a more prominent theme was her feeling that everyone, she and her students, was tired of the textbook.

When describing her Unit 2 learning goals, Kasey said she hoped that her students knew the ratios and the special right triangles, but that they also knew properties of the trigonometric ratios and how to solve triangles using the ratios. She stressed connections and representations in her instruction. She used problem-solving tasks (e.g., the Well Problem) to encourage her students to think about situations that could be solved mathematically; then they created representations to aid in solving the problems. These types of tasks also helped the students make connections between mathematics and the real world. However, Kasey also stressed the connections within mathematics, as directed by the textbook, such as between the Pythagorean theorem and distance formula, between tangent and slope, and between the ratio of sine and cosine and the tangent ratio.

Kasey's focus on connections within mathematics led me to classify the majority of her implementation of tasks as *procedures with connections*. This classification seems reasonable; the text generally presents *procedures with connections* tasks, and Kasey used or enhanced the tasks in the book. Further support is provided from Kasey's reflection on a bonus problem on her quiz that asked students to develop their own mnemonic devices for remembering the trigonometric ratios: "I know they help, but I—I'd rather them just remember it instead of memorizing a little saying" (Interview 2). Although she wanted her students to understand the ideas, she knew that the pace of the course might mean that some students needed "memory tricks" to remember content.

Unit 3: Circles and Spheres

During the first observation, Kasey provided her students with definitions of the terms needed for their circle unit. As she sat at the front of the classroom, writing and illustrating the definitions on the overhead projector, the students copied the definitions and answered questions she posed, such as “What is the difference between a secant and a chord?” Her list of terms and their definitions came from the skills practice section of their assignments book. After completing the list of definitions, the students completed the same skills practice page, along with three other pages to illustrate their understanding of the terms. This lesson was an improvised lesson to accomplish a specific goal: to prepare the students for the unit on circles.

The second and third days of the unit were spent on the Patty Paper Investigations (Serra, 1994). Kasey instructed her students to start a list of their conjectures, which she referred to as *theorems*, when they completed the investigations. She then assigned pages from the assignments book that would allow the students to apply some of the theorems they discovered in the investigations. This lesson represents an offload of instructional authority to the investigations.

The final two observations represented additional examples of materials offloads. One day, she offloaded to the McDougal Littell Math 2 textbook (*Georgia High School Mathematics 2*, 2008), and the next day, she offloaded to the Carnegie textbook. The first of these days she addressed the angles formed by lines and segments in circles. She provided her students with two theorems about tangent and secant lines and how they influence the angle measures in circles:

> If a tangent and a secant, two tangents, or two secants intersect outside a circle, then the measures of the angle formed is one half the difference of the measures of the intercepted arcs.
>
> If a tangent and a chord intersect at a point on the circle, then the measure of each angle formed is one half the measure of its intercepted arc.
>
> (*Georgia High School Mathematics 2,* 2008, p. 212)

As they discussed the theorems, Kasey helped the students understand the theorems, asking questions about terminology and what the students thought the theorems meant, drawing pictures to accompany the theorems. She then assigned practice problems out of the McDougal Littell textbook. She said that one of her reasons for using this text was that it had problems that required the students to find out additional information about the circle before finding the answer (e.g., the problem in Figure 10 from *Georgia High School Mathematics 2*, 2008, p. 214), unlike the Carnegie text, which seemed to have simpler, one-step exercises.

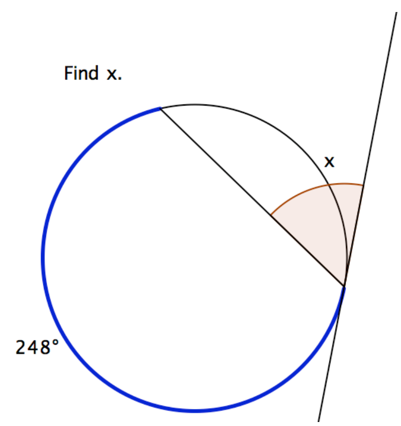

Figure 10. A circle arc and angle problem from Kasey's class.

The last day of observation was similar to Helen's last day: Kasey went through the arc length section of the book with her class. Generally, the class talked through the section together, with Kasey providing the students with 20 minutes to work through developing the arc length formula with the investigation in the text. When going over the formula, Kasey stressed the importance of students understanding the formula and remembering it in a way that made sense to them.

> Kasey: You were just completing a generalized statement about how to find this [arc length]. … They said [reading from the book], "The arc length of minor arc AB is the measure of arc AB over 360 times" what?
>
> Student: The circumference.

Kasey: The circumference, which is given by?
[Different students give answers of $2\pi r$ and πd]
Kasey: Two times π times r. So in that blank, you could write $2\pi r$ or πd. … Some of you wrote the word *circumference*.
Student: Well, what do we write?
Kasey: $2\pi r$, or like you did, circumference. …That's fine with me. I just want you to understand how to do this. I'm not really picky about which way you remember it.

The students finished class by working on practice exercises from their assignments book.

Kasey's attention to the process standards sometimes mimicked what was stressed in the materials she was using. However, she continued to stress the use of representations and reasoning, even when they were not evident in her materials. Each definition or theorem I observed Kasey discuss with her class was accompanied by a diagram to help the students better understand the idea. Her focus on reasoning was apparent when she discussed solutions with her students:

> There's a bunch of ways to do these. If you didn't do it the way we did it up here, it's okay. Let me know, so we can make sure it's not a coincidence. But there's many, many ways to find the same thing.

She had expressed this sentiment in an earlier interview:

> A lot of them are scared to mess up. … So I think that's been hard, that they're just lacking in confidence and really think that in math there is one right answer. That's a big misconception: [that] there is one right way to do everything. Because I've seen kids that have a problem worked out one way, and then we start to go over it, and we started it a different way, but the ultimate result was the same thing. And it's just a different method to do it, and they'll just erase everything they had and just copy the one example that we had on the board. And that's been hard to be, like, "No, no, no, you can do it that way. But you did it THAT way." It's just, just getting them to see there's more than one way to do things, that it's okay to make mistakes, and that it's really about the method instead of the final answer. (Interview 2)

Kasey wanted her students to reason through mathematics and make sense of it in their own way, and she wanted them to have confidence in their own mathematical ability.

In terms of the mathematical tasks framework (Stein et al., 2000), Kasey's implementation was similar to Helen's, falling primarily within the *memorization* and *procedures without connections* categories. However, the occasions in which Kasey offloaded her instruction to the paper-folding investigations and arc length section of the text provided evidence of using *procedures with connections*. The additional lesson offloaded from the McDougal Littell text as well as the improvised lesson on vocabulary were *memorization* activities—vocabulary and learning formulas—and *procedures without connections* activities—using the formulas. Part of this implementation style might be explained by Kasey's inexperience with teaching geometry. She also wanted her students to see how to use the theorems.

> They did okay with the, like, they knew the—they knew, like, the theorems, and they could tell me that. And then I'd be like, "If you're missing that piece, how do you find it?" And they couldn't switch back and do—. "Show me algebraically how you would find it, find the number." And they would be, like, "I know the rule, but I don't know how you would possibly get that number." So, that's why I was, like, "we need to work on practice problems." That's important also. (Interview 3)

Kasey believed that her students understood the geometric ideas in Unit 3 but needed additional practice translating those ideas into algebraic equations. She also thought that the algebraic manipulation of solving these types of exercises was a weakness for her students, indicating a need for additional practice.

Comparison of Implementation Across Three Units

In the first two units, Kasey primarily adapted and improvised her lessons; however, in the geometry unit, she tended to offload instructional authority to the text she chose to use. Because she had taught Algebra 2 and Trigonometry while student teaching and thought that she was not good at geometry, she may have been more comfortable with the content in Units 1 and 2 than the content in Unit 3. The improvising and adapting Kasey did in these units increased the critical thinking required in, connections in, and applicability of the lessons. However, she was not always able to carry the connections from her improvised activities into the planned, offloaded activities; for example, from the area model Inside-Out Game to factoring quadratic expressions. In the circles unit, after using the paper-folding activities, Kasey offloaded instruction to both the Carnegie textbook and McDougal Littell textbook, usually focusing on skill development.

Another difference that might be attributed to Kasey's treatment of algebraic versus geometric topics was her desire for "straightforward" factoring problems in Unit 1 but for multi-step problems in Unit 3. Although Kasey used lots of connections in the quadratics unit, she was not able to, or chose not to, connect factoring to graphs or area models. This absence of connections indicated that she might have a procedural understanding of factoring; therefore, Bob's method was a good teaching strategy for her. Further, her students needed—or possibly, she needed—exercises that allowed them to work only with the new procedure and not other mathematical ideas such as distributing terms and simplifying expressions. Similarly, because she might not have been comfortable with the content in Unit 3, Kasey may have felt the need to assign more complex exercises so that she, too, could practice applying the theorems. Alternately, Kasey may have preferred the skill development problems because she saw their value in enhancing her students' abilities to solve algebraic problems, a skill she deemed important. This latter hypothesis is further supported by her response to a survey question; Kasey agreed that students should master basic procedures before approaching complex problems, commenting, "Students can see vague ideas without knowing basic skills, but it is really hard to implement those ideas without the basics."

When Kasey stressed the process standards of representations, connections, communication, and reasoning and proof, which occurred to the greatest extent in the first two units, her initial task implementation was *procedures with connections* (Stein et al., 2000). However, after her students had opportunities to see the connections, often investigating the connections or deriving formulas on their own or as a class, there was a shift to *memorization* and *procedures without connections*. For example, after the students had learned the formulas for calculating the coordinates of the vertex of a quadratic function, Kasey no longer expected them to indicate the concepts used to develop the formulas; she was content for them to use the formulas.

Eva Sailors

Eva's planning decisions were influenced by her beliefs about mathematics and mathematics teaching, as well as by her past experiences. She tended to improvise lessons based on her students' comments and the mathematical connections she saw in those comments. Some decisions were also influenced by her collaboration with Matt, Helen, and Kasey. This section describes how Eva implemented instructional materials with her students.

Unit 1: Quadratic Functions

I observed Eva's class on the second, fourth, seventh, and eighth days of Unit 1 instruction. Matt was the primary teacher on Days 2 and 8, with Eva providing clarification when needed; Eva taught the class the middle 2 days. During my observations, the students studied determining the characteristics of quadratic functions, different methods for finding the vertex of a parabola, converting between the two forms of a quadratic equation, and transformations of quadratic functions.

To begin Day 2, Eva asked her students what they had learned the previous week, to which a student replied "a new way to factor," which in turn helped them locate the vertex of a quadratic function. Eva then asked how factoring related to roots and how to find the vertex using factoring. When no one answered, Eva asked the students to find the *x*- and *y*-intercepts of a simple quadratic function. They plotted the intercepts, and a student suggesting averaging the

x-intercepts to locate the vertex. After the students found both coordinates of the vertex, they graphed the parabola. They continued by practicing these types of problems until Matt took over to give notes on Section 1.5, determining the vertex of a quadratic function. Matt projected his teaching notes on the overhead and showed the students how to determine various characteristics of quadratic functions. He also showed the students the different forms of a quadratic equation and how to identify the vertex in the vertex form. He then asked them to graph functions taken from the beginning of the section to help them see the effect on the graph of changing the a and c terms of the standard form. Next he gave the formulas for the vertex of a quadratic function in standard form. Finally, he gave the students a worked-out example of using the y-intercept and its symmetric point to determine the vertex of the quadratic function, the process that the text intended to use to derive the formulas he had provided.

When Eva taught class on Day 4, she reviewed the three methods for finding the vertex of a quadratic function using reasoning and graphical representations. In trying to help her students make wise decisions about which method to use, Eva asked the following series of questions: "Can we find the factored form? Can we find the x-intercepts? Can we find the y-intercept? Can we have more than one y-intercept? Why not?" This exchange led to using the y-intercept method for finding the vertex. To illustrate the idea of the symmetric point, Eva used paper folding. The students then completed the problem. They worked on problems taken from the book, but they were asked to follow different instructions; they needed to find the factored form, the x- and y-intercepts, the symmetric point, and the axis of symmetry and then determine if the vertex was a maximum or minimum and the intervals in which the function was increasing or decreasing. For one of the problems completed as a class, Eva first graphed the function to determine which method they should try. Because there were no x-intercepts, the students narrowed down the possible methods, for example, they would not try to average the *x*-intercepts because there were none. As Eva stated, "Our job is to give you choices and tools so you can make decisions." For homework, she asked the students to write an essay explaining the characteristics of a quadratic function and how they could use algebraic methods to determine those characteristics.

Again on Day 7, Eva reviewed the three methods for finding the vertex of a quadratic function as well as converting between the forms of a quadratic. In addition to going through the methods, Eva asked her students to graph the function on a calculator to find the quadrant of the vertex. They used the graph to determine if their answers, especially when using the formulas, were reasonable. She continued to stress the use of graphs to determine the reasonableness of their results.

Matt taught transformations of quadratic functions on the last observation day. It appeared that he adapted what was in the text into a differently ordered presentation of facts about the transformations. As Matt continued through his presentation, Eva stopped him to suggest that he allow the students time to investigate the parameters. After the students practiced identifying basic transformations, Eva again reviewed the three methods for finding the vertex and their connections to each other and to the graph of the quadratic function.

Eva was clear and consistent in her learning goals for her students:

> I wanted my students to make connections between representations and solutions to quadratic equations, and to the vertex, and to the symmetry. I just wanted the big picture, to see it all. Like I wanted them to see the connections between the methods: "Like why is averaging the *x*-intercepts, why did that give you the vertex? And why does using the *y*-intercept and its symmetric point, why does it also give you the vertex? What do these two methods have in common?" And [I want] them to be able to use wise choices about which method to use and be able to back that up with some rationale of this is why I did that. (Interview 1)

She believed that "making connections between representations" helped students make sense of the mathematics, helped them see the big picture. As Eva stated on her survey, "I believe when students can connect their solution path(s) with those of their classmates that are different. ... This creates rich mathematical connections and understanding." Like only two other survey respondents, Eva focused on conceptual over procedural understanding:

> I feel that necessary procedural skills should be addressed, as they are needed in a complex problem. I would rather get to a point in a problem where we need to add rational expression[s], stop there, introduce/review/practice the skill and then apply it back to the problem. When students see the need for the procedure, it is more meaningful.

Throughout the lessons, Eva stressed reasoning through answers and procedures, making connections among ideas, using representations to aid mathematical understanding, and engaging in effective mathematical communication. For example, to determine the vertex of a quadratic function, Eva expected her students to use a calculator to find the vertex and then to provide two mathematical ways to prove that the vertex given by the calculator was correct. This approach required the students to be able to explain their reasoning and connect their algebraic work to the graphical representation. Also, Eva expected her students to be problem solvers who could determine the appropriate strategies to use in a given situation. The process standards, although not named as a group, played a significant role in Eva's view of mathematics as well as in what she expected of her students.

My classification of Eva's materials use during Unit 1, based on the days observed, may not provide an accurate view of her materials appropriations. Her student teacher, Matt, tended to have an adaptation approach to the textbook. When he began teaching a section, he stated the objectives from the text but often rearranged the presentation of material; more specifically, he provided students with the rules and formulas that were developed in the section before asking them to look at the problem sets in the text. According to Eva, she and Matt planned together, but what they discussed was often not implemented. As a result, when she taught the class, Eva's materials use could be classified as improvisation; she would "either pick up that same day or the next day sort of reviewing what he said in a much more conceptual way" (Interview 1). She felt that Matt was "sort of teaching from skills, and I'm trying to come back and say, this is how they are connected" (Interview 1).

The activities conducted by Eva, although not composing new lessons, would generally be considered *procedures with connections* tasks (Stein et al., 2000). Unlike her colleagues, Eva did not favor the use of memorized formulas. Although Eva agreed to teach the factoring procedure Helen demonstrated during the planning meeting (Bob's method), Eva worried that her students did not really know what they were finding. However, when discussing the three methods for finding the vertex of a quadratic function—averaging the x-intercepts, using the y-intercept and its symmetric point, and the formulas for the coordinates—Eva happily reported that her students did not usually opt for the formulas. Helen and Kasey were content with their students using the formulas; Eva, on the other hand, preferred that her students use reasoning, connections, and representations. She also expressed a concern over spending so much time on the quadratic formula: "I just think we have so many other cool methods for finding zeros that I don't see why it's so important" (Interview 1). When it was necessary to provide a formula, Eva stated that she did not "like to just give them any [formulas]. But I hope with that with every formula ... that we've made connections from numerical examples, that we've build from specific to general" (Interview 1). Hence, she tried to connect the procedures for deriving the formulas to the mathematics underlying the formula.

Unit 2: Right Triangle Trigonometry

Eva taught Unit 2 without the student teacher; therefore, unlike Unit 1, all of the planning and implementation decisions were Eva's. The first of four observations, the third day of the unit, began with Eva reviewing homework problems on the Pythagorean theorem. Although Eva intended to move to the next section, the connection between the Pythagorean theorem and the distance formula, discussion with the students led to additional discussion about ratios and the relationship between the slope of the hypotenuse of a right triangle and the tangent ratio. After reviewing the homework problems, Eva asked the students to make observations about two given right triangles. Observations included noting the tilt of the hypotenuse and that the length of the segment opposite an angle made the angle more acute or more obtuse. The students were then challenged to write a sentence in their groups to describe the differences between the angles and why those differences existed. After a few students shared their sentences, Eva challenged the students to draw a variety of triangles whose hypotenuses had different slopes. Reflecting on the lesson, Eva said,

> Going from Pythagorean theorem to tangent that day was not intentional. Making very explicit connections between slope of a line and tangent was really important to me. So I knew going into this unit that was something that I really wanted to come out of it. So when the opportunity presented itself on that first day, you know, it wasn't like I just said, "Oh, that's a cool idea." I knew that was the most significant part of this unit for me. So because the conversation turned that way, I took it there. It wasn't intentional on that day but it was intentional big picture. … It was so beautiful, so much better than I could have planned. (Interview 2)

After their discussion, the students were assigned to work through the textbook lesson on tangent—content they had already discussed.

On the next observation day, Eva led the class in a discussion of the definition of the tangent ratio, the relationship between the tangent ratios of the two acute angles in a right triangle, the relationship between the tangent ratios of corresponding angles in similar triangles, and the definition of *inverse tangent*. While reviewing specific problems from the text, problems the students should have completed for homework, Eva, coming upon a problem about isosceles right triangles, stated, “If you can find ML and QP [the hypotenuses in the triangles], we can skip a whole section.” They worked through those problems, addressing the required content about the 45-45-90 special right triangle. Again, reflecting on the unit, Eva explained why she placed little emphasis on her students learning the special right triangle rules:

> I knew that I didn’t really care so much about special right triangles. I just think, what is the point? I mean, I can see the point when they’re going to develop the unit circle. But if you want to solve a triangle, isn’t that what we’re about to learn, is all the skills to solve for any missing side or angle? … So I knew that that section I was either going to miss or just kind of blow over. (Interview 2)

This is exactly what Eva did; she addressed the 45-45-90 triangle side lengths while teaching the tangent ratio but she did not teach the 30-60-90 side ratios during any of my observations.

The primary activities on the next two days were assessing the students’ understanding of isosceles right triangles and initial instruction of the sine and cosine ratios. Day 7 included a practice quiz with questions such as “If the perimeter of an isosceles right triangle is $8+4\sqrt{2}$, what is the area?” and “A square has an area of 25. What is the length of the square’s diagonal?” These were not questions the students had previously encountered. After discussing the practice quiz, Eva provided the students with the definitions of the sine and cosine ratios, told them to read about them in their book, and assigned practice problems. In a later conversation, Eva indicated to me that she believed her students could learn about 30-60-90 triangles from one of the homework problems.

I considered the majority of the instruction on this unit as improvisation. Although Eva began the unit with Section 3.1 in the textbook, she then moved to the content in Sections 4.1 and 4.2, back to Section 3.3, and then finished with Sections 4.3 and 4.4, but she rarely used the text to guide her actual instruction. Because her initial departure from the text grew out of classroom discussions, Eva continued her instruction in what she deemed was a logical order. She realized that this could be confusing for students:

> I'll change direction in the middle of a lesson, which I think could be good, and then sometimes it could be really confusing for kids. … Sometimes it's not as linear and there's not a great conclusion. I think that's the way I think about mathematics, is this connects to this and to this and to this, and that's the part that I love about mathematics, so I get a little carried away sometimes in class. (Interview 2)

However, her reliance on the text for her students' learning about the sine and cosine relationships represents an instance of offloading instructional authority to the text. Considering her other statements, I think it is possible that Eva did not deem these ratios to be as important as the tangent ratio and, therefore, chose to spend less class time on those ratios.

Eva's implementation of this unit and her focus on the big ideas in mathematics highlight her focus on conceptual understanding and, in particular, the importance of mathematical connections, reasoning, and communication. Her students were expected to connect ideas in the unit through reasoning and representations and to communicate orally in their groups and in written assessments. Further, she did not see value in teaching topics that do not connect to other topics being studied. For example, she did not understand the point of teaching the special right triangles unless they were being connected to the unit circle, a topic not addressed in Math 2. She also downplayed procedural skills that she felt unnecessary, such as rationalizing denominators of radical expressions. I classified Eva's implementation of tasks in this unit as *procedures with connections* (Stein et al., 2000). The one exception would be learning the sine and cosine ratios. Also, Eva never listed the rules for the side lengths of the special right triangles or the distance formula; instead, the class problems required the students to make sense of the relationships and to use reasoning to answer the questions about those topics.

Unit 3: Circles and Spheres

I observed Eva's class five times (Days 2, 3, 4, 6, and 7) during Unit 3 instruction, but she was absent on Days 2–4, leaving instruction up to her student teacher, Matt. So as was the case with Unit 1, little data are available about Eva's implementation of this unit. Eva planned the lessons, using the Patty Paper Investigations (Serra, 1994) and the *Mathematics II, Unit 3: Circles and Spheres* (GADoE, 2009) tasks, and Matt implemented the activities with the class. Because Eva chose the activities for this unit and left them for Matt to implement, it might be reasonable to assume that, had she been teaching, she might have offloaded instruction to these materials. However, during her second interview, which was held the day before Unit 3 instruction began, Eva was unsure how she wanted to teach the unit:

> And then we're going to take those theorems and go to the tasks. And the tasks sort of have them discovering the theorems, and then there's a lot more application of it. So we're trying to decide, or I'm trying to decide, whether we're going to go through the patty paper investigations and develop a list of theorems and then go do the tasks. Or come up with a few theorems and then go work on the tasks that connect. There's not a very good one-to-one relationship between them. I think it would be really fun to just do this really open-ended investigation and come up with some theorems. You know, they know some geometry. They'll be able to prove some of these theorems. And then go to the tasks, and we can make the tasks however we want. We can give them little pieces of it because they will have already investigated it. I'm really looking forward to it. (Interview 2)

When Eva returned to school, she worked across the sets of materials—the paper folding, the state tasks, the Carnegie textbook, and the McDougal Littell textbook. Therefore, I wonder if all of the instruction on Unit 3 might have been an improvisation of materials, with each day's instruction having a particular purpose (e.g., determining and applying different methods for finding the center of a circle) but utilizing a variety of materials interchangeably.

The sixth day of the unit was the first day I observed Eva teach. She began by reviewing four of the theorems from the paper-folding investigations. She then provided her students with exercises from the McDougal Littell textbook that would allow them to apply these theorems. For example, the last two theorems discussed were the following: “Tangent segments are congruent when they share a point external to the circle” and “A line is tangent to a circle if and only if the line is perpendicular to the radius at the point of tangency.” Eva asked the students to complete problems that integrated algebra with the geometric theorems (*Georgia High School Mathematics 2*, 2008, pp. 186–187; see Figure 11). After beginning the first problem and writing the equation $56^2 + x^2 = (x + 32)^2$, which reduces to a linear equation, Eva said, “That makes me kind of sad, because, now, we don’t have a quadratic to solve. Boo. I thought we were going to have a quadratic.” This statement indicated that Eva had not prepared for the lesson; she had planned what materials to use but had not worked through the materials herself. Eva wanted to assign a problem that required the students to solve a quadratic equation, providing her an opportunity to review ideas about quadratic functions with her students. So she was happy when she worked the second problem, which did require the students to solve a quadratic equation: $2x^2 + 3x - 2 = 3$.

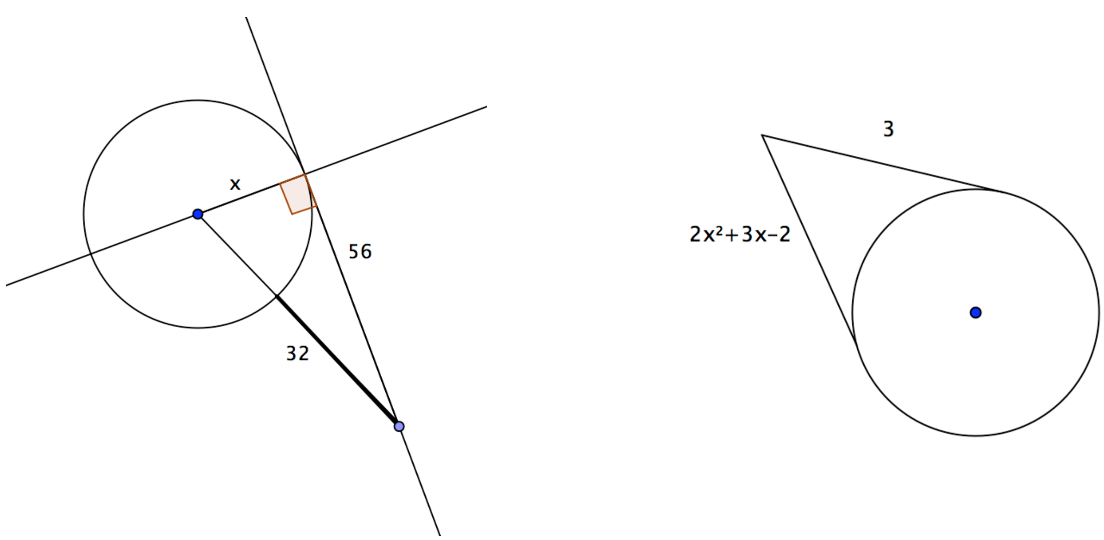

Figure 11. Circle tangent problems in Eva’s class.

Comparison of Implementation Across Three Units

In all three units, Eva typically improvised the lessons as they were presented in the materials used. When she chose to offload authority to the instructional materials, she did so for one of two reasons. First, because of the wealth of materials available for teaching the GPS, Eva expressed a desire to use some materials without adapting them during her first use; therefore, she may have chosen to use them, for example, the Unit 3 state frameworks tasks, without altering them. Second, there were specific topics in the Math 2 curriculum that Eva explicitly categorized as not as important for her students to learn as other topics: the quadratic formula (unless they were working with imaginary numbers), rationalizing denominators, and the special right triangle relationships (unless they were related to the unit circle).

I hypothesize that this latter reason provides insight into Eva's decision to use Bob's method, the factoring procedure Helen introduced. Using a procedure that she can not connect to the underlying mathematics was atypical for Eva. However, she did not view factoring quadratics to be important for her students:

> Most of what we want is approximation of roots anyway. So if you can find them on the calculator, I don't guess it really matters which method you really use. ... It was one of those things that felt like a waste of time, doing all of that by hand. (Interview 1)

Eva was concerned that the students did not understand what they were finding when they used Bob's method; Matt did not require the students to check their factorizations by multiplying the binomials together. Therefore, Eva did not think the students connected Bob's method with multiplying binomials.

In every class I observed Eva teach, I classified some of the tasks as requiring *procedures with connections* (Stein et al., 2000). Although she selected other tasks that could be considered *doing mathematics* tasks, Matt often implemented those tasks. Because Eva attempted to stay on pace with the other teachers and use the text and state tasks—lessons and tasks that I previously classified as *procedures with connections*—it is reasonable that her instruction had this level of cognitive demand. Eva's implementation of higher-level cognitive demand tasks (*procedures with connections*) was not surprising given her desire for more open-ended tasks to use with her students, tasks that would be classified as *doing mathematics* tasks, and given that she openly criticized the Carnegie textbook and the state frameworks units as not being open-ended enough.

The cognitive demand of the tasks Eva implemented reflects her attention to the process standards. Higher-level cognitive demand tasks require students to recall mathematical connections, use problem solving, employ a variety of representations, and use strategic reasoning, and Eva's implementation stressed all of these process standards, as well as communication. More so than Helen and Kasey, Eva focused on providing her students with different ways to think about the mathematics—using representations and various connections, understanding how different methods for determining the same value were related, and understanding how to make strategic decisions when choosing solution methods. She also required her students to discuss and write out their understanding of the mathematics and the connections among the ideas being studied, stressing the importance of communicating one's knowledge to one's teacher *and* peers. Eva chose and used tasks that would help her build mathematical connections, use representations, and provide opportunities for making strategic decisions, reasoning about mathematics, and communicating her students' mathematical understanding.

CHAPTER 6

ADDITIONAL RESULTS AND DISCUSSION

The previous two chapters described the three teachers' selection of materials and their implementation of the curriculum using their selected materials in isolation. In this chapter, I compare the teachers' general materials use, from planning to implementation, and hypothesize possible reasons for the patterns I found. Additionally, I relate the decisions of the three teachers to findings from others' research. A summary of the findings from chapters 4 and 5—each teacher's materials selection, evaluation, and implementation—is provided in Table 3.

Table 3
Summary of Planning and Implementation Findings

	Basis of planned materials use	Implementation of instructional materials		
		Materials use	Attention to process standards	Cognitive demand[a]
Helen	External pressures Teaching experience Perception of students	Offloads and adaptations	Connections and communication	PNC and MT
Kasey	New state curriculum Understanding of materials Reading comprehension Student motivation	Offloads, adaptations, and improvisations	All process standards except problem solving	PWC, PNC, and MT
Eva	Views about mathematics and mathematics teaching Teaching experience and graduate study	Improvisations	All 5 process standards evidenced	PWC

[a]Abbreviations used for the cognitive demand categories of the mathematical tasks framework (Stein, Smith, Henningsen, & Silver, 2000): *Procedures with connections* (PWC), *procedures without connections* (PNC), and *memorization tasks* (MT).

Factors in Teachers' Materials Use in Planning and Implementation

Teachers' decisions regarding materials appropriation are a result of the participatory relationship between the teacher and characteristics of the materials (Remillard, 2005). In an effort to explain some of the differences in this relationship exhibited by the participants, I re-examined Remillard's framework, searching for reasons for the comparisons (see Figure 1 in chapter 1, p. 6). The factors she cites in the framework grew out of research by other investigators, and I could not easily identify evidence for some of the constructs, such as pedagogical content knowledge and pedagogical design capacity, in the limited observations and interviews I conducted. I did attempt, however, to provide evidence for how Remillard's other factors might have influenced the participants' evaluation, selection, and use of instructional materials.

Contextual Factors

The context of teaching contributes to the enacted curriculum but is neither a teacher factor nor a curriculum attribute. The context, however, does influence materials evaluation, selection, and implementation. Helen, Kasey, and Eva mentioned a number of these contextual factors that influenced their decisions. One such factor is the culture of accountability in schools, leading many teachers to focus on preparing students for tests. This focus especially seemed a concern of Helen's. Her implementation decisions, in addition to being based on instructional time and student behavior, often reflected a concern with the procedures and skills that would be assessed on state end-of-course tests.

Perception of curriculum. When asked why the state of Georgia changed its mathematics curriculum, most of the regional teachers mentioned test scores and the former curriculum's characterization as "a mile wide and an inch deep." Some cited the need to increase students' critical thinking and problem-solving skills. Helen, Kasey, and Eva also mentioned that the Georgia students consistently performed low on national tests. Kasey and Eva further specified that the new curriculum provided opportunities for students to develop conceptual understanding of the mathematics as well as to see the connections among mathematical ideas and to contexts outside of the classroom.

Helen, Kasey, and Eva had vastly different opportunities to learn about the Georgia Performance Standards (GPS)—the rationale for the changes to the curriculum and how to teach using standards-based tasks. These differing experiences may have contributed to the teachers' perception of the curriculum standards, and thus how they chose materials to support those standards. Kasey and Eva perceived the GPS as raising expectations for all students, whereas Helen perceived the GPS, coupled with the policy decision to eliminate tracking, as watering down the curriculum. Eva was a strong advocate of the GPS and had trained middle grades teachers to implement the standards; in her role as department chair, she was also expected to oversee and support the high school teachers in their implementation of the standards. Kasey participated in an undergraduate teacher education program that lauded the merits of the GPS, demonstrated implementation of high cognitive demand tasks, and helped her develop a vision of standards-based teaching. Helen, however, returning to teaching after 20 years in the business world, had fewer opportunities to learn about standards-based teaching or materials. She attended the professional development workshops provided by the department of education and the textbook publishers, but that was the extent of her training on the GPS and on standards-based teaching. Additionally, the teachers had different amounts of experience *teaching* the GPS courses. Kasey and Eva taught only GPS courses the previous year; Helen only taught Math 1

Part 1 to students who had already failed the course. These different experiences might also help account for differences in the teachers' perceptions of the curriculum.

Perception of materials. All three teachers expressed dissatisfaction with their primary instructional materials, leading to a variety of materials appropriations (see chapter 4). Kasey and Eva were unhappy with what they deemed excessive amounts of contextual information in the learning tasks as well as how the materials walked students through the lessons. Helen, in contrast, did not believe the materials provided enough guidance or explanation for the students.

Perception of students. One possible explanation for Helen's focus on preparation for standardized tests might be her perceptions of the students and their needs. Helen was both a teacher and a parent at Park Valley High School; she had a daughter in the tenth grade, a daughter who was part of the group of students that was to experience the first year of mathematics GPS implementation for each of Grades 6–12. In addition to concerns with educating her students, Helen likely was also concerned with the mathematics education her daughter received and whether the daughter would be prepared for standardized tests. Her interactions with other parents may have also influenced her views of the curriculum, the materials, and the students.

Despite the personal connection to the school, Helen did not emphasize relationships with her students in her discussions of effective teaching or as part of her concerns in selecting and implementing materials with her students. In contrast, both Kasey and Eva expressed the necessity of positive, supportive relationships with students. More specifically, Kasey stated that teaching the new curriculum required good relationships with students. Eva ascribed her pedagogical strengths and weaknesses to her relationships with her students. She believed her students felt safe to take intellectual risks in her classroom. Because she did not want to risk her students' withdrawing their participation, she did not always push the students' thinking as far as she believed she should. Helen did not specify a stance on her relationship with her students but offered that she often focused on the mathematics to be covered rather than on whether all of her students understood what she was teaching.

In discussing the challenges of teaching the GPS, Helen and Kasey, along with the majority of the regional teachers surveyed, mentioned student knowledge and motivation. Many of the teachers perceived the students as having insufficient knowledge of skills and lacking the motivation needed for the teachers to effectively teach the GPS. Eva added that the students were not prepared to work in collaborative settings. Another general sentiment was the challenge in motivating students to think conceptually and persevere through a problem.

Other Teacher Factors

Remillard (2005) identified additional factors that may influence teachers' use of instructional materials. Some of the factors that surfaced in the data from the three participants were subject matter knowledge, teaching experiences, teacher preparation, and educational philosophies, which I associate with the teachers' beliefs and educational goals.

Subject matter knowledge. Like Bonnie and Gina, the teachers studied by Manouchehri and Goodman (2000), the three participants' mathematical knowledge influenced how they implemented the curriculum standards. Eva's ways of talking about mathematics provided evidence of her view that mathematical ideas in the curriculum were connected to each other; therefore, one topic could easily motivate the study of another. Her instructional style was similar to Gina's in that both allowed student input to determine the class instructional path. Eva and Gina were confident enough in their own subject matter knowledge to allow class discussions to diverge from the plan in the text. Kasey also seemed comfortable with her own mathematical knowledge, except when she taught geometry. Like Bonnie, she valued student thinking but had difficulty capitalizing on that thinking to guide instruction. I had difficulty discerning Helen's subject matter knowledge from our interviews and observations; she was quite guarded. When I asked her mathematical strengths and weaknesses, she answered with pedagogical strengths and weaknesses. Also, when I posed mathematical problems to her during the interviews—such as, "How would you teach students this mathematical topic?"—Helen seemed unsure of the mathematical methods she would use, stating that she would want to see how her text taught the topic before making a decision. Like the teachers in Drake and Sherin's (2009) study, Helen, in her first year implementing an entire GPS course and using a new textbook, was more concerned with the text's approach to the mathematical topic than she was about how the topic contributed to the mathematical goals of the curriculum.

Teaching preparation and experience. In contrast to the materials use of beginning teachers in Remillard and Bryans's (2004) study, the least experienced teacher in this study, Kasey, followed her chosen instructional materials closely only when she was ill or uncomfortable with the content. Because her secondary mathematics methods course had focused on teaching the GPS, the cognitive demand of tasks, and effective question strategies, Kasey, like the novice teachers in Cyprus (Christou, Menon, & Philippou, 2009) and two of the student teachers in Behm and Lloyd's (2009) study, may have felt at ease with using a variety of materials in ways that she believed would accomplish her learning goals. Also, because Kasey did her student teaching with Eva, an arrangement that likely reinforced what Kasey was taught about teaching and learning in her preparation courses, she may have picked up some of Eva's instructional strategies that focused on connections and representations.

Helen and Eva, like the experienced teachers in Remillard and Bryans's (2004) study, drew on their past teaching strategies and materials when teaching the GPS. Helen's initial teacher preparation occurred prior to the NCTM standards movement, and she had limited knowledge of the ideas associated with the reform or how to teach using the reforms. She enjoyed teaching geometry, however, and had activities she believed helped students make connections between topics. Thus, in teaching geometric topics, she preferred using materials from her past teaching that focused on applications and constructions rather than use the adopted text, which she did not believe adequately addressed applications. She drew primarily on specific materials that contained detailed explanations, whereas Eva drew on her knowledge of student learning trajectories and her repertoire of teaching strategies.

Educational ideologies. The ways in which Kasey and Eva talked about their classroom practice, their students, and their learning outcomes led me to believe their educational ideologies would be closely aligned with Ernest's (1991) progressive educator. (See Table 1 in chapter 2, p. 23, for a summary of the mathematical elements of Ernest's educational ideologies.) Eva and Kasey emphasized student success and efficacy in their classrooms and the importance of a supportive learning environment. Eva's view of mathematics, however, aligned even more closely with that of the public educator: Mathematics is a social construction. Kasey seemed to view mathematics as an unquestioned body of knowledge that students come to know, ideally, through investigation. Both of these teachers exhibited evidence of high expectations for all students and believed that the GPS would help their students learn more meaningful mathematics than what students likely learned under the former curriculum.

Consistent with the theories of teaching and learning of mathematics in the progressive educator ideology, Eva and Kasey appeared to value investigation, discovery, and cooperative work in their classrooms; it was their responsibility to provide students with activities "that challenge students to have their own hypothesis and be able to pursue them while also directing towards certain mathematical ideas" (Eva, Survey response). For students to be able to pursue their hypotheses, they must have access to a variety of resources, again a belief consistent with the progressive educator ideology. In fact, this educational ideology seemed to account for Kasey's disappointment in the available instructional materials. Both teachers sought out activities that allowed their students to investigate and explore mathematical ideas and were critical of the lack of open-ended tasks in their provided materials.

Helen's statements about her learning goals, her desire for more step-by-step explanations in the teaching materials, and comments about the GPS align with Ernest's (1991) old humanist ideology. She emphasized correct mathematical terminology and notation in her classes, along with a focus on mastering procedures and skills. Helen valued conceptual understanding, but she did not believe that all students would be capable of mastering the mathematics in the GPS. When asked why students might struggle with the GPS in high school, Helen stated that high school mathematics is "more complicated." Students may have been "very good when they were just adding, subtracting, and multiplying. But now that they're looking at more in-depth problems, that could make a difference" (Interview 3). This opinion, along with her decision to differentiate instruction by helping students with tests, may indicate that Helen does not believe all students can successfully complete the GPS courses. I contend that this represents a fixed view of ability. This view is consistent with the old humanist theory of ability: Students need to be tracked because of their different mathematical ability levels.

Helen admitted focusing on the mathematics and not the individual needs of her students in her planning and teaching. Her primary instructional strategy was that of lecturer or explainer:

Even when the students had investigated an idea on their own, she sat in the front of the room and lectured about the content. Helen's statement to her class about investigating geometric ideas in the circles unit versus proving theorems as she claims she would do in a traditional geometry class also indicates agreement with the old humanist's theory of resources in the classroom: Theoretical mathematics (including proving) is appropriate for higher-ability students, and hands-on resources should be reserved for those less capable of mathematics (Ernest, 1991). Interestingly, however, Helen did not see a difference in her former geometry students' and her present Math 2 students' abilities to justify mathematical ideas. She discouraged the use of graphing calculators, instead preferring her students to complete paper-and-pencil exercises, often with the assistance of a less powerful calculator that could convert fractions and decimals for the students.

CHAPTER 7

SUMMARY AND IMPLICATIONS

This study examined the selection, evaluation, and implementation of instructional materials by a group of three teachers in the same high school during their first semester teaching a particular course in Georgia's new integrated, process standards-based curriculum, the Georgia Performance Standards (GPS) for mathematics. Each of the three teachers completed a Mathematics Georgia Performance Standards Knowledge Survey (Appendix A); these data provided information about the teachers' own mathematical experiences, their beliefs about mathematics pedagogy, and their understanding of and preparation for teaching the GPS. As a way to compare the participants with a larger set of teachers, I also administered the survey to 21 teachers from the same geographic region of the state who had gathered together to write instructional activities for the ninth and tenth grade GPS mathematics courses. I observed the three participants' classes during their instruction on three mathematics units: quadratic functions, right triangle trigonometry, and circles and spheres. One teacher was supervising a student teacher, which resulted in fewer observations of her instruction. The teachers also participated in individual interviews after the scheduled observations in each unit. Using data obtained during a planning meeting and from the interviews, I classified the teachers' materials selection in terms of offloads, adaptations, and improvisations (M. W. Brown, 2009; Brown & Edelson, 2003). I also classified their actual use of the materials, the cognitive demand of the implemented tasks (Stein, Smith, Henningsen, & Silver, 2000), and the teachers' attention to the process standards.

The teachers planned together at times, but they varied in their rationales for their evaluation and selection of materials as well as in how they implemented the similar materials. The most experienced teacher engaged primarily in improvisations of lessons, based on her students' mathematical ideas and her view of how mathematical ideas connect with each other; she attended to all five process standards, rarely asking her students to memorize or apply a formula that was not derived in class or not connected to other mathematical ideas. The least experienced teacher, who had completed her student teaching with the most experienced teacher 2 years before, offloaded instructional authority when she did not feel well or was not comfortable with the content; otherwise, she adapted the materials or improvised the lessons to increase the critical thinking required in the task, to increase possible student motivation, or to more closely align with how she understood or was taught the content of the lesson. Her students completed memorization tasks and procedural exercises, but they were also exposed to the connections between topics, especially connections among representations. The third teacher, who had taken a 20-year hiatus from teaching, primarily adapted materials because of lack of time or poor student behavior, or she offloaded instructional authority to the materials. She stressed connections with topics outside of mathematics and using correct terminology and notation as she engaged the students in procedural and skill exercises.

I attributed how the teachers evaluated and selected materials and their ensuing implementation of the curriculum to a number of contextual and teacher factors. Two teachers held positive views of the curriculum; they also had more opportunities to learn about this curriculum and the teaching strategies that support NCTM (2000) standards-based teaching than the third teacher. Their training may help account for the fact that they attended to the process standards to a greater extent than the remaining teacher. Additionally, unlike the third teacher, these two teachers had more experience teaching the new mathematics curriculum. This third teacher did not believe all students could be successful with the GPS, a view that may have contributed to the contrast between her practice and some of her survey response; her survey responses indicated closer agreement with standards-based teaching than what she exhibited in her classroom. The teacher factor that may account most for the teachers' decisions was each teacher's educational philosophy. The teacher who questioned students' ability to complete the curriculum focused on the procedures and basic skills she believed her students needed, whereas the other two focused on their students' understanding of the mathematics, often stressing the use of multiple representations, manipulatives, and connections among mathematical ideas.

There were a number of limitations to the study. I examined the practice of only three teachers with varied backgrounds and teaching experiences. The inferences I have drawn from the data must be considered in terms of the teachers' backgrounds. Additionally, I was able to observe only one planning meeting in which the teachers read and evaluated the materials, discussing reasons for using or not using specific activities. The remainder of the data about the teachers' planning was reported during their interviews. Because one of my participants was the department chair, issues of power may have played into the other teachers' decisions, resulting in their decisions to relegate materials selection to this teacher. I was unable to observe this same teacher as much as I did the other teachers because of the presence of her student teacher. Also, one of the participants experienced a number of behavioral problems; observing a different class with fewer problems, using the same materials might result in different implementation of the curriculum (Eisenmann & Even, 2009). This same teacher did not elaborate on her interview responses; therefore, it was difficult to determine if she lacked knowledge about the questions, if she did not want to admit that she had not engaged in the type of reflection required during the interviews, or if she was just, by nature, cautious about allowing others in on her thoughts.

Conclusions

The findings of this study confirm the findings of other studies about teachers' instructional materials use and the factors that influence that use. The two primary factors influencing the teachers' decisions were (1) the teachers' opportunities to learn about the new curriculum and how to use appropriate teaching strategies to support the curriculum and (2) the teachers' educational philosophies. One participant echoed Drake and Sherin's (2009) findings that, in the first year implementing a new set of curriculum materials, she was more concerned with determining how to use the materials (e.g., pacing and lessons to omit or add) than with how the mathematical ideas in each unit contributed to the overall curriculum goals. The other participants, who had additional knowledge of the state curriculum, although concerned with the above details, also expressed a desire to help their students connect the unit topics together.

Previous studies mention teacher beliefs as a factor influencing materials use; I consider the combination of beliefs, or one's philosophy, as a significant contributing factor to a teacher's instructional decision making. For example, a teacher's preparation program may challenge or support the teacher's beliefs about mathematics, teaching, and learning. In either case, validation of a particular way of viewing teaching mathematics may contribute to the teacher's mathematics education philosophy. Similarly, if teachers are supported in their use of innovative teaching strategies and materials, they may integrate a valuing of such activities into their philosophy. From another perspective, teachers who view themselves as effective when their students are successful on standardized tests when using a different curriculum or set of materials may be reluctant to risk sacrificing their self-efficacy as teachers to embrace a new curriculum or try new materials. Thus, their identities as teachers contribute to their educational philosophies.

I distinguish between philosophy and ideology in the following way. An ideology is a set of theoretical beliefs that fit together in a reasonable manner. A philosophy is a collection of beliefs that may or may not fit within a single educational ideology. A mathematics teacher, either explicitly or implicitly, has a philosophy of mathematics education. Aspects of this philosophy may fit within different educational ideologies. This distinction between philosophy and ideology allows for teachers to hold beliefs about teaching and learning that do not match their beliefs about mathematics or their instructional practices (Raymond, 1997; Thompson, 1992). It is possible for teachers' views of mathematics to align with one ideology while their view of teaching and learning align with a different ideology. If mathematics educators can identify a teacher's educational philosophy, they may be able to determine how he or she would make use of specific instructional materials by considering how those materials might support the teacher's aims for mathematics learning as well as the teacher's theories of teaching and learning.

Identifying teachers' educational philosophies might also provide a means for studying the construct of pedagogical design capacity—the ability of teachers to mobilize their knowledge in order to design instructional activities and sequences of activities to accomplish their learning goals (M. W. Brown, 2009). Kasey, a second year teacher, professed and exhibited a belief in experiential learning; however, she was not always able to find or craft investigative instructional activities that would meet her mathematical learning goals. When she was able to create an activity, she was not necessarily able to connect the activity to the other materials being used or to the other content in the lesson. She also expressed dissatisfaction with the materials but did not know how to modify them appropriately. This inability indicates that she had not fully developed her pedagogical design capacity, which is not surprising considering her inexperience. The other two teachers, however, had a more developed pedagogical design capacity: Their evaluation and use of instructional materials reflected their educational goals. Eva chose and used materials in such a way as to support an appreciation for mathematics and for the development of mathematical connections. Helen's adaptation and improvisation of materials to make them more skill-driven reflected an alignment with her focus on helping all students learn the basic ideas of the course.

Implications for Teacher Education and Professional Development

Many states are discussing the adoption of curriculum standards that may not be adequately captured in a given textbook. The school district in the present study adopted a textbook that aligned to the new state curriculum standards, although the teachers did not always agree with the approach taken in the book. Teachers who are provided texts that *do not align* to the curriculum are faced with challenge of using their texts or seeking supplemental materials. To help teachers make these decisions, teacher educators should provide support for interpreting curriculum standards. Are there layers to the standards, for example, content and process standards? What are the instructional implications of the inclusion of both content and process standards in curriculum documents? What are the overall goals of the curriculum? How do the topics in a given course complement each other mathematically? What was the rationale or philosophy behind decisions to arrange standards in particular ways? Are there specific pedagogical ideas inherent in the curriculum? Teachers must also consider their own instructional goals, including whether their goals correspond to the goals of the curriculum.

Over the last two decades, much teacher education has focused on helping teachers understand standards-based pedagogy. Numerous documents (e.g., NCTM, 1991, 2007) and articles have been written explaining the importance of and demonstrating standards-based teaching. However, in many cases, teachers' instructional materials did not support those ideas; teachers replaced standards-based activities and pedagogy for those suggested in their textbooks. Also, with the No Child Left Behind Act of 2001 (2002), many teachers feel pressure to prepare their students for standardized tests. Although such pressure should not necessitate abandoning standards-based teaching strategies or textbooks, that is a common consequence. With the abundance of available print and online instructional resources, teachers must be prepared to evaluate the materials and also to adapt or craft activities that enable them to meet their instructional goals, including teaching both conceptual and procedural mathematics. This evaluation must include helping teachers attend to the overall mathematical goals of the materials while also determining how to use the materials effectively (e.g., task transitions, introducing tasks, omitting or adding to tasks). These types of professional development activities, however, must continue beyond the first year of implementation of a new course.

Reflecting on goals could increase teachers' pedagogical design capacity (M. W. Brown, 2009) and develop their curriculum vision (Drake & Sherin, 2009). Explicating both the goals of the materials and one's own goals may help teachers evaluate and select materials that support their goals, and potentially lead them to use materials in ways consistent with their goals. Once prospective or practicing teachers understand their own goals and the goals of the materials available to them, teacher educators can engage those teachers in evaluating materials. They can discuss the intent of the lesson and the affordances and constraints of the task. From there, teachers can be supported in their adaptation and improvisation of available materials. Teacher educators could also help teachers search for tasks with similar content that address different goals, such as conceptual understanding or skill development.

Although the curriculum in the present study was integrated, meaning that aspects of algebra, geometry, data analysis, and probability were taught each year, the participants did not refer to this integration in their decision making. However, two of the teachers' materials selection and evaluation differed according to the mathematical strand and their comfort with that strand. This finding is reminiscent of teachers asking me, when I was a department chairperson, if I would assign them to teach only algebra or geometry because they were most comfortable with one or the other strand. There was also a fear of teaching statistics. My personal experiences, along with the differences in materials use found in the study, indicate that many teachers are not confident in their knowledge or ability to teach different strands of mathematics. Teacher education must prepare teachers to teach all strands of high school mathematics effectively and with confidence.

A policy decision accompanying the new state curriculum in this study was the reduction in the tracking system that had characterized the previous curriculum. Some teachers view this as a positive change; others view it as a negative change. Regardless of one's opinion, teacher education must prepare teachers to differentiate instruction for different students, including special education and limited English proficient students, while remaining true to the mathematical goals and expectations of the curriculum.

This study also has implications for curriculum developers. One teacher chose to adapt or improvise her lessons if she did not understand the intent of the materials, that is, if the materials lacked transparency (Stein & Kim, 2009). The same teacher, however, offloaded instructional authority to the textbook when she did not feel well. Also, when two of the teachers offloaded authority to lessons that included a focus on connections and process standards, the general cognitive demand of tasks they used was higher than when they offloaded to other materials or when they chose to adapt or improvise their lessons. These findings provide two major implications for designers of instructional materials: (1) the mathematical intent of the lessons and their ordering should be made transparent and (2) including greater attention to process standards in the textbook lessons may result in implementation of tasks with higher-level cognitive demand.

Implications for Future Research

The present study examined the materials use of three teachers in the same school using qualitative methods. Future research could include studying a variety of teachers from different schools with different primary instructional materials and different teacher preparation backgrounds. A study might examine how teachers with similar backgrounds and experience, using similar primary instructional materials but working with different contextual pressures use their instructional materials. Another could focus on how teachers with different initial teacher preparation programs but in similar teaching contexts differ in their materials use. Large-scale qualitative studies, however, can be quite expensive and time-consuming. An alternative might be to conduct a large-scale quantitative study to study the materials evaluation, selection, and implementation. Senk and Thompson (2009) developed a set of reliable and informative quantitative instruments for examining implementation of the University of Chicago School Mathematics Project (UCSMP) Geometry text. I would like to develop a similar set of instruments to examine how Georgia teachers implement the GPS.

Silver et al. (2009) discussed the emergence of the curriculum implementation plateau in teachers using a specific curriculum program. In contrast, the present study examined teachers' decisions in beginning to implement a state curriculum. A longitudinal study could be conducted, looking for shifts in how teachers select tasks and implement curriculum standards. Longitudinal studies tend to be expensive and difficult to manage; a mixed methods approach, using quantitative instruments and supporting classroom observations and interviews, could provide manageable data collection and analysis possibilities. Such a study could also address issues of teaching context, teaching experience, opportunities to learn about the GPS, and teacher preparation.

In an era of school and teacher accountability, one might wonder if student achievement could be tied to how teachers select and implement materials. Does a teacher's view of policy decisions (e.g., reduction in the tracking system) influence her teaching decisions and her students' achievement scores? The choice of materials use—offloading, adapting, or improvising—however, is nonevaluative; this idea may be better addressed by studying a teacher's pedagogical design capacity (M. W. Brown, 2009).

Other research implications also address pedagogical design capacity. Like pedagogical content knowledge, this construct is difficult to study and measure. One possibility for studying pedagogical design capacity might include using interviews and observations to examine teachers' selection of materials, their written lesson plans, and their implemented lessons, focusing specifically on goals. Data attesting to consistency within teachers' stated educational goals, their selection of materials, and their implementation might provide evidence of a high level of pedagogical design capacity; inconsistency might reveal a lower level of capacity. Such a study could lead to additional research questions: If teachers possess a low pedagogical design capacity, can they develop a higher level? If so, how? What factors contribute to shifts in pedagogical design capacity? Are the factors the same as those in the teacher-curriculum relationship: factors such as context, teaching experience, and perception of the curriculum (Remillard, 2005)?

A final research implication relates to the place of pedagogical design capacity within the Framework for Mathematical Proficiency in Teaching (MPT), in development at Pennsylvania State University and the University of Georgia (Wilson & Heid, 2010). MPT is viewed through three lenses: mathematical proficiency, mathematical activity, and the mathematical work of teaching. Mathematical proficiency, unlike mathematical knowledge, is dynamic; one's proficiency and ability to engage in mathematical activity contributes to the mathematical work of teaching. I contend that, like MPT, pedagogical design capacity is dynamic and is, in fact, included in the mathematical work of teaching. If we can determine defensible methods for studying pedagogical design capacity, how might understanding pedagogical design capacity contribute to studying MPT?

Final Thoughts

Teachers' decisions determine the learning opportunities available to their students. With the recent increased focus on state and U.S. national standards, mathematics educators must examine how teachers craft those learning opportunities. As such, I studied how the teachers in a single high school mathematics department determined appropriate materials to use with their students to support the curriculum standards and how they implemented those instructional materials. These teachers considered their previous experiences as students and teachers, their knowledge of mathematics, their understanding of the curriculum, and their perception of the students' abilities, motivations, and prerequisite knowledge when evaluating and selecting materials. When the teachers were comfortable with the mathematical content in the lessons, they adapted or improvised the lessons; when they were unsure of the mathematics or the intent of the lesson or when they believed the text lesson was necessary for future lessons, the teachers offloaded instructional authority to the texts. Also, the two teachers with more opportunities to learn about the new curriculum and standards-based pedagogy exhibited a greater focus on the process standards and helping their students make sense of the mathematics being studied in the classroom than the teacher with fewer opportunities.

Two features distinguish this study from others that focus on the teachers' use of instructional materials. First, many studies examine mathematics teachers' implementation of curricular programs funded by the National Science Foundation (Senk & Thompson, 2003). Others (e.g., Chval, Chávez, Reys, & Tarr, 2009) focus on whether teachers use textbooks in ways consistent with the aims of the curricular program. This study, however, examined how teachers use the materials at their disposal to support implementation of new state mathematics standards. Curriculum programs often include mathematical content and pedagogical approaches unfamiliar to some teachers. However, if that content is not in the assigned curriculum standards, teachers might be able to skip over it. In a situation in which no single instructional resource was deemed sufficient by the teachers, as was the case in this study, it may be important to study how the teachers view and understand the standards. Two teachers in this study repeatedly stated that the state curriculum standards determined their student learning goals, yet neither attended to the process standards—consistent elements in each GPS mathematics course—in their planning or implementation.

Second, rather than examining individual teachers' selection, evaluation, and implementation of a new course, I studied a set of teachers who participated in shared materials selection decisions. The teachers worked together to interpret the curriculum standards and determine what materials should be used to meet their learning goals. Therefore, the teachers' planning decisions were often influenced by the others' ideas, knowledge, and experience. However, their instruction with the same materials was often different; a finding that was not surprising given their different experiences and beliefs and the fact that the teachers did not observe each other teach. Additional research, examining teachers working individually and collaboratively, might reveal the influence of collaboration and mentoring on teachers' understanding and implementation of curriculum standards.

Although previous research on curriculum implementation has focused on implementation of specific materials, current trends in curriculum policy necessitate additional research on how teachers implement state and national curriculum standards. Mathematics educators must continue examining how teachers, both individually and in collaborative situations, interpret standards, how they use those interpretations to evaluate and select materials, and whether teachers are able to implement the curriculum with integrity to the goals of the standards.

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APPENDIX A

MATHEMATICS GEORGIA PERFORMANCE STANDARDS KNOWLEDGE SURVEY

Directions: Please complete this on your own. Please do not discuss with others or refer to outside sources in completing this survey.

Part 1: Background Information

1. Which GPS courses have you taught or are you scheduled to teach?

2. How long have you been teaching?

3. In which school district do you teach? How long have you taught in this school district?

4. What is your highest degree? When did you complete this highest degree?

5. What type of initial teacher preparation did you complete?
    a. Undergraduate mathematics education preparation
    b. Undergraduate degree outside education; Masters' mathematics education
    c. Undergraduate degree outside education; Alternative preparation program (please describe)
    d. Other (please describe)

If it is okay for the researcher to contact you with follow-up questions, please provide your name, email, and/or phone number.

For questions 6–9, please circle the response that best reflects your experience.

6. When you were a high school student, how did you feel about mathematics?	1-Very comfort-able	2-Somewhat comfort-able	3-Neither comfort-able nor anxious	4-Somewhat anxious	5-Very anxious	0 – None of these describes my experience
7. When you were a high school student, how successful were you in mathematics?	1-Usually success-ful	2-More successful than not	3-Successful about half the time	4-More unsuccessful than not	5-Usually unsuccess-ful	0 – None of these describes my experience
8. Which statement best describes your high school experiences with non-traditional mathematics problems?	1-They were very difficult	2-They were somewhat difficult	3-They were neither easy nor difficult	4-They were somewhat easy	5-They were very easy	0 – Not applicable. I did not experience non-traditional problems in high school.
9. Choose the description that best fits the majority of your high school mathematics experiences.	1-The teacher explained a way to solve problems. The students practiced the skill individ-ually.		2-The teacher sometimes explained concepts. Sometime the students invented their own ways to solve problems. We often worked in groups.		3-The teacher gave us problems to figure out on our own. We often used manipu-latives and talked to each other about mathe-matics.	0 – None of these describes my experience

10. What, if any, of your high school experiences have influenced you to be the teacher you aspire to be?

Part 2: Indicate your agreement with each of the following statements by circling the appropriate column word/phrase. If you would like to expand on an answer, please include those comments beneath your response.

1. I believe that one of my primary responsibilities as a teacher is to select and develop mathematical tasks.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

2. I like to use problems with multiple solutions / paths often in my classes.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

3. I like my students to master basic procedural skills before they tackle complex problems.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

4. I encourage students to use manipulatives and other representations to explain their mathematical ideas to each other.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

5. Creativity, reasoning, and problem solving are fostered in my classes.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

6. I regularly engage students in real-life math problems that are of interest to them.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

7. When students are working on math problems, I put more emphasis on getting the correct answer than on the process.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

8. I don't necessarily answer students' math questions but rather let them puzzle things out for themselves.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

9. In my math classes, students learn best when they can work together to discover mathematical ideas.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

10. The district-provided textbook and supporting materials are the main sources for mathematics in my classroom.

N/A	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comments: ____

Part 3: Georgia Performance Standards

This section addresses your knowledge and views of the new mathematics curriculum. Please be honest. Please do not refer to other sources as you complete this survey.

Understanding of the GPS Curriculum

1. Why did the state of Georgia change its curriculum?

2. How does classroom teaching look under the two different curricula?

3. What are the challenges to teaching the new curriculum?

4. What are the benefits to teaching the new curriculum?

5. How were you prepared to teach the Georgia Performance Standards? What additional support do you need to adequately teach the GPS?

Materials for Teaching the GPS

1. What curriculum materials have you used / will you use to teach the GPS? Are there other materials you would like to have to better teach the GPS?

2. If you have used / plan to use the state frameworks tasks, how do you decide which ones and how much of each task to use?

THANK YOU FOR YOUR PARTICIPATION!

APPENDIX B

OBSERVATION PROTOCOL

Teacher:	Duration of Lesson:
Date of Observation:	Instructional Materials Used:

BEFORE THE LESSON (Information to be gathered before the lesson)

1. What is the main topic and purpose of the lesson? What GPS are being addressed?

2. Where is the lesson situated within the unit?

3. Has the teacher taught this lesson (or topic) before? In what context?

4. What materials does the teacher plan to use and why?

AFTER THE LESSON

After the lesson is finished, please review your notes and then respond to each of the following sections:

1. Describe the <u>main activities</u> that occurred during the class period and the <u>amount of time</u> devoted to each activity.
   Example: Opening problem – 5 minutes; Review homework – 10 minutes; Instruction by teacher – 15 minutes; Group work – 10 minutes; Summary by teacher – 5 minutes; Students work individually on homework – 10 minutes

Activity	**Time**

2. What was the **primary mathematical focus** of the lesson (check the strand that best applies)?
   Strand: ___ Number; ___ Geometry; ___ Algebra; ___ Statistics; ___ Probability; ___ Other:

3. Which of the following **best describes the primary emphasis** of the lesson?
   ___ Memorization ___ Procedures without connections
   ___ Procedures with Connections ___ Doing Mathematics

(If the cognitive demand changed during the set-up and/or implementation, provide a pictorial analysis of the change.)

4. Which process standards were engaged? How was their use evident?
   ___ Problem Solving ___ Reasoning & Proof
   ___ Communication ___ Connections ___ Representations

5. a. Did the students use the district textbook or state frameworks during the lesson? If yes, which materials and/or tasks and in what capacity?

5. b. Were materials other than the district textbook or state frameworks used by the students? If yes, describe the materials.

6. a. Did the teacher use materials from the district textbook or state frameworks? If yes, which materials and in what capacity?

__ teachers selected tasks from materials
__ teacher followed the lesson as laid out in the materials
__ teacher adapted tasks from the materials __ other:
__ teacher drew examples from the materials

6. b. Did the teacher use other materials? If yes, describe the materials. How were they used and in what capacity?

__ teachers selected tasks from materials
__ teacher followed the lesson as laid out in the materials
__ teacher adapted tasks from the materials __ other:
__ teacher drew examples from the materials

APPENDIX C

INTERVIEW PROTOCOLS

Helen Bradley Interview 1

Survey-based questions: Personal Mathematical Ability

1. Why did you become a teacher? What did you do before teaching? What brought you back to teaching?
2. You stated on the survey that you were "more successful than not" in high school mathematics. Can you describe an unsuccessful high school mathematics experience and what made it unsuccessful?
3. You also said that you generally had trouble with non-traditional math problems in high school. What would you consider a non-traditional problem? (How does that compare to what you are doing with the GPS?)
4. What do you feel are your mathematical strengths and weaknesses? What about in Math 2?

Teaching Quadratics (Mathematical)

5. What were your student learning goals for Ch 1/2? Do you think you accomplished them? Examples?
6. During one of the classes I observed, you and the students used area models to illustrate the distributive property. You used both the area model and the multiplication table. What is your rationale for using both?
7. In the planning meeting, you stated that you taught factoring the last two years using the trick. How did you teach it in previous years? What are the pros and cons of each method? How would you teach them to factor $2x^2 - 11xy - 21y^2$ or $x^3 + 5x^2 + 3x + 15$?
8. Can you think of a way to connect area models to teaching factoring? (How does the distributive property (with binomials) relate to factoring?)
9. Many books teach the quadratic formula by completing the square. This book derives it using vertex form of a quadratic in terms of the a, b, and c of the standard form. Which do you prefer and why?
10. How do you decide which formulas to derive in class and which to leave to the students who want to derive them?

Instructional Planning

11. Sometimes you followed the book very closely and other times you didn't. Do you have any general reasons for the difference?
12. How might you teach this unit next time? What would you use to help your instruction?
13. How do you think you will get ready to teach Chapter 3?

Helen Bradley Interview 2

General Teaching questions

1. What do you see as the purpose of mathematics education?

2. Can you describe your ideal class? What would the students do? What would you do? What are some challenges you've had to implementing this ideal in your classroom, especially in terms of the GPS courses?

3. What do you feel are your pedagogical strengths and weaknesses?

Teaching Right Triangles

4. What were your student learning goals for Ch 3/4? Do you think you accomplished them? Examples?

5. You have previously taught the trig ratios. How does the way you taught them this semester compare with how you've taught them in the past?

6. You used nothing from the state frameworks this unit. Why not?

7. Look at *discovering special right triangles task.*
    a. Can you compare how you taught this topic with how the framework addresses it?
    b. If you had chosen to use this task, would you leave it as is, alter slightly, or design a complete overhaul? Why?

Instructional Planning and Expectations

8. How might you teach this unit next time? What would you use to help your instruction?

9. In the culminating task for unit 1, what types of written explanations were you expecting?

Helen Bradley Interview 3

Survey-based questions: GPS and curriculum

1. If you had to explain to a parent how GPS math is different from what you learned, what would you say? What makes the GPS so different or difficult for students?

2. How do the materials you use (Carnegie, McDougal Littel, Frameworks) support the vision of the GPS? How do you use the teacher editions? (just answers, student errors, supporting information in the front)

3. With using so many different types of materials, how do you know if you addressed everything you were supposed to teach?

Teaching

4. There were two major standards in this unit: understanding properties of circle and of spheres. One part of the circles standard was "Justify measurements and relationships in circles using geometric and algebraic properties." What does that sub-standard mean to you? What do you expect your students to be able to do to demonstrate mastery of this sub-standard? (Explain? Prove?)

5. What is the role of proof in Math 2? How important is it? How important is proof in traditional Geometry (or other courses)?

6. For this unit, after the Patty Paper, you used the Carnegie book a great deal. Did you use your old Geometry book as well? When did you use which? What went into those decisions?

7. In addition to thinking about the content, do you have a framework for how you judge or decide how and when to use mathematics tasks or activities in your classroom?

Other:

8. What is your overall goal as a teacher?

Kasey Turner Interview 1

Survey-based questions: Personal Mathematical Ability

1. Why did you become a teacher?
2. You stated on the survey that you were "more successful than not" in high school mathematics. Can you describe an unsuccessful high school mathematics experience and what made it unsuccessful?
3. You also said that you generally had trouble with non-traditional math problems in high school. What would you consider a non-traditional problem? (How does that compare to what you are doing with the GPS?)
4. What do you feel are your mathematical strengths and weaknesses? What about in Math 2?

Teaching Quadratics (Mathematical)

5. What were your student learning goals for Ch 1/2? Do you think you accomplished them? Examples?
6. On the survey, you stated that in Math 1, you taught factoring pretty traditionally. What would you do differently now? How does it compare with what you did this year?
7. You've stated a number of times that you don't use the word "FOIL." Why not? (If possible, ask about using the factor trick. How would you teach them to factor $2x^2 - 11xy - 21y^2$ or $x^3 + 5x^2 + 3x + 15$?)
8. One of the days I observed, your class played the Inside-Out Game to build up to factoring trinomials. How did you come up with the game and how did it connect with the rest of the lesson?
9. In your student teaching, you taught the quadratic formula by completing the square, but here you taught it using vertex form of a quadratic in terms of the a, b, and c of the standard form. Which do you prefer and why?

Instructional Planning

10. Sometimes you followed the book very closely and other times you didn't. Do you have any general reasons for the difference?
11. How might you teach this unit next time? What would you use to help your instruction?
12. How do you think you will get ready to teach Chapter 3?

Kasey Turner Interview 2

General Teaching questions

1. What do you see as the purpose of mathematics education?

2. On the survey, you stated that you like to engage students in the process of mathematics, not just getting the correct answer; that they should puzzle out the mathematics; and that they should work together. What are some challenges you've had to implementing these beliefs in your Math 2 classes?

3. What do you feel are your pedagogical strengths and weaknesses?

Teaching Right Triangles

4. What were your student learning goals for Ch 3/4? Do you think you accomplished them? Examples?

5. Although you followed the book's order exactly, you combined lessons. In fact, for the sine, cosine, and tangent lesson, you used three sections of the book but had the students take notes instead of follow through the book.
    a. Why did you decide to teach all three sections at once?
    b. Why did you decide to have students take notes rather than follow through the book?

6. You used no tasks from the state frameworks. Why not?

7. Look at *discovering special right triangles task.*
    a. Can you compare how you taught this topic with how the framework addresses it?
    b. If you had chosen to use this task, would you leave it as is, alter slightly, or design a complete overhaul? Why?

Instructional Planning and Expectations

8. How might you teach this unit next time? What would you use to help your instruction?

9. In the culminating task for unit 1, what types of written explanations were you expecting?

Kasey Turner Interview 3

Survey-based questions: GPS and curriculum

1. If you had to explain to a parent how GPS math is different from what you learned, what would you say? What makes the GPS so different or difficult for students?

2. How do the materials you use (Carnegie, McDougal Littell, Frameworks) support the vision of the GPS? How do you use the teacher editions? (just answers, student errors, supporting information in the front)

3. With using so many different types of materials, how do you know if you addressed everything you were supposed to teach?

Teaching

4. There were two major standards in this unit: understanding properties of circle and of spheres. One part of the circles standard was "Justify measurements and relationships in circles using geometric and algebraic properties." What does that sub-standard mean to you? What do you expect your students to be able to do to demonstrate mastery of this sub-standard? (Explain? Prove?)

5. What is the role of proof in Math 2? How important is it? How important is proof in traditional Geometry (or other courses)?

6. For this unit, after the Patty Paper, you used the McDougal Littell book a great deal and then used the Carnegie some. When did you use which? What went into those decisions?

7. In addition to thinking about the content, do you have a framework for how you judge or decide how and when to use mathematics tasks or activities in your classroom?

Other:

8. One day, you expressed concern that no one likes math anymore. Why do you think this is so? (9/08/2009)

9. What is your overall goal as a teacher?

Eva Sailors Interview 1

Survey-based questions: Personal Mathematical Ability

1. Why did you become a teacher?
2. You stated on the survey that you were usually successful in high school mathematics. Can you describe an unsuccessful high school mathematics experience and what made it unsuccessful?
3. You also said that non-traditional math problems in high school were neither easy nor hard. What would you consider a non-traditional problem? (How does that compare to what you are doing with the GPS?)
4. What do you feel are your mathematical strengths and weaknesses? What about in Math 2?

Teaching Quadratics (Mathematical)

5. What were your student learning goals for Ch 1/2? Do you think you accomplished them? Examples?
6. How do you and Matt Wood determine what he will teach? Do you talk about it? Challenges to him being in and out? Other things you're willing to share about how you two interact? Do YOUR plans depend on how well you feel Matt addressed the content?

7. When I came in one morning, Matt handed out his notes from Friday that included the factoring trick. However, on the board was the following problem (note card). Can you explain what is happening in this factoring method? Were both approaches taught in your class? Why or why not? (Can you think of a way to connect area models to teaching factoring?)
8. How have you previously taught factoring? What are the pros and cons of each method? How would you teach them to factor $2x^2 - 11xy - 21y^2$ or $x^3 + 5x^2 + 3x + 15$?
9. Many books teach the quadratic formula by completing the square. This book derives it using vertex form of a quadratic in terms of the a, b, and c of the standard form. Which do you prefer and why?
10. How do you decide which formulas to derive in class and which to leave to the students who want to derive them?

Instructional Planning

11. How might you teach this unit next time? What would you use to help your instruction?
12. How do you think you will get ready to teach Chapter 3?

Eva Sailors Interview 2

General Teaching questions

1. What do you see as the purpose of mathematics education?

2. On the survey, you described a very student-focused, problem-driven style of instruction. What are some challenges you've had to implementing these beliefs in your classroom, especially in terms of the GPS courses? Where did you develop this style of instruction?

3. What do you feel are your pedagogical strengths and weaknesses?

Teaching Right Triangles

4. What were your student learning goals for Ch 3/4? Do you think you accomplished them? Examples?

5. You initially talked about the importance of the relationship between tangent of an acute angle and the slope of the hypotenuse. Do you think your students understand this relationship?

6. Solve the following problem: The distance between (x, -5) and (0, 3) is 10. Find x.

7. The lessons were taught out of order – Pythagorean theorem, tangent, 45-45-90, sine and cosine. Did you consciously choose to teach the unit out of order? How do you feel your treatment was compared with the book's treatment?

8. You used nothing from the state frameworks. Why not?

9. Look at *discovering special right triangles task.*
   a. Can you compare how you taught this topic with how the framework addresses it?
   b. If you had chosen to use this task, would you leave it as is, alter slightly, or design a complete overhaul? Why?

Instructional Planning and Expectations

10. How might you teach this unit next time? What would you use to help your instruction?

11. In the culminating task for unit 1, what types of written explanations were you expecting?

Eva Sailors Interview 3

Survey-based questions: GPS and curriculum

1. If you had to explain to a parent how GPS math is different from what you learned, what would you say? What makes the GPS so different or difficult for students?

2. Did you teach with a student-centered approach before the GPS roll out? If so, do you see any major differences in the students, their achievement, etc., from the QCC to the GPS?

3. How do the materials you use (Carnegie, McDougal Littell, Frameworks) support the vision of the GPS? How do you use the teacher editions? (just answers, student errors, supporting information in the front)

4. With using so many different types of materials, how do you know if you addressed everything you were supposed to teach?

Teaching

5. There were two major standards in this unit: understanding properties of circle and of spheres. One part of the circles standard was "Justify measurements and relationships in circles using geometric and algebraic properties." What does that sub-standard mean to you? What do you expect your students to be able to do to demonstrate mastery of this sub-standard? (Explain? Prove?)

6. What is the role of proof in Math 2? How important is it? How important is proof in traditional Geometry (or other courses)?

7. For this unit, after the Patty Paper, you used the Frameworks a great deal and then used the Carnegie some. When did you use which? What went into those decisions?

8. In addition to thinking about the content, do you have a framework for how you judge or decide how and when to use mathematics tasks or activities in your classroom?

Other:

9. What is your overall goal as a teacher?

APPENDIX D

SELECTED SURVEY RESULTS

Part 1: Background Information

	2. How long have you been teaching? (average in years)	**3a. How long have you taught in your present district?** (average in years)	**3b. How long have you taught in your present school?** (average in years)
Regional Teachers	12.48	9.57	7.95
3 Park Valley Teachers	10	5.67	4.67

4. Highest degree earned*	**Bachelor's**	**Master's**	**Specialist of Education**	**Doctorate (PhD or EdD)**
Regional Teachers	4	12	4	1
3 Park Valley Teachers	1	1	0	1

* Highest Degree is not necessarily a mathematics education degree. Some are leadership or divinity degrees.

5. Initial teacher preparation	**Bachelor's**	**Master's**	**Alternative Certification**
Regional Teachers	12	5	4
3 Park Valley Teachers	3	0	0

6. When you were a high school student, how did you feel about mathematics?	Very comfort-able	Somewhat comfort-able	Neither comfort-able nor anxious	Somewhat anxious	Very anxious	None of these describes my experience
Regional Teachers	16	3	1	1	0	0
3 Park Valley Teachers	2	1	0	0	0	0

7. When a high school student, how successful were you in mathematics?	Usually success-ful	More successful than not	Successful about half the time	More unsuccess-ful than not	Usually unsuccess-ful	None of these describes my experience
Regional Teachers	19	2	0	0	0	0
3 Park Valley Teachers	1	2	0	0	0	0

8. Which statement best describes your high school experiences with non-traditional mathematics problems?	They were very difficult	They were somewhat difficult	They were neither easy nor difficult	They were somewhat easy	They were very easy	Not applicable. I did not experience non-traditional problems in high school.
Regional Teachers	0	9	2	6	2	2
3 Park Valley Teachers	0	2	1	0	0	0

9. Choose the description that best fits the majority of your high school mathematics experiences.	The teacher explained a way to solve problems. The students practiced the skill individually.	The teacher sometimes explained concepts. Sometime the students invented their own ways to solve problems. We often worked in groups.	The teacher gave us problems to figure out on our own. We often used manipulatives and talked to each other about mathematics.	None of these describes my experience
Regional Teachers	18	0	2	1
3 Park Valley Teachers	3	0	0	0

Part 2: Beliefs about Teaching Mathematics

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I believe that one of my primary responsibilities as a teacher is to select and develop mathematical tasks.	**RT:**	0	1	2	12	6
	PV:	0	0	0	2	1
2. I like to use problems with multiple solutions / paths often in my classes.	**RT:**	0	1	3	11	6
	PV:	0	0	0	1	2
3. I like my students to master basic procedural skills before they tackle complex problems.	**RT:**	1	2	3	12	4
	PV:	0	1	1	1	0
4. I encourage students to use manipulatives and other representations to explain their mathematical ideas to each other.	**RT:**	0	2	0	7	12
	PV:	0	0	1	1	1
5. Creativity, reasoning, and problem solving are fostered in my classes.	**RT:**	0	0	1	14	6
	PV:	0	0	0	2	1
6. I regularly engage students in real-life math problems that are of interest to them.	**RT:**	0	1	7	9	4
	PV:	0	1	2	0	0
7. When students are working on math problems, I put more emphasis on getting the correct answer than on the process.	**RT:**	7	11	2	1	0
	PV:	1	2	0	0	0
8. I don't necessarily answer students' math questions but rather let them puzzle things out for themselves.[a]	**RT:**	0	2	3	12	2
	PV:	0	0	0	2	1
9. In my math classes, students learn best when they can work together to discover mathematical ideas.[b]	**RT:**	0	0	4	12	4
	PV:	0	0	0	1	2
10. The district-provided textbook and supporting materials are the main sources for mathematics in my classroom.	**RT:**	2	12	4	3	0
	PV:	0	0	1	2	0

Note. RT indicates frequency counts of responses from the Regional Teachers. PV indicates responses from the 3 Park Valley High School teachers.
[a]Two regional teachers selected "not applicable."
[b]One regional teacher selected "not applicable."

Part 3: Georgia Performance Standards

Understanding of the GPS Curriculum

2. How does classroom teaching look under the two different curricula?

Representative Statements from Regional Teachers:

- QCC: teacher focused, students as individuals, graded on errors; GPS: student focused, students as groups, learning from errors
- Sadly for some it looks the same! In an ideal situation the new curriculum shows students constructing mathematical knowledge and making sense of mathematics, with the teacher facilitating. Although some teachers taught this way under QCC, most used a "sit and get" type of approach.
- GPS is more hands on, student focus, task/real problem oriented; QCC was teacher driven, few word problems!
- QCC: teacher-focused, skill focused; GPS: student-focused, open-ended thought provoking questions, real-life context, standards posted and referred to, word wall and referred to, student learning map posted and referred to, student work on wall
- In the traditional classroom, teachers presented the content and students practiced it. The GPS curriculum requires students to read much more often, and decide on a route to the solution. It also provides more opportunity for group work, problem solving, and application.
- There is more student-driven work. The tasks provide more real-world applications. There is less practice over skills.
- Classroom teaching today uses the teacher as a facilitator of learning. Traditional teaching allows disconnect with the teacher & students are not actively participating but rather just receiving information.
- Under QCC, I lectured and the students would practice. The times the kids were participating they were probably at the board. Under GPS, my students were more involved – there was some lecture, but not every day. The students were presenting, discussing, and exploring.

Helen: Focus on learning mathematics thru problem solving and working on multi-step problems/activities that demonstrate what the student is to learn.

Kasey: Under the new curriculum the classroom is more student-focused. The students are writing and talking more about math.

Eva: Honestly that depends on the teacher and their understanding of the intent of the GPS standards. Those that look at GPS as a list of objectives to be covered may approach the teaching of the standards in the same way as QCCs. Those teachers who really catch the vision of the framework tasks most certainly change their classrooms from teacher-focused to student-focused. Of course there were teachers already teaching this way with the QCCs.

3. What are the challenges to teaching the new curriculum?

Representative Statements from Regional Teachers:

- Biggest challenge with the new curriculum is helping students have the self-confidence that they can do the material!
- Giving up the traditional classroom (i.e. what it looked like when I was a high school student); getting comfortable with the framework tasks.
- Developing/finding good tasks for students to discover new concepts. Students struggle with more complex work.
- Time to plan; training students to communicate mathematically-show their work, talk about the processes, write in complete sentences, etc. Explaining the change to parents, students, and even other teachers.
- Somewhat, in that some of the tasks are long and tedious, and students are not adequately prepared to take on this higher level curriculum.
- Getting through/becoming knowledgeable about standards & tasks. Having adequate preparation time. Classroom management. Asking open-ended questions often.
- 1) Motivating students who are used to doing minima work to pass math to step up their efforts 2) Finding different ways to present concepts
- In the beginning, one challenge was pulling together the materials. No textbooks exactly aligned to the standards and materials were <u>everywhere</u> on the internet. Careful planning for the tasks is required. Another big challenge is finding a good balance of skills practice, tasks, and applications.
- The state has not well-thought out everything and new problems arise everyday. I wonder if the state, future boards, future governors, et al., will have the patience to wait out the 10 or 12 years to see if it will truly work out. Teachers need a lot of time to plan and supplement, supplement, supplement! The students have to put some stock and ownership into this.
- Quite honestly, we were never taught the new curriculum….we were taught how to teach Algebra and Geometry….now we are having to present material such as Mean Absolute Deviation which I had never seen in my life. It is scary for math teachers. When my husband, who is a history teacher, changed curriculum….it was just less not new. Ours is new in a lot of ways.

Helen: All new material, getting a good text book, figuring out pacing.

Kasey: In my system the amount of reading and writing has been hard for many of the ESOL and SPED students. Also many of the students have not been coming in with the appropriate amount of basic mathematical knowledge. It seems that I have to continue to go back and teach every basic when I am trying to do a more complex problem. It has been very time consuming.

Eva: Not having the necessary information and units on a timely basis for adequate preparation time. Not enough resources allocated for training. No effective means of mass communication to all Georgia math teachers.

4. What are the benefits to teaching the new curriculum?

Representative Statements from Regional Teachers:

- Long range - students will have a deep, solid understanding of all math concepts.
- I've worked as hard as I did my first year.
- Students are learning more! Students under the old Tech Prep seal would have seen the same concepts as 10th or 11th graders that our 9th graders now see, and do!
- Learn how and what students really know about mathematics; easier to identify students' misconceptions about concepts; application-driven so students see why the mathematical ideas are relevant.
- Students seem to enjoy math.
- Applications are much better. It is more interesting to the students. It is more challenging for students.
- Students are truly "learning" and retaining the math skills and are going to be better prepared to be successful beyond high school.
- More fun; students see how math is useful; students become better thinkers and problem solvers.
- Shows students how the different branches of mathematics are related.
- Student can recognize a more relational understanding of math; increase student achievement; less teacher focus, more student explorations & discoveries; more engaging for students and teachers.
- The level of mathematics all of the students have access to is way above the traditional QCC. Students have the opportunity to advance to higher levels.
- From the beginning, kindergarten, the students are supposed to have that spiral effect. Not a lot of repetition, but layers of mathematics. This is supposed to help the students remember more each year. They are not memorizing but understanding.

Helen: Like building on algebra, geometry, etc. each year; longer math problems are structured more like real life situations.

Kasey: The students are really starting to make connections and understand the math on a deeper level. They also gain mathematical confidence but working on their own or with classmates to solve problems without laid out steps.

Eva: It's a dream come true. Finally the state is putting its stamp of approval on an integrated, problem based curriculum by offering both well thought out pacing guides, framework tasks and assessment that supports this kind of curriculum.

Materials for Teaching the GPS
2. If you have used / plan to use the state frameworks tasks, how do you decide which ones and how much of each task to use?

Representative Statements from Regional Teachers:

- After looking at each task, I will decide which ones are most helpful, which ones the students can relate to best, and use as many as time allows.
- We plan to use the frameworks tasks. We choose those that are easier to read and are laid out well, and then edit questions within them. Some of the tasks are poorly worked and are not very well laid out.
- I will first have to get to know my students, and I will use as many of the tasks that will sufficiently enable me to prepare them for successfully completing the course.
- I look at the time I have to complete the unit, the time it will take to complete the task, and the standards addressed by the task. Then I consider the tasks from Carnegie that cover the same standards and how long they will take. I also consider my students and their interests. I may also look at a few other sources such as [regional professional development agencies] and NCTM illuminations as well as others I have collected over the years and have stored in my head. Then I choose the one that will get the job done with the least amount of time with the most fun.
- If I have to read a task more than twice to understand it and/or if I can't finish it in 30 min, I don't use it.
- I go through them in their entirety (which takes a <u>ton</u> of time!) then I correlate questions to the standards. I evaluate them as how many standards covered/how deeply covered and how much time we have to cover the unit.
- Well, it was trial and error. We would ask advice from [regional professional development agency] as to which were the best. Then, we tweaked them by breaking them up into much more manageable parts. I felt like the kids were being experimented on. We were all just so confused – do we do all the tasks …parts ….will they have gaps if we don't do them all?

Helen: After using the first couple of Math I frameworks tasks last year we began to review the tasks and remove sections that were very repetitive; or we looked at a point where we could delete a section and still maintain the intent of the problem. This was done with a group consensus of teachers planning together.

Kasey: In Math 1 I used the frameworks for everything because I did not like the 1st edition of the Carnegie Book. I cut the frameworks down lots because there was not time to finish all of them. I did not use many for the geometry section because the constructions were so time consuming. I also taught factoring in a more traditional way because I was unclear about how the students would learn how from the task. I really liked some of the culminating task. I think this year I will use the culminating tasks more than the regular framework tasks. They will be great assessments.

Eva: Trial and error: It is critical that work through all tasks in the entire unit before making any decisions about what to omit or expand on. Unless you see how ideas are built on throughout the tasks, it is unwise to make those decisions.