Preservice Elementary Teachers' Learning With Mathematics Curriculum Materials During Preservice Teacher Education

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ABSTRACT

Following the release of the *Curriculum and Evaluation Standards for School Mathematics,* (NCTM, 1989) substantial federal funding in the 1990s supported the development of curriculum materials intended to help teachers enact new visions of mathematics teaching and learning. Although a great deal of research about the "*Standards*-based" curriculum materials has focused on student achievement, an equally important body of research has investigated *teachers'* experiences with these materials. While this research about teacher-curriculum interactions continues to mature and offer insights into teachers' curriculum use, we face a critical shortage of information about *preservice* teachers' use of mathematics curriculum materials.

To address this gap, I conducted two separate but related qualitative studies focused on preservice teachers' interactions with mathematics curriculum materials. The first study examined a teacher education activity in which 23 preservice elementary teachers analyzed sections of different mathematics curriculum materials and textbooks. The second study focused on three student teachers' uses of mathematics curriculum materials and textbooks during their student-teaching internships. The overall purpose of these studies was to examine the views and experiences that appear to influence preservice teachers' initial interpretations of *Standards*-based curriculum materials and to document preservice teachers' experiences using *Standards*-based and other instructional resources during student teaching. I also aimed to explore how mathematics curriculum materials might be more carefully positioned to play a more critical role in preservice teacher learning throughout typical teacher education opportunities and also in teachers' future use and learning with *Standards*-based curriculum materials and other instructional resources.

Results of this manuscript dissertation indicated that preservice teachers found themselves immersed in professional development with mathematics curriculum materials, textbooks, and state curriculum guides during coursework and fieldwork experiences. They had the opportunity to develop an understanding of the variety of mathematics instructional resources available to them that were different from what they were used to, and also had opportunities to consider the unexpectedly complex nature of many of the materials. The preservice teachers found themselves negotiating balance between university coursework and fieldwork expectations as they evaluated, adapted and supplemented materials during coursework and fieldwork. The results from these chapters not only illustrate teacher learning with and about curriculum materials, but also point out opportunities within teacher education for preservice teachers to question well-established beliefs and practices regarding mathematics teaching and mathematics instructional resources as they encountered disequilibrium in multiple contexts. Overall results also highlight possible missed opportunities for learning and the importance of *human resources* within teacher education as it relates to preservice teachers' encounters with mathematics curriculum materials and instructional resources.

DEDICATION

TO

My wonderful parents:
Albert and Laura Behm

My sister and friend:
Katie Behm

My loving fiancé:
Seth Cross

Mom, Dad, and Kate, your love and encouragement over the past 10 years have given me the strength and courage to pursue my professional dreams. Thank you for believing in me and for supporting my decisions as I completed this journey. Your patience and unconditional love means more to me than you will ever know.

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Chapter 1. Introduction

Current reform efforts in the United States, largely informed by the *Standards* (1989; 2000) of the National Council of Teachers of Mathematics [NCTM], set out to promote mathematics teaching and learning focused on student exploration, problem solving, and communication in mathematics. These recommendations represent substantially different ideas about mathematics teaching and learning, focused on critical thinking and conceptual development in addition to the memorization of basic facts and basic skills development. Due to dramatically altered visions of mathematics instruction, following the release of the 1989 *Standards,* substantial federal funding in the 1990s supported the development of curriculum materials intended to help teachers enact these new visions of mathematics teaching and learning. Research surrounding the use of these materials by students and teachers became critical.

A great deal of research about the "*Standards*-based" curriculum materials has focused on student achievement (e.g., Carroll & Isaacs, 2003; Harwell et al., 2007; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Post et al., 2008; Riordan & Noyce, 2001; Tarr et al., 2008). An equally important body of research has investigated *teachers'* experiences with these materials. These studies have documented "teachers in transition" as they implement unfamiliar curriculum materials (Keiser & Lambdin, 1996; Lloyd, 2008b; Lloyd & Wilson, 1998; Manouchehri & Goodman, 2000; Wilson & Lloyd, 2000), highlighted the significant variation in curriculum use among teachers (Herbel-Eisenmann, Lubienski, & Id-Deen, 2006; Lambdin & Preston, 1995; Lloyd, 1999; Remillard & Bryans, 2004; Sherin & Drake, in press), and portrayed teachers engaging with, adapting, and learning from *Standards*-based curriculum materials (Collopy, 2003; Lloyd, 2002b; Remillard, 2000). Although research about teacher-curriculum interactions continues to mature and offer insights into teachers' curriculum use, we face a critical shortage of information about *preservice* teachers' use of mathematics curriculum materials.

Many preservice and beginning teachers enter classrooms to teach for the first time with *Standards*-based curriculum materials, but we are only starting to develop understandings of these initial experiences. Two recent studies about inservice teachers suggested that beginning teachers, lacking curricular repertoires of their own, seem to appreciate the guidance of published textbooks and curriculum materials (Kauffman, Johnson, Kardos, Liu, & Peske, 2002; Remillard & Bryans, 2004). Because preservice teachers' uses of and learning from curriculum materials may have different characteristics than more experienced teachers' use, close examination of preservice teachers' experiences with *Standards*-based materials is crucial, yet limited. This dissertation aims to provide information about preservice teachers' experiences as they evaluate, adapt, engage with, and learn from their experiences with *Standards*-based mathematics curriculum materials.

Several recent publications have described ways that teacher educators have begun to incorporate *Standards*-based curriculum materials into university coursework for preservice teachers (Lloyd, 2002a, 2006; Lloyd & Pitts Bannister, accepted for publication; Tarr & Papick, 2004). However, further research in this area is important in view of the extensive time needed for teachers to learn with these materials (Clarke, 1997; Manouchehri & Goodman, 1998), to grapple with reform ideas (Lappan, 1997) and to develop new understandings of the mathematical concepts presented in the materials (Ball & Feiman-Nemser, 1988; Lloyd, 2002b). Many preservice and beginning teachers enter classrooms to teach for the first time with *Standards*-based curriculum materials, but we are only starting to develop understandings of these initial experiences. Only three published reports have addressed student teachers' use of *Standards*-based mathematics curriculum resources (Lloyd, 2007, 2008a; Van Zoest & Bohl, 2002). In Van Zoest and Bohl's study, curriculum-based discussions between a student teacher and her mentor teacher afforded opportunities for both teachers to learn about mathematics and pedagogy. Lloyd's studies offer preliminary insights into the nature of student teachers' interactions with curriculum materials for the design and enactment of mathematics instruction. These studies raise questions about student teachers' use of and learning from different kinds of curriculum resources in varying classroom contexts.

Research Methods and Questions

I conducted two separate but related qualitative studies focused on preservice teachers' interactions with mathematics curriculum materials. The first study, conducted during the 2002-2003 academic year, examined a teacher education activity in which 23 preservice elementary teachers analyzed sections of different mathematics curriculum materials and textbooks. The primary data source was the written lesson analysis assignments from 23 students enrolled in a mathematics content course for preservice elementary teachers. The purpose of this study was to gain an understanding of preservice teachers' interpretations of different instructional materials. The final text version of the published report of this study (Lloyd & Behm, 2005) appears in Chapter 3.

The second study, conducted during the spring semester of 2004, focused on three student teachers' uses of mathematics curriculum materials and textbooks during their student-teaching internships. This study aimed to examine ways in which three student teachers engaged with varying curricular resources throughout student teaching. Primary data sources for this study consisted of interviews with the student teachers, classroom observations, and instructional artifacts such as lesson plans, lesson reflections, and handouts. Chapter 4 focuses in detail on one student teacher's experiences using two different curricular resources for her mathematics instruction. Chapter 5 presents a manuscript, accepted for publication (Behm & Lloyd, in press), which describes key factors affecting all three student teachers' use of curriculum materials and other instructional resources.

The overall purpose of these studies was to examine the following questions:

(1) What views and experiences seem to influence preservice teachers' initial interpretations of *Standards*-based curriculum materials?

(2) What are preservice teachers' experiences using *Standards*-based mathematics curriculum materials and other instructional resources during student teaching?

(3) How might mathematics curriculum materials be positioned to play a role in preservice teacher learning throughout typical teacher education opportunities?

As I researched these questions, I also hoped to develop ideas about how preservice teacher education might better prepare teachers for their future use of and learning with *Standards*-based curriculum materials and other novel instructional resources that will emerge in years to come.

Outline of the Dissertation

In Chapter 2, I situate these studies through consideration of relevant educational research and theory. This review centers on past and current reform in mathematics education and accompanying research, emerging theoretical perspectives on teachers' use of curriculum materials, and research focused on preservice teachers' uses of instructional resources. In Chapter 3, I present a manuscript about preservice teachers' analysis of mathematics instructional materials. In Chapters 4 and 5, I present research about student teachers' varying uses of mathematics curriculum materials, textbooks, and state frameworks. In Chapter 6, I synthesize the findings from Chapters 3, 4, and 5, revisit my main research questions, and draw overall conclusions and implications that emerge when the three manuscripts are viewed together.

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Chapter 2. Literature Review and Conceptual Framework

Research about preservice teachers' interactions with mathematics curriculum materials is motivated and informed by several distinct yet related bodies of literature. First, studies focused on past and current reform efforts in mathematics education are important to consider. In particular, literature that documents successes and pitfalls of past reform movements and highlights current political issues surrounding reform points to the complicated nature of the teacher-textbook relationship. Consideration of studies focused on students' and *inservice* teachers' curriculum use also helps to inform and situate research on *preservice* teachers' use of recently developed curriculum materials. Consideration of this literature comprises the first section of this chapter.

Another important body of literature to consider is the theoretical perspectives emerging from research on teachers' use of curriculum materials. The second part of this chapter discusses teachers' past roles in curriculum-making and current research perspectives on teachers' use of curriculum materials. This section also outlines various dimensions of teachers' use of curriculum materials and highlights differing descriptions of teachers' curriculum use found in the literature.

The third section of Chapter 2 examines studies that focus on *preservice* teachers' experiences with and uses of mathematics curriculum materials. This section highlights recent findings, outlines current perspectives, and identifies current gaps in research and thinking surrounding preservice teachers and curriculum resources. Finally, this section offers an argument for why research about preservice teachers and mathematics curriculum materials is an important area of inquiry.

Reform in Mathematics Education

Current interest in teachers' use of mathematics textbooks and curricular resources is partially motivated by the dynamic and sometimes controversial history of mathematics teaching and learning in the United States. As Cooney (1988) pointed out, "It is important for us to consider that [the current] effort at reform… is but one of many efforts to reform mathematics education" (p. 352). In this section, I consider the history of reform in mathematics education, the political climate surrounding current efforts to improve mathematics teaching and learning, and initial studies emerging from the development of new mathematics curriculum materials in the 1990s.

A History of Reform

Over the past 100 years, a number of different reform efforts have emerged from concerns about mathematics teaching and learning. At the turn of the century, educators at the University of Chicago High School and several other Illinois schools aimed to reform the structure of high school mathematics classes, specifically attempting to merge algebra and geometry courses to ensure all students received a broad view of mathematics. E. H. Moore, retiring president of the American Mathematical Society, supported this reform effort, and called for "the unification of pure and applied mathematics" and "the correlation of the different subjects" (Cooney, 1988; Kilpatrick, 1997a). Although experimental courses were developed for middle schools in an attempt to reach all students, many of whom dropped out by the end of ninth grade, few schools adopted these integrated tracks.

The start of the 20th century was characterized by a social efficiency movement supported by a decade of enthusiasm for business. Influenced by business management, the curriculum specialists of the 1920s focused on task and activity analysis and rigid divisions among subject areas. Following the stock market crash in 1929, however, progressivism replaced social efficiency as the primary paradigm. Dewey's works (e.g., Dewey, 1938), and the establishment of the Progressive Education Association [PEA], focused on child-centered education and worked to lessen the sharp separation of subject matter. In April 1930, the PEA met to discuss ways in which U.S. secondary schools might better serve students. The resulting Eight-Year Study, a comprehensive study and field experiment with secondary school curriculum during the 1930s, remains today as one of the major curriculum studies in the history of the field (Pinar, Reynolds, Slattery, & Taubman, 1995). Receiving cooperation from over 300 colleges and universities to release participating schools from entrance requirements in mathematics and other subjects, the study aimed at progressive reform of secondary schools. Participating schools were charged with deciding for themselves what changes should be made to the curriculum – keeping in mind the characteristic goals of social sensitivity, aesthetic appreciation, physical health, building a philosophy of life, and a general broadening of interests.

The 1950s saw criticism yet again of American schools and the curriculum, fueled in part by the Soviet Satellite launching in 1957. This event inspired national reaction that focused curriculum discussions specifically on enhancing mathematics and science education. Reformers perceived a need to “bridge the widening gap between school and collegiate mathematics” (Kilpatrick, 1997a, p. 2). The National Defense Act of 1958, developed partly in response to military and space competitiveness, made money available for curriculum development in mathematics and science. However, instead of providing these funds to curriculum specialists, the major recipient of the National Defense Act funds was the National Science Foundation [NSF] (Pinar et al., 1995). Although initially focused on summer institutes for teacher training, in the late 1950s, NSF began funding programs aimed at creating high quality instructional materials in mathematics and science. In the 1960s, NSF supported the development of a variety of instructional materials exemplifying the goals of what is now known as the “new math” movement (Senk & Thompson, 2003). As Walmsley (2003) described, the new mathematics content

> consisted of abstract algebra, topology, symbolic logic, set theory, and Boolean algebra, and was taught in conjunction with much of the traditional curriculum. Set theory and general principles of modern algebra made the “new mathematics” more abstract than the traditional mathematics. (p. 4)

The new math reform not only offered new mathematical content, but also new pedagogical approaches. In fact, Max Beberman, the leader of the University of Illinois School Mathematics project, the first of several large scale projects funded by NSF, stressed that “the most important issue in the new curriculum was not the content, but the fact that students must really understand what they were learning” (Walmsley, 2003, p. 34). The idea that students should “discover” principles on their own with guidance from their teacher also characterized the new math. Walmsley points out that discovery learning can still be seen today in reform efforts under the guise of “guided discovery.”

Despite the efforts of researchers and educators working on these funded projects, many teachers were not well equipped to deal with the formal mathematical content, precise mathematical language, and new pedagogical strategies found within the new math textbooks (Fey & Graeber, 2003; Klein, 2003). While it has been popular to assert that the new math was tried and that it failed, it has also been suggested that in most classrooms the reforms were never really implemented. Schools that were attempting to implement reform ideas, “most greatly underestimated the need to reach teachers, parents, and students with their proposals and to ensure teachers in particular were comfortable with them” (Kilpatrick, 1997b, p. 5).

Morris Kline, one of the loudest opponents of the new math reforms, wrote *Why Johnny Can't Add: The Failure of the New Math* (1973). Kline called to combine mathematics with science in the high school curriculum and emphasized the importance of mathematics as part of a liberal education connected to culture and history (Kilpatrick, 1997a). In the early 1970s, new math was replaced by a strong back-to-basics movement that emphasized computational skills.

Reform efforts resurfaced again in the early 1980s with the release of two influential documents – *A Nation at Risk* (1983) and, focused specifically on mathematics, results from the Second International Mathematics Study [SIMS] (Travers et al., 1985). Both reports contained alarming information about the status of mathematics education in the U.S. For example, in regard to mathematics education, *A Nation at Risk* highlighted the increased need for remedial mathematics courses in public 4-year colleges. This report also noted complaints from business and military leaders that new recruits were in need of remedial training in, among other things, mathematics and computation (National Commission on Excellent in Education, 1983). Reports from the SIMS study also indicated a dire situation in mathematics education within the U.S. For example,

- Achievement in geometry for the U.S. was among the bottom 25% of all countries;
- Since the First International Mathematics study conducted in 1964, eight grade mathematics classes showed a decline in mathematics achievement; and
- The U.S. mathematics curriculum was characterized by a great deal of repetition and review, with the result that topics were covered with little intensity (McKnight et al., 1987).

The recommendations emerging from the report were large: "a fundamental revision of the U.S. school mathematics curriculum" (McKnight et al., 1987, p. 113). More specifically, the committee recommended the elimination of excessive repetition of topics within the curriculum, a more intense and in-depth treatment of topics, and the inclusion of topics such as geometry, probability, and statistics, as well as algebra. The committee also highlighted the need to revise the role and quality of textbooks: "In most US schools, commercially published textbooks serve as the primary guides for curriculum and instruction. Any significant reform effort must take this fact into account" (McKnight et al., 1987, p. xiii). These reports created widespread public concern about mathematics education, and resulted in a number of states creating task forces to measure their own programs against the recommendations in *A Nation at Risk.*

During this time, the National Council of Teachers of Mathematics [NCTM], founded in 1920, became the leader in promoting a reform agenda in mathematics. Although NCTM had supported the new math movement, they did not play a dominant role in that reform effort (Klein, 2003). Taking on a more active role as a voice for teachers, the NCTM published *An Agenda for Action* (1980) and, several years later, the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989). These documents stressed the importance of problem solving and called for an extensive set of changes to school mathematics curriculum, instruction, and assessment that set the stage for the present *Standards*-based reform movement in mathematics education.

The Current Reform in Mathematics Education

The current reform movement in mathematics education has been largely shaped by the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989). In the development of this document, four working groups, each made up of classroom teachers, supervisors, educational researchers, teacher educators, and university mathematicians, were charged with two tasks:

> (1) Create a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields, and
>
> (2) Create a set of standards to guide the revision of the school curriculum and its associated evaluation towards this vision. (National Council of Teachers of Mathematics, 1989, p. 2)

The document outlines a plan for "what mathematics students need to know, how students are to achieve the identified curricular goals, what teachers are to do to help students develop their mathematical knowledge, and the context in which learning and teaching occur" (NCTM, 1989, p. 2). The "standards" throughout the document are statements about what is valued, both mathematically and pedagogically. In fact, this document and others that followed from NCTM are typically referred to as the *Standards* documents that catalyzed the current *Standards* reform movement.

The committee created standards in four sections: K-4, 5-8, 9-12, and evaluation standards for all grades. Throughout these sections, content standards focus on number and operations, algebra, geometry, measurement, and data analysis and probability, and process standards focused on reasoning and proof, problem solving, communication, connections, and representation. In addition to content and process standards, this document articulated five general goals for all students. Students should learn to value mathematics, become confident in their ability to do mathematics, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically (NCTM, 1989). Toward this end, the committee envisioned classrooms as

> places where interesting problems are regularly explored using important mathematical ideas. Our premise is that *what* a student learns depends to a great degree on *how* he or she has learned it. For example, one could expect to see students recording measurements of real objects, collecting information and describing their properties using statistics, and exploring the properties of a function by examining its graph. This vision sees students studying much of the same mathematics currently taught but with quite a different emphasis; it also sees some mathematics being taught that in the past has received little emphasis in schools. (NCTM, 1989, p. 6)

Although some specific lesson ideas are included throughout this document, for the most part the 1989 *Standards* outlined an educational philosophy more than it dictated a curriculum (Walmsley, 2003). Therefore, in response to the calls made throughout the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989), in 1991 the NSF solicited proposals for the design of new mathematics instructional materials. With over a dozen projects underway in the early 1990s and field-testing taking place in the mid-1990s, these new mathematics curriculum programs were utilized by several million students and teachers by the 1999-2000 school year (Senk & Thompson, 2003). In fact, between 1990 and 2007, the NSF "will have devoted an estimated $93 million, including funding for revisions, to 13 mathematics projects to 'stimulate the development of exemplary educational models and materials and facilitate their use in the schools'" (NSF, 1989, p. 1 as cited by National Research Council, 2004). Given that textbooks are a major influence on mathematics teachers' instructional decision-making (Bush, 1986; McKnight et al., 1987; Woodward & Elliot, 1990), and suggestions from the SIMS study that mathematics textbooks needed revision, it is not surprising that this reform movement, like others, has included extensive curriculum development.

Standards-based mathematics curriculum materials, as these newly developed materials have come to be known, are instructional resources for both teachers and students. As Trafton, Reys, and Wasman (2001) described, these *Standards*-based materials are "resources that serve as daily guides for students and teachers in directing activities related to math instruction" (p. 259). They typically "differ in substantive ways from traditional textbooks used in the U.S., which tend to focus on acquisition of skills, to cover many topics superficially, and to be highly repetitive" (p. 259). Additionally, NSF-funded *Standards*-based mathematics curriculum materials

> focus on mathematics as action undertaken by the student to make mathematical sense of situations, the use of contexts, the gradual development of content, the approach of moving from the concrete to the more abstract, and students' development or analysis of algorithms as well as their implementation. (Robinson, Robinson, & Maceli, 2000, p. 112)

Tarr et al. (2005) offer further distinction, noting that NSF-funded *Standards*-based materials were designed to "focus on a smaller set of mathematical topics, treat those topics in depth, and utilize instructional strategies such as hands-on learning and student discussion," whereas more traditional publisher-generated textbooks are "generally organized around 2-page lessons that include worked-out examples and practice sets on a variety of topics" (p. 2).

Since the release of the 1989 *Standards* document, NCTM (1991; 1995; 2000; 2006) has published four other documents aimed at reforming mathematics curriculum, instruction, and assessment, as well as a host of other publications that support or illustrate the current reform effort. The 2000 document, *Principles and Standards for School Mathematics,* aimed to clarify and elaborate on ideas in the 1989 document, and is now viewed as "the *Standards.*" Adding further clarification to recommendations in the *Standards*, NCTM recently published *Curriculum Focal Points* (NCTM, 2006), a document that highlights specific focus within each grade level from prekindergarten through grade eight.

Politics Surrounding Standards and Standards-based Curriculum Materials

The math wars. In 1999 the U.S. Department of Education endorsed ten K-12 mathematics programs as either "exemplary" or "promising" (U.S. Department of Education, 1999). Of the 10 endorsed, 6 were NSF-funded *Standards*-based curriculum materials. Despite, or perhaps in light of, strong support for the reform from three major educational organizations (NCTM, NSF, and the U.S. Department of Education), strong opposition to the *Standards* documents and the newly created and advocated materials arose quickly. In 1999, David Klein, a mathematics professor at California State University at Northridge, wrote an open letter to then U.S. Secretary of Education, Richard Riley, urging him to withdraw the list of exemplary and promising mathematics curriculum programs (Klein et al., 1999). Although he does not include specific details about the shortcomings of the endorsed curriculum programs, Klein's letter included reference to letters, websites, and published journal articles from respected scholars in the field of mathematics who similarly opposed the reform. His letter included 216 cosigners – 160 mathematicians, 40 professors in closely related fields including physics, computer science, chemistry, biology, engineering, and geophysics, and 16 teacher educators. Opposition also surfaced online through the internet-based, influential parent organization *Mathematically Correct.* In Plano, Texas, 600 parents fought to sue one school district because of their exclusive use of the *Standards*-based middle school materials of the *Connected Mathematics Project* (Klein, 2000).

For the most part, opposition to the *Standards* reform movement has been fueled by mathematicians. These mathematicians argue that, while conceptual understanding is important, it cannot be fully realized without a focus on precision and fluency in basic skills. Klein (2000) argued, for example,

> in other domains of human activity, such as athletics or music, the dependence of high levels of performance on requisite skills goes unchallenged. A novice cannot hope to achieve mastery in the martial arts without first learning basic katas or exercises in movement. A violinist who has not mastered elementary bowing techniques and vibrato has no hope of evoking the emotions of an audience through sonorous tones and elegant phrasing. Arguably the most hierarchical of human endeavors, mathematics also depends on sequential mastery of basic skills (p. 53).

Opponents have also raised concern about extensive calculator use and the use of non-standard algorithms (see e.g., Klein, 2000; Wu, 1997). In addition, opponents have critiqued the compilation of the working group members who wrote the *Standards* – no mathematicians, two K-12 educators, with the remaining group made up of teacher education professors – and critiqued the reform for advocating pedagogical practices based on opinion rather than research (Wu, 1997). In 2003, however, NCTM released *A Research Companion to Principles and Standards for School Mathematics* (Kilpatrick, Martin, & Schifter, 2003). This book explores the scholarly underpinnings of the 2000 *Standards* and outlines ways in which research should be expected to influence standards for school mathematics.

On April 18, 2006, President Bush created a National Mathematics Advisory Panel, charged with advising the President and the Secretary of Education on the best use of scientifically-based research to advance the teaching and learning of mathematics. Among the members of this task force (made up of mathematics educators, general educators, educational psychologists, policy researchers, mathematicians, educational researchers, mathematics teachers, and principals) were the past president of NCTM (Fennell) and one of the strongest opponents of the *Standards*-based reform (Wu). As a result, the "math wars" have recently gained national attention. The panel issued an interim report in August 2007 (U.S. Department of Education, 2007) and a final report on March 13, 2008 (U.S. Department of Education, 2008). The panel made recommendations across six broad topics within mathematics education including curricular content, learning processes, teachers and teacher education, instructional practices, instructional materials, assessment, and research policies and mechanisms. It remains to be seen how the report from this panel will impact educational research, recommendations for teaching and professional development, and educational standards.

State standards and testing. Another political consideration related to the current reform is the national movement towards high-stakes testing and accountability in education. As of 2000, all states had at least one form of a state-wide test (Olson, 1999), and the number of tests per state continue to grow. Some states, such as Virginia, have attempted to align their state mathematics frameworks with the NCTM *Standards* (Dorgan, 2004; Reys, 2006). However, Cuban (1993) suggested that starting in the early 1980s, "reformers latched on to state and national testing as potent tools to convince teachers and students to stick to the official curriculum, particularly if the stakes attached to these tests were ratcheted upward" (p. 184).

In fact, the stakes were increased. On January 8, 2002, President Bush signed into law the No Child Left Behind Act (NCLB). The purpose of the act was (a) to increase accountability for student performance (i.e. states, districts, and schools that improve performance will be rewarded, failure will be sanctioned), (b) to spend money on what works (i.e. federally determined effective research-based programs and practices), (c) to increase flexible funding for states and school districts, and (d) to increase parental involvement and empowerment (U.S. Department of Education, 2001). Since 2002, following the release of NCLB, 39 states have published revised mathematics standards (Reys, 2006).

High-stakes testing, defined by the American Educational Research Association [AERA] (2001) as tests that carry serious consequences for teachers and parents, became an even bigger part of life in schools. As described by AERA,

> These various high-stakes testing applications are enacted by policy makers with the intention of improving education. For example, it is hoped that setting high standards of achievement will inspire greater effort on the part of students, teachers, and educational administrators. Reporting of test results may also be beneficial in directing public attention to gross achievement disparities among schools or among student groups. However, if high-stakes testing programs are implemented in circumstances where educational resources are

> inadequate or where tests lack sufficient reliability and validity for their intended purposes, there is potential for serious harm. Policy makers and the public may be misled by spurious test score increases unrelated to any fundamental educational improvement; students may be placed at increased risk of educational failure and dropping out; teachers may be blamed or punished for inequitable resources over which they have no control; and curriculum and instruction may be severely distorted if high test scores per se, rather than learning, become the overriding goal of classroom instruction. (p. 1)

As highlighted by AERA, although intentions may be good, the accountability movement also has major challenges and many opponents. A key concern raised in this debate is that despite the intentions of NCLB to reduce inequities in our education system, the enactment of such policies actually tends to increase existing inequities especially in low-achieving schools (Darling-Hammond, 2004; Diamond & Spillane, 2004; McNeil, 2000; Muller & Schiller, 2000).

Together, the math wars and high-stakes testing and accountability have put pressure on researchers to examine the effects of the use of *Standards*-based curriculum materials on both students and teachers. The emergence of this new field of research is described below.

The Emergence of a New Field of Research

Student achievement and Standards-based mathematics curriculum materials. A body of research about the outcomes of students' use of *Standards*-based curriculum materials, including student achievement and attitudes towards mathematics, has grown rapidly. In order to judge the achievement of students using *Standards*-based mathematics curriculum materials, most studies compared these students' achievement to that of students using more traditional texts.

For example, during the 1993-1994 school year, Thompson and Senk (2001) tracked the development of high school algebra students in four schools over 1 year. Four classrooms within each school participated in the study, with two classes using *Standards*-based materials (UCSMP) and the other two comparison classrooms continuing to use the mandated traditional texts. The 16 heterogeneous classrooms reportedly represented students with a variety of educational and socioeconomic conditions. The authors used a matched-pair design for the study. At the beginning of the year, all students completed a pretest to measure incoming knowledge of algebra and geometry. At the end of the year, teachers administered a multiple-choice post-test to assess students' knowledge of the content of algebra and a problem-solving post-test to assess ability to solve multi-step problems.

Riordan and Noyce (2000) utilized a similar design, comparing 4^{th} and 8^{th} grade student achievement in elementary and middle schools utilizing *Standards*-based mathematics curriculum materials, to similar schools using more traditional texts. In this study, 67 elementary schools and 21 middle schools using the *Standards*-based materials were selected and then matched with comparison group schools with similar baseline state mathematics test scores and percentage of students receiving free or reduced lunch. Using a post-treatment, quasi-experimental design, state tests scores at the end of the 1999 school year were used to compare the two groups across differing student populations.

Thompson and Senk (2001) and Riordan and Noyce (2000) reported similar findings: On achievement tests, all students using *Standards*-based curriculum materials outscored their counterparts who had used more traditional mathematics textbooks. On tests designed to assess students' ability to solve real-world problems, Thompson and Senk also found that students using *Standards*-based curriculum materials outperformed students learning with traditional textbooks on procedural tasks and on tasks involving real-world problem contexts.

However, results from Huntley, Rasmussen, Villarubi, Sangtong, and Fey (2000) tell a different story. Huntley et al. used a similar research design to the two previous studies discussed. The authors identified six U.S. schools, each with two classrooms utilizing a *Standards*-based high school curriculum program and two, three, or four comparison classrooms utilizing more traditional textbooks. Each comparison group was paired with a *Standards*-based group in regard to prior ability. Three different instruments were designed to assess students' understanding, skill, and problem-solving ability in algebra. Like Thompson and Senk (2001) and Riordan and Noyce (2000), Huntley et al. found that students using *Standards*-based curriculum materials were better able to solve algebraic problems presented in real-world contexts than students learning with more traditional textbooks. However, Huntley et al. also found that students using more traditional textbooks outperformed students using *Standards*-based materials in regard to manipulating symbolic expressions. This result confirmed the fears of some that students using *Standards*-based curriculum programs might have fewer opportunities to develop proficiency at traditional, procedural aspects of mathematics.

In 2002, a committee assembled by the National Research Council, was charged with "assessing the quality of studies about the effectiveness of 13 sets of mathematics curriculum materials developed through NSF support and six sets of commercially generated curriculum materials" (National Research Council, 2004, p. 188). In response to their charge, the committee found that "the corpus of evaluation studies as a whole across the 19 programs studied does not permit one to determine the effectiveness of individual programs with a high degree of certainty" (p. 189). This finding was due to the restricted number of studies for any particular curriculum, limitations in the array of methods used, and the uneven quality of the studies. The committee called for, among other things, studies that focused more closely on and reported more specifically about teachers' relationships with mathematics curriculum materials. In fact, one implication of differing results from studies focused on student achievement is the critical nature of context surrounding students' use of *Standards*-based mathematics curriculum materials, especially the role of the teacher in enacting the curriculum program.

Research about teachers' use of Standards-based mathematics curriculum materials. A great deal of research about *Standards*-based curriculum materials has focused on student achievement (e.g., Carroll & Isaacs, 2003; Harwell et al., 2007; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Post et al., 2008; Riordan & Noyce, 2001; Tarr et al., 2008), but an equally important body of research has investigated *teachers'* experiences with these materials. These studies have documented "teachers in transition" as they implement unfamiliar curricula (Keiser & Lambdin, 1996; Lloyd, 2008b; Lloyd & Wilson, 1998; Manouchehri & Goodman, 2000; M. Wilson & Lloyd, 2000), highlighted the significant variation in curriculum use among teachers (Herbel-Eisenmann, Lubienski, & Id-Deen, 2006; Lambdin & Preston, 1995; Lloyd, 1999; Remillard & Bryans, 2004; Sherin & Drake, in press), and portrayed teachers engaging with, adapting, and learning from *Standards*-based curriculum materials (Collopy, 2003; Lloyd, 2002b; Remillard, 2000).

Some of the earliest studies of teachers in transition centered on California's new curricular resources and state mathematics frameworks. In one of the most widely cited reports, Cohen (1990) documented the experience of one teacher, Mrs. Oublier, and her critical role in enacting curricular reform. Although Mrs. Oublier embraced the reform ideas expressed in the new state curricular resources and framework, her teaching was a mixture of both novel and traditional instructional practices. Cohen (1990) speculated on the role of teachers' perceptions of the new materials, mathematical knowledge, and previous traditional pedagogical beliefs in the enacted curriculum. Cohen concluded that as teachers work with new reforms, they are faced with

> acquir[ing] a new way of thinking about mathematics, and a new approach to learning it. They would have to additionally cultivate strategies or problem solving that seem to be quite unusual. They would have to learn to treat mathematical knowledge as something that is constructed, tested, and explored, rather than as something they broadcast, and that students

> accept and accumulate. Finally, they would have to unlearn the mathematics they have known. (p. 327)

Following from the California studies, many researchers focused on teachers making the transition from teaching with traditional mathematics textbooks and materials to *Standards*-based curricular resources and found similar results. For example, Manouchehri and Goodman (1998) studied 66 teachers' implementation of four different *Standards*-based curricular series over a 2-year period. They found that teachers' knowledge of newly advocated innovative teaching practices, their mathematical content knowledge, their personal theories about teaching and learning, and support from administration, greatly affected the extent to which programs were implemented. Some of the biggest issues facing teachers in this study were a lack of adequate time for planning instruction, and a lack of understanding of the long-range goals of the program and the new instructional practices that were expected of them. Similar to Mrs. Oublier (Cohen, 1990), these teachers also tended to struggle to find a balance between what they perceived as the necessary algorithmic knowledge and the development of new conceptual understandings.

Studies focused on teachers in transition also documented teachers changing roles in newly conceived mathematics classrooms in which *Standards*-based mathematics materials were in use. For example, Wilson and Lloyd (2000) described three mathematics teachers struggle to define where the mathematical authority would lie in their classrooms as they utilized the curriculum materials of the *Core Plus Mathematics Project*. They found that all three teachers were committed to the recommendations espoused in *Core Plus*, were supported by school personnel, and had relatively strong and flexible content knowledge. However, the teachers frequently referred back to past experiences when deliberating about "the *type* of mathematics that should be consider in class, and the *ways* in which it should be considered" (p. 167). Consequently, the teachers tended to struggle in their attempt to share mathematical authority with their students and change their role from "dictator" to "facilitator" (p. 168).

As teachers in transition struggle with changing conceptions of their role within the mathematics classroom, they similarly struggle with issues of time surrounding their new roles. Studies have highlighted the critical need for extensive time for teachers to learn with the materials (Clarke, 1997; Manouchehri & Goodman, 1998), to grapple with reform ideas (Lappan, 1997) and to develop new understandings of the mathematical concepts presented in the materials (Ball & Feiman-Nemser, 1988; Lloyd, 1999). Teachers need extended time outside the classroom to grapple with new ideas, but they also struggle to work with time constraints in the classroom. Keiser and Lambdin (2001) found, for example, that the cooperative group work, manipulatives, and alternative assessments involved with implementing the new materials contributes to difficulties with lesson pacing.

Whereas some researchers have attempted to explore the challenges teachers face as they implement new reform ideas and utilize *Standards*-based mathematics curriculum materials, other research has highlighted the significant variation in teachers' conceptions of curriculum in general and conceptions of particular curriculum materials in use. For example, teachers from Lloyd's (1999) study, Ms. Fay and Mr. Allen, interpreted the problems in the *Core-Plus* curriculum materials very differently. Whereas Ms. Fay felt the problems were overly structured and limited exploration, Mr. Allen viewed the problems as challenging and, at times, too open-ended. Although utilizing the same curriculum materials, these teachers' varying interpretations of the materials led, in part, to variation in their curriculum use.

Highlighting similar results, Remillard and Bryans (2004) found substantial variation in nine teachers' views about curriculum and its role in their teaching. The authors defined each teacher's orientation toward and use of the *Standards*-based elementary curriculum *Investigations*. For example, one teacher's curriculum orientation was described as "adherent and trusting" while another was described as "quietly resistant." The authors concluded that

> we see a teacher's orientations toward a curriculum as a frame that influences how he or she engages the materials and uses them in teaching. This orientation is not only influenced by the teachers' beliefs about mathematics teaching and learning, but also reflects the teacher's view of curriculum materials in general as well as the particular curriculum. Because this orientation figures in the teacher's use of the curriculum, it plays a role in shaping the opportunities to learn available to the teacher. (p. 383)

A unique example of teachers' varying orientations towards curriculum is highlighted by one teacher's use of two different texts for instruction – a traditional algebra text for one class and *Standards*-based curriculum materials (*Core Plus*) in another class (Herbel-Eisenmann et al., 2006). Herbel-Eisenmann et al. found that the teacher's pedagogy differed considerably between the two courses – using group work, graphing calculators and extended problem contexts in the *Core Plus* classroom, and lecturing for most of the traditional algebra class. Whereas the teacher's overall orientation towards curriculum and reform did not change from one class to the next, her consideration of the history of reform in her district and her concern for parents and students' decisions regarding which class to enroll shaped her differing curriculum use and resulting pedagogical strategies.

Research about teachers' interactions with state mathematics frameworks and testing. Numerous studies have also investigated challenges that teachers face as they respond to policy and accountability issues (Barksdale-Ladd & Thomas, 2000; Cimbricz, 2002; Craig, 2004; Smith, 1991). Smith (1991) reported that teachers faced with external testing in the 1980s felt burdened by the demands the tests placed on their work and some felt shamed by the process. The pressures of mandated accountability testing were described by the school principal in Craig's (2004) study as "the dragon in your backyard" (p. 1230). Barksdale-Ladd and Thomas (2000) wrote, "Teachers view tests as hurting their performance as good teachers and hurting children by forcing teach-to-the-test instruction and inflicting unnecessary stress and anxiety. Yet these teachers felt powerless to do anything except prepare children for the tests" (p. 395). This literature identifies many influences (including status and experience, grade level and subject matter focus, and school context) that shape how teachers respond to high-stakes testing.

As Cimbricz (2002) concluded from her review of the literature, "The influence state-mandated testing has (or not) on teachers and teaching would seem to depend on how teachers interpret state testing and use it to guide their actions" (p. 14). In fact, a recent survey of teachers and administrators suggests that teachers are paying close attention to these new state standards and that these documents are significantly influencing classroom instruction, professional development, and the selection of textbooks (Reys, Dingman, Sutter, & Teuscher, 2005). However, as Kauffman, Johnson, Kardos, Liu, and Peske (2002) found, while teachers do attend to state mathematics frameworks, these documents appear to create a sense of urgency for teachers without providing enough support for instruction. The teachers in Kauffman et al.'s study were left to create their own curriculum to correlate with their state standards in Massachusetts, and many left the profession prematurely. In this way, the current political climate surrounding mathematics education has an effect on what textbooks are adopted and how teachers elect to use the adopted texts. As districts adopt textbooks that align with state and national standards with the goal of improving test scores, the system of accountability and teachers' curriculum use become intricately connected.

What Have We Learned?

Overall, these studies highlight the dynamic and complicated relationship between teachers and mathematics curriculum materials. Research focused on student achievement and the use of *Standards*-based curriculum highlighted the importance of teachers' roles in student learning. An important body of research focused on teachers' use of *Standards*-based mathematics curriculum materials emerged concurrently, highlighting teachers' efforts to make the transition from teaching with traditional materials to *Standards*-based resources and struggle with past conceptions of mathematics and mathematics teaching and learning. Complicating the relationship are teachers' differing orientations towards curriculum in general and to new materials in particular. Most studies show that time is critical for teachers to develop successful pedagogical strategies, to understand and feel comfortable with their changing roles, and to learn from the use of these materials. These studies also highlight teachers' differing uses of *Standards*-based mathematics curriculum materials and the complicated nature of teachers' curriculum use in light of state frameworks, personal factors, and local contextual issues.

Cuban (1993) suggested that "none of the pitiful history of curricular reform seems to matter in the 1990s, when national goals, standards, and tests are rushing forward like an 18-wheeler careering down a steep grade" (p. 183). Yet his suggestion that "we must work to integrate curricular reform with efforts to build the capacity of teachers to create, use, and choose their own materials" (p. 184) highlights a changing and evolving field focused on *teachers'* use of mathematics curriculum materials.

Theoretical Considerations in Research on Teachers' Use of Curriculum Materials

Defining Curriculum

Curriculum theory and curriculum studies have undergone dramatic changes in the past 40 years. In the 1970s, the field took a dramatic turn moving away from a primary focus on *developing* curriculum and toward an increased interest in *understanding* curriculum (Pinar et al., 1995). This paradigm shift included a reconceptualization of curriculum as exclusively school materials to curriculum as symbolic representation: "the institutional and discursive practices, structures, images, and experiences that could be identified and analyzed in various ways, i.e. politically, racially, autobiographically, phenomenologically, theologically, internationally, and in terms of gender and deconstruction" (p. 16). This reconceptualization of the field still includes attention to curriculum development (and analysis) as an institutionalized or bureaucratic function; however curriculum development is now just one small piece of a larger focus on curriculum more generally. The idea of curriculum as text has expanded and diversified from the "how to's" of curriculum development to a focus on *describing* and *understanding* curriculum development.

In 1976, mathematicians, mathematics educators, and educational researchers came together to make recommendations about the focus of the Second International Mathematics Study (SIMS). The study's eventual purpose was to "compare and contrast, in an international context, the varieties of curricula, instructional practices, and student outcomes across the schools of twenty countries and educational systems" (Travers & Westbury, 1989, p. 1). Because of this emphasis, curriculum played a large role in the conceptualization and design of SIMS, creating a need to define this ambiguous term. As such, the SIMS developers defined curriculum

> as a structure that is *intended* to control the scope of what should be done in schools; it may be seen as the body of content and practices that are in fact being *implemented* in schools; it may be seen as something that is realized or achieved in the understandings of students. In SIMS, these different aspects of the curriculum have been termed the *intended curriculum,* the *implemented curriculum,* and the *attained curriculum* (Travers & Westbury, 1989, p. 111).

Viewing curriculum from three perspectives – the intended curriculum, the implemented curriculum (sometimes called opportunity-to-learn), and the attained curriculum – provided a rich context for studying student outcomes. As Travers and Westbury (1989) assert, "This SIMS model permitted triangulation on student outcomes from two basic points: the intended and the implemented curriculum" (p. 203). The SIMS researchers emphasized the centrality of the implemented curriculum in influencing student achievement and helped not only to define particular aspects of curriculum, but also to highlight the importance of the teacher in matters of student learning.

In 1993, the Third International Mathematics and Science Study [TIMSS] added the term "enactment" to the list of varied curriculum. The *enacted curriculum*, while similar in meaning to the implemented or taught curriculum, adds slightly different meaning to the curriculum that occurs in the classroom. As Connelly and Ben-Peretz (1980) point out, "the use of implementation terminology has been unfortunate… we are all now aware that research findings and new curriculum programs are rarely implemented according to the spirit and intentions of the researcher and developer" (p. 100). Many researchers apply the term "enactment" to refer to the curriculum created jointly by teachers and students as they use official or intended curriculum materials to create classroom activities (see e.g., Porter & Smithson, 2001; Remillard, 2005).

Other researchers have attempted to define and name aspects of the curriculum. In 1993, Cuban suggested that "tenured academics and practitioners alike have an obligation to students and the public to state in a convincing manner that there are four curricula, not one…" (p. 184). These curricula, the *official*, the *taught*, the *tested*, and the *learned*, highlight another, similar way to distinguish what actually occurs in the classroom as externally created curriculum materials make their way into particular classroom settings. As Cuban describes, the taught curriculum is what teachers actually choose to do based on their knowledge, their experiences, their preference for certain topics, and their views of their particular students each year. Cuban's (1993) suggestion that we focus on "the curriculum that really counts – the one used by teachers in classrooms" (p. 184), and the addition and clarification of the term "enactment" to the list of varying curriculums, further signify the importance of the teacher in enacting *Standards*-based materials and mathematics frameworks in the classroom.

Curriculum itself has always been a part of teachers' daily work and has therefore been the subject of many studies of classrooms around the world. It is only recently, however, that teachers' use of particular curriculum materials and textbooks have become the explicit focus of research. This research has helped position the teacher as critical players in curriculum enactment. As Connelly and Ben-Peretz (1980) assert, "It is generally recognized that teachers do *not* neutrally implement programs; they develop programs of study for their classrooms by adaptation, translation, and modification" (p. 95). Despite this general belief, perspectives on teachers' use of curriculum materials are quite diverse.

Perspectives on Teachers' Use of Curriculum Materials and Textbooks

Research perspectives. Pinar et al. (1995) stated that "teaching is commonly characterized as the means by which curriculum is implemented" (p. 745). The term "implementation," however, has come to mean many different things. Consider the curriculum continuum proposed by Snyder, Bolin, and Zumwalt (1992). The authors categorized three differing perspectives on curriculum implementation: (a) the fidelity perspective, (b) the mutual adaptation perspective, and (c) the enactment perspective. Researchers who perceive curriculum with a *fidelity* lens are interested in studying the degree to which a planned curriculum is implemented by teachers in ways intended by curriculum writers. The role of the teacher is one of a consumer who should "implement the curriculum as those possessing curriculum knowledge have designed it" (p. 429). Although many researchers have moved away from this perspective, a few important studies still attempt to measure the degree to which certain *Standards*-based mathematics materials are implemented as written. For example, Tarr, Chavez, Appova, and Regis (2005) investigated "fidelity of implementation" of several NSF-funded *Standards*-based and publisher-generated curricula used by 39 teachers across six states. Using teachers surveys, textbook-use diaries, table-of-contents implementation records, and teacher interviews, the researchers set out to report the extent to which teachers' implemented the content of textbooks in use. This perspective has received increased attention in recent years, mostly due to the release of the NRC (2004) report. As this report highlights, "a standard for evaluation of any social program requires that an impact assessment is warranted only if two conditions are met: (1) the curricular program is clearly specified, and (2) the intervention is well implemented" (p. 100). As many studies reviewed in the NRC report offered limited discussion of teachers' fidelity of implementation, student achievement results in relation to curriculum materials in use were questioned. Helping to move the field towards a more clearly defined research perspective on curriculum implementation and fidelity, Chval, Chávez, Reys, and Tarr (in press) defined a set of research tools that could be used to measure textbook integrity, including "(a) regular use of the textbook, (b) coverage of a significant portion of the textbook, and (c) instruction that mirrors the pedagogical orientation of the textbook as represented in suggested activities and other teacher notes" (p. 31). Based on their work, the authors concluded that it is both important and possible to measure textbook integrity and that "only by doing so can we legitimately study the possible influence of particular kinds of textbooks on student learning outcomes" (p. 32). Similarly, as Lloyd, Herbel-Eisenmann, and Remillard (2005) contend,

> [whereas] research revealing the ways that teachers shape or transform curriculum materials raises questions about the possibility of curricular fidelity…it would be inaccurate and irresponsible to conclude that all interpretations of a written curriculum are equally valid. The field is in need of ways to characterize reasonable and unreasonable variations or instantiations of a particular curriculum that are tied to features most central to its design. Research on variations in teachers' use of curriculum materials is critical to these efforts…" (p. 1)

Inherent in the design of these studies is the importance of the situational contexts in regard to implementation and point towards a second research perspective outlined by Snyder et al. (1992).

Further along the continuum are those researchers who perceive curriculum implementation as “mutual adaptation.” Snyder et al. (1992) have distinguished between two camps of mutual adaptation – those closer to the fidelity perspective who hold a more practical view and those aligning more closely with the enactment perspective who hold a more critical view on curriculum implementation. Overall, the mutual adaptation perspective (influenced heavily by the Rand Change Study headed by McLaughlin (1976) focuses on how the planned curriculum is shaped by adapters and the situational context. Researchers falling within this perspective view curriculum knowledge as either residing in the outside experts who developed the curriculum or as a combination of external curriculum knowledge coupled with practitioners’ curriculum knowledge. The role of the teacher is more central in shaping the curriculum and, depending on where the researchers fall along the continuum, is viewed as pragmatically necessitated or required in successful implementation in particular settings.

Most research focused on teachers’ uses of *Standards*-based mathematics curriculum materials tend to fall within this perspective. Consider, for example, Remillard’s (2005) review of research on teachers’ use of mathematics curriculum materials. In this review, Remillard posed four general perspectives on mathematics curriculum use: (a) following or subverting the text, (b) drawing on the text, (c) interpretation of text, and (d) participation with the text. The third and fourth perspectives – curriculum use as *interpretation of the text* (which views teachers as interpreters of the written curriculum) and curriculum use as *participation with the text* (which focuses not only on how teachers adapt and interpret materials, but also on how the curriculum changes and shapes the views of the teacher) – pervade most recent studies on teachers’ use of mathematics curriculum materials (see e.g., Cohen, 1990; Collopy, 2003; Lambdin & Preston, 1995; Lloyd, 1999; Lloyd & Wilson, 1998; Remillard, 2000; Remillard & Bryans, 2004; S. M. Wilson, 1990).

Finally, researchers viewing curriculum implementation from an enactment perspective view the actual or enacted curriculum as their focus. They are interested in how the curriculum is shaped *and* how it is experienced by teachers and students. Curriculum knowledge is viewed as an ongoing process and is not necessarily dependent on an externally created piece of curriculum as the center of the study. Researchers from this viewpoint view the role of the teacher and students as critical as there would be no curriculum without them. As Snyder et al. (1992) emphasized, “Whether using an externally created and imposed curriculum, adapting a curriculum, or developing their own, teacher and students in the classroom create the curriculum that is worthy of study" (p. 429). Researchers utilizing this perspective on curriculum use include Ben-Peretz (1990), Brown (Brown, 2002, in press; Brown & Edelson, 2003), Paris (1993), and Clandinin and Connelly (1992; Connelly & Clandinin, 1990). These researchers tend to view teachers as developers of curriculum and view curriculum as something experienced in particular classroom situations instead of viewing curriculum as externally imposed through materials and texts. Ben-Peretz and Connelly have been writing about teachers as partners in the development of curriculum materials since the early 1980's (Ben-Peretz, 1984, 1990; Connelly & Ben-Peretz, 1980). Fueled in part by the failed notion of "teacher-proof" materials in the 1960s, their research and scholarly writings advocated "a more sophisticated notion of a teacher's relationship to…proposed curriculum programs" (Connelly & Ben-Peretz, 1980, p. 95). In their eyes, the most sophisticated conceptualization of teachers' as curriculum users is the idea of teachers as adapters and partners in development. In this sense, teachers are assumed to be full partners in the development of curriculum. Teachers' inquiry is "oriented toward discovery of curriculum potential, change, and transformation of materials, devising of new alternatives, and decision making" (Ben-Peretz, 1984, p. 12).

More recently, Brown and Edelson (2001) proposed a view of teachers' curriculum use as *teaching by design.* This teacher-text perspective focuses specifically on how teachers adapt curriculum materials and aims to understand this interaction by viewing teacher appropriation of instructional resources as a design practice. As Brown and Edelson (2001) emphasized,

> The process of instruction involves teachers' mediation of cognitive and material resources – that is, what teachers do is create opportunities for learning through the mobilization and coordination of resources in order to accomplish their instructional goals. (p. 3)

Within this perspective, it is as important to consider the nature of the curriculum materials themselves as it is to consider how teachers use such resources. For example, the study prompting this perspective examined teachers' uses of AIM (Adaptive Instructional Materials) within science education. As described by Brown (2004),

> AIM integrates an indexed and annotated database of electronic resources with the ability to compose and adapt such resources into personalized lesson and course plans. AIM is designed to accomplish two primary objectives: (1) to support teacher engagement with the concepts and issues of a given subject area, and (2) to support teachers with resources and activity ideas that they can use to create or adapt instructional materials of their own. (p. 7)

In this case, the nature of the materials in use may necessitate a teacher-text perspective such as teachers' curriculum use as *design* (Brown, in press).

Snyder et al.'s (1992) curriculum implementation continuum might be described as moving from the idea of fidelity toward more and more extreme forms of variation – some researchers are concerned with the implementation of a particular set of curriculum, others are concerned with the relationship forged between teachers and a particular set of curriculum materials, and still others are focused on the overall enacted curriculum including teachers' and students' experiences with the curriculum.

Multiple dimensions of curriculum use. In considering research on teachers' uses of mathematics curriculum materials and texts, researchers not only develop their own conceptions of teachers' curriculum use to inform their research designs and analyses, but they also categorize teachers' use of curriculum as they examine teachers working with texts in a variety of arenas.

Teachers' interactions with curriculum materials occur throughout the entire teaching process. Remillard (1999) proposed a model for examining teachers' curriculum use throughout multiple arenas in which teachers engage in curriculum decision-making. The *design arena* involves selecting and designing mathematical tasks. Here teachers consult with the textbook and decide whether to adopt, adapt, or invent their own classroom tasks. The *construction arena* involves enacting these tasks in the classroom and responding to students' encounters with them. Finally, within the *curriculum mapping* arena, teachers work with curriculum materials to determining the organization and content of the entire curriculum into which daily events fit. As Remillard describes, "unlike the first two arenas, the mapping arena is not directly related to daily, classroom events; rather it impacts and is impacted by them" (p. 322). These categories – the *design arena,* the *construction arena,* and the *curriculum mapping* arena – highlight the multiple aspects of teachers' curriculum development in which teachers make explicit and implicit decisions regarding curriculum use. Researchers attending to these categories are able to highlight the multiple facets of curriculum enactment among teachers.

Descriptions of teachers' curriculum use. As studies on teachers' use of curriculum materials continue to emerge, it is evident that teachers use these materials in a variety of ways. Two sets of researchers, Brown and Edelson (2003) and Remillard and Bryans (2004), have contributed to our understanding of broad categories of curriculum materials use among teachers.

Although slightly different in description, the categories from these reports progress along a continuum from instruction centered on close and frequent use of a particular set of curriculum materials towards instruction loosely based on a set of curriculum materials. *Thorough piloting* (Remillard & Bryans) and *offloading* (Brown & Edelson) categorize use consistent with significant reliance on curriculum materials to support instruction. Teachers using textbooks in this way tend to use most or all suggested parts of the curriculum during instruction. *Adopting and adapting* (Remillard & Bryans) and *adaptation* (Brown & Edelson) occurs as teachers adopt certain elements of the curriculum but also tended to adapt tasks and activities using their own strategies and approaches. This category necessitates a shared responsibility for curriculum design between teachers and texts. Finally, the third category, *intermittent and narrow use* (Remillard & Bryans) and *improvisation* (Brown & Edelson) occur when teachers use materials only minimally to design instruction. In this case, the materials may provide an initial idea for each lesson, but teachers use their own familiar instructional repertoires to guide lessons. While these categories are somewhat discrete, teachers may move from one category to another or incorporate aspects of two or more categories. For example, Lloyd (2008a) characterized curriculum use by one student teacher in her study as *adaptation* of her cooperating teacher's *improvisation* of a curricular approach. Similarly, Roth McDuffie and Mather (in press) characterized two experienced middle school mathematics teachers initial interactions with a *Standards*-based curriculum materials as *thorough piloting with transformations*. These teachers initially used the curriculum materials as their primary guide, however they moved gradually to transforming the materials to align more closely with their state learning expectations.

Theoretical perspectives on teachers' curriculum use help to define the important role of the teacher in curriculum-making in the classroom. They also help researchers to articulate their own perspectives as they design research studies, collect data, and report findings. The final section of this chapter focuses on my particular research interest: preservice teachers' experiences with mathematics curriculum materials. This section discusses research related to preservice teachers' curriculum use and makes explicit how my research and perspectives on teachers' use of curriculum materials fall within this body of literature.

Preservice Teachers' Uses of Mathematics Curriculum Materials

Researchers and educators over several decades have set out to define, characterize, and understand teachers' work during various phases of the teaching career – from novice teachers to mid-career teachers to experienced and expert teachers (e.g., Berliner, 1986; Steffy, Wolfe, Pasch, & Enz, 2000). Research within the realm of teachers' use of curriculum materials is no exception. Consider, for example, findings from five studies focused on either beginning or experienced teachers' uses of curriculum materials. In a study of beginning elementary teachers textbook use, Kauffman (2002) found that all four teachers preferred having detailed guidance from the textbook, with the expectation that they would need less guidance as they gained more experience. Similarly, in their study of three English and three mathematics beginning secondary school teachers evaluations and modifications of curricular resources, Reynolds, Haymore, Ringstaff, and Grossman (1988) found that over the course of teacher education and their first year of teaching, teachers "evaluations and modifications of curricular materials reflected a growing understanding of students, of pedagogy, of other curricular materials, and, in some cases, even of content" (p. 23). The authors document changes in the six teachers' evaluation and use of curricular materials; over time the teachers made more modifications to the materials and did not feel as though the materials had to be used "as is." In their study of 50 first and second year teachers, Kauffman, Johnson, Kardos, Liu, and Peske (2002) found that when new teachers received little guidance for what to teach or how to teach it, they struggled greatly to prepare content and materials.

Alternatively, Silver, Mills, Ghousseini, and Charalambous (in press) suggested that after several years of experience teaching with *Standards*-based mathematics curriculum materials, many teachers reach a *curriculum plateau* – that is, teachers become comfortable enacting increasingly familiar curriculum materials even if they have not yet gained proficiency in using the curriculum materials for maximum effectiveness. Finally, Sosniak and Stodolsky (1993), in their study of four experienced 4^{th} grade teachers, found that textbooks did not necessarily play the dominant role that is often assumed. The teachers in the study saw themselves as teaching knowledge and skills to a group of children, not teaching a book or a specific set of materials.

These studies allude to different perspectives on and approaches to curriculum use by beginning and experienced teachers. Beginning teachers appear to benefit from and appreciate the explicit guidance that curriculum materials tend to offer, whereas more experienced teachers tend to rely less heavily on the specific suggestions within the materials as they modify and adapt their instruction. However, some teachers may reach a curriculum plateau as they become increasingly familiar with specific curriculum materials.

Even more telling, other studies focus on both beginning and experienced teachers within the same study, hoping to highlight differences in focus. For example, Remillard and Bryans (2004) found that three of the four beginning teachers in their study of teachers' uses of mathematics curriculum materials appreciated the explicit guidance of curriculum materials and were considered "thorough piloters" of the curriculum. This stance towards curriculum was different from more experienced teachers in the study. In a study of teachers' concerns regarding the adoption of a new curriculum, Christou, Eliophotou-Menon, and Philippou (2004) found that the concerns of beginning and experienced teachers fell into different categories. For example, beginning teachers were most concerned with changes that would occur in their own personal work situations given a new curriculum, whereas experienced teachers were more concerned with the consequences of the innovation for their students.

Taken together, these studies highlight the need for researchers to learn more about the experiences of *particular groups* of teachers as they use curriculum materials. For example, many beginning teachers are entering classrooms to teach, for the first time, with *Standards*-based mathematics curriculum materials. This raises interesting and potentially very different issues than curriculum use for more experienced teachers attempting to make the transition from traditional instruction and textbook use to the use of *Standards*-based materials and pedagogical practices. As Kauffman (2002a) points out, more research is needed about "whether, what, and under what conditions new teachers learn from different types of curriculum materials" (p. 23). Although several studies do in fact focus on beginning teachers, notably absent is a focus on preservice teachers' uses of curriculum materials.

Preservice Teachers' Use of Curriculum Materials in Teacher Education Coursework

As Shulman (1986, 1987) pointed out, part of learning to teach is the development of a knowledge base for teaching. Consisting of content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, this extensive knowledge base includes understandings developed from formal educational scholarship and also from wisdom of practice. As Shulman (1986) explained, the third category of knowledge—*curricular knowledge*—consists of an understanding of

> the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and

> the set of characteristics that serve as both the indications and contradictions for the use of particular curriculum or program materials in particular circumstances. (p. 10)

Adding to this definition, Lloyd (2002a) drew attention to the role of teachers' beliefs about curriculum materials in their developing curricular knowledge. According to Lloyd, these beliefs about curriculum materials

> encompass understandings of the role of curricular materials in the teaching and learning process, the philosophies of teaching and learning that underlie diverse curriculum materials, knowledge of the appropriateness of particular materials for certain classes and individuals, and the practical and intellectual understandings necessary for making adjustments to curricular approaches. (pp. 156-157)

These multiple dimensions of curricular knowledge highlight the complicated nature of teachers' curriculum use. As Ben-Peretz (1984) pointed out, "The ability to grasp the full meaning of curriculum materials is a prerequisite for their professional use in classrooms. This ability has to be developed in pre- and inservice teacher education programs" (p. 11). An important aspect of that experience is preservice teachers' learning from and uses of textbooks and curriculum materials during teacher education coursework.

As new *Standards*-based mathematics curriculum materials were developed, teacher learning was considered an important component of the design (e.g., Ball & Cohen, 1996; Davis & Krajcik, 2005; Remillard, 2000; Van Zoest & Bohl, 2002). Ball and Cohen (1996) suggested that turning curriculum materials into a site for teacher learning requires a reconceptualization of curriculum design: the curriculum as a whole, including the student books and teacher's guides, would have to provide a terrain for teacher learning. *Standards*-based curriculum materials have come to be thought of as *educative* curriculum materials. They are intended to promote teacher learning of subject matter, help teachers anticipate and interpret learners' understandings, and support teachers' design capacity as they make decisions about curriculum adaptation (Davis & Krajcik, 2005).

Most teachers require extensive experiences and time working with and learning from new curriculum materials, especially *Standards*-based curriculum materials. Calls have been made to incorporate curriculum materials into methods courses and professional development practices to help teachers develop both an understanding of and familiarity with these new materials (Ball & Cohen, 1996; Bush, 1986; Manouchehri & Goodman, 1998). One particularly interesting context proposed and studied extensively by Lloyd (Lloyd, 2002a, 2004, 2006; Lloyd & Behm, 2005;

Lloyd & Pitts Bannister, accepted for publication), is the incorporation of *Standards*-based curriculum materials into mathematics courses for preservice teachers, offering teachers the chance to learn mathematics in a manner consistent with the reform effort. Research indicates that teachers teach in the ways in which they were taught (Ball, 1988; Lortie, 1975). Lloyd has argued that when preservice teachers revisit the mathematics they will eventually teach through the use of novel curriculum materials, they are provided with opportunities to consider the nature of mathematics, make connections between their own learning and that of their students, and develop personal visions of *Standards*-based instructional practice.

Tarr and Papick (2004) developed and reported on four mathematics courses for preservice middle school teachers, with each course utilizing *Standards*-based mathematics curriculum materials for over 50% of the course content. Feedback on the course was reportedly positive, as teachers felt they had further developed their own mathematical understanding and also gained important ideas about instructional strategies and resources that they could use with their own future students.

Although these studies advocate for the use of mathematics curriculum materials within preservice coursework, particular details about how one might use these materials with preservice teachers is not explicit throughout most of the studies. However, my first manuscript however, appearing in Chapter 3, focused specifically on one teacher education activity that engages preservice teachers in the analysis of two distinctly different mathematics lessons – one from a traditional mathematics textbook and another from the *Standards*-based *Connected Mathematics Project.* This manuscript contributed much needed detail to our understanding of preservice teachers' interactions with *Standards*-based curriculum materials, provided a rationale for using such activities in preservice coursework, and suggested ways to enhance this and similar activities within preservice teacher education (Lloyd & Behm, 2005).

Whereas preservice teachers' uses of mathematics curriculum materials and instructional resources throughout coursework is interesting to consider, so is preservice teachers' use of similar materials during student-teaching. Research about student teachers' curriculum use is discussed below.

Student Teachers' Uses of Mathematics Curriculum Materials

In the U.S. and most parts of the world, the student-teaching internship is the culminating experience of initial teacher education programs (Guyton & McIntyre, 1990; McIntyre, Byrd, &

Foxx, 1996). Most teachers view the student-teaching internship as the most valuable and beneficial part of their preparation (Feiman-Nemser, 1983; Guyton & McIntyre, 1990), claiming that most of what they know comes from first-hand teaching experience (Feiman-Nemser & Buchmann, 1985). Highlighting a time of cross-purposes, focused simultaneously on teaching effectively and learning to teach, this experience characterizes a unique and complex component of teacher learning (Feiman-Nemser & Buchmann, 1985; Wildman, Niles, Magliaro, & McLaughlin, 1989).

Almost two decades ago, Ball and Feiman-Nemser (1988) reported on student teachers who emerged from their teacher education programs with the impression that good teachers do not follow textbooks or rely upon teacher's guides. Despite these perceptions, the teachers in the study were found to make extensive use of textbooks during their student-teaching internships. Similarly, more recent studies focused on beginning teachers' use of *Standards*-based mathematics curriculum materials found that these teachers, typically lacking curricular repertoires of their own, appear to greatly appreciate the explicit guidance about what and how to teach that textbooks can offer (Kauffman et al., 2002; Lloyd, 2007; Remillard & Bryans, 2004). Some of these studies report seemingly positive outcomes in regard to student teachers' interactions with mathematics curriculum materials. For example, Van Zoest and Bohl (2002) described a student teacher (Alice) and her mentor teacher's (Gregory) experiences during a student-teaching internship in which *Standards*-based curriculum materials were used. The study aimed to "provide an initial conception of how the reform materials used during the internship impacted the character of Alice and Gregory's interactions and Alice's development as a reform-oriented mathematics teacher" (p. 267). The authors found that the use of innovative mathematics curriculum materials played a central role in situating the interactions between Alice and Gregory. More specifically, their use of these materials helped to challenge their mathematical knowledge and their ideas about teaching and provided them with questions that effectively stimulated planning and discussion.

Other studies have raised questions about the role curriculum materials play in an internship. Lloyd (2007) found that although the student teacher in her study, Bridget, appreciated the guidance of several published curriculum materials and state frameworks as she taught mathematics for the first time, she was forced to make compromises in her teaching. Lloyd questioned the long-term impact of compromises made during student-teaching on future teaching practices. Similarly raising questions as to the role of curriculum materials in teacher learning across time, Van Zoest and Stockero (2006) followed seven teachers from preservice education through their second year of teaching. The authors found that the novice teachers who excelled in their use of *Standards*-based curriculum materials during student-teaching later struggled in classrooms with limited or traditional curricular resources.

Studies about student teachers' use of the mandated national mathematics curriculum in England have also raised questions about the value of such experiences. Edwards and Protheroe (2003) found that as student teachers utilized the mandated national curriculum, they "placed emphasis on curriculum delivery at the expense of responsive pedagogical decision-making" (p. 240). Similarly, Twiselton (2000) found that although student teachers' use of the highly prescriptive national mathematics curriculum moved them beyond a focus on task management, it also contributed to the teachers' focus on curriculum delivery. This focus, in turn, restricted student teachers' ability to reflect on the skills and concepts they were teaching.

Individually, these studies contribute to our knowledge of student teachers' use of particular sets of mathematics curriculum materials and begin to exemplify the powerful influence and role of curriculum materials in the work of student teachers and beginning teachers. However, looking across these reports, one notices a diversity of studies – each seeming to involve different curricular resources, various research designs, and quite varied results. In addition, studies pay differing attention to particular factors affecting student teachers' use of curriculum materials. In these studies, some student teachers appeared to excel when using *Standards*-based materials, others appeared to be limited by the use of mandated materials, and still others reported a lack of preparedness to work with a range of materials during first year teaching despite successful use of *Standards*-based materials during student-teaching. These differences across studies raise questions about what we might take from this emerging body of literature as a whole. More research focused on opportunities for teacher learning with curriculum materials in varied contexts, both during teacher education and as a catalyst for future learning and reflection, remain critical.

My own research on student teachers' use of mathematics curriculum materials and instructional resources (Chapters 4 and 5) helps to define more clearly what factors seem to contribute to student teachers' uses of mathematics curriculum materials. The manuscript in Chapter 4 focuses on one student teacher, offering information about her use of the *Standards*-

based *Everyday Mathematics* program and her contrasting use of a more traditional textbook during one lesson. The manuscript in Chapter 5 focuses on all three elementary student teachers' experiences with differing instructional resources for mathematics teaching. Factors affecting these teachers' use of their primary curricular resources are identified and explored. These chapters describes the nature of the curriculum materials in use, illustrates the student teachers' curriculum use, and makes recommendations for the restructuring of coursework and fieldwork experiences for preservice teachers.

Importance of Research on Preservice Teachers' Use of Mathematics Curriculum Materials

As previously highlighted, many beginning teachers appreciate the guidance of a published curriculum (Kauffman, 2002b; Remillard & Bryans, 2004) and tend to struggle when given little or no guidance in regard to what and how to teach (Kauffman et al., 2002). However, curriculum use is a complicated facet of teaching, especially for beginning teachers who may be using *Standards*-based curriculum materials for the first time. How might we better prepare beginning teachers to work with the mathematics curriculum materials they desire (or are mandated) to use, when these materials represent complicated and new visions of mathematics, teaching, and learning? The key to investigating this question lies in part in work with preservice teachers throughout teacher education experiences. The need for further research stems from three main issues:

(1) Preservice and inservice teachers are asked to utilize a variety of mathematics curriculum materials, instructional resources, and state mathematics frameworks for the teaching of mathematics. We are just starting to develop a detailed understanding of *preservice teachers' uses of particular mathematics instructional resources*.

(2) *Preservice* teacher learning is the focal point of most teacher education programs. Very few studies have focused on *opportunities for teacher learning with mathematics curriculum and instructional resources* throughout university coursework and fieldwork.

(3) Classroom experience is an integral part of most teacher education programs. However, as Feiman-Nemser and Buchmann (1985) point out, experience alone might not be the best teacher of teachers. We know little about what *specific teacher education experiences* might better prepare teachers to engaged critically with mathematics instructional resources.

Because many beginning teachers will find themselves in school systems that mandate the use of a particular *Standards*-based curriculum or a state curriculum framework, creating opportunities for *preservice* teachers to interact with instructional resources and investigating these interactions is critical. While differing trends emerge among curriculum use by *inservice* teachers at varying levels, it becomes apparent that teachers may need varying forms of support throughout their professional careers.

The three reports that follow focus specifically on *preservice* teachers at the start of their careers and were guided by more than one discrete perspective on teachers' use of curriculum materials. My own perspective on teachers' curriculum use encompasses the idea of teachers drawing on, interpreting, and ultimately designing their own curriculum. As such, my perspective focuses on the ways teachers use and also learn from materials (or how they *participate* with texts) and also on how teachers develop their own unique curriculum with their particular students (or how they *develop* curriculum). Together, the three papers that follow contribute to our understanding of preservice teachers' experiences with mathematics curricular resources throughout coursework and fieldwork. These studies document preservice teachers' experiences evaluating, planning with, enacting, and reflecting on curricular resources. These studies also provide insight into opportunities for learning when preservice teachers are engaged with mathematics curriculum materials across varying experiences within coursework and fieldwork. However, as Feiman-Nemser and Buchmann (1985) suggest, experience alone may not necessarily produce the kind of learning envisioned by current reform efforts. It is important to reflect critically on the specific learning experiences provided in teacher education, the role of teacher educators and cooperating teachers in shaping these experiences, and the potential effects of those experiences on beginning teaching practices. Findings from these studies not only advance our understanding of preservice teachers' experiences with mathematics curriculum materials, but also challenge our thinking about important teacher-curriculum encounters during preservice teacher education.

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Chapter 3. Preservice Teachers' Analysis of Mathematics Instructional Materials[1]

In most subject areas of the school curriculum, new standards and guidelines have been published over the past decade (e.g., National Council for the Social Studies, 1994; National Council of Teachers of English and the International Reading Association, 1996; National Council of Teachers of Mathematics [NCTM], 1989, 2000; National Science Teachers Association, 1996). In response to these new curriculum standards, many innovative instructional materials have been published with the explicit intent of helping teachers and students enact reform-oriented subject matter and pedagogical goals. These standards-based instructional materials not only incorporate novel approaches to content, but also invite teachers and students to participate in more student-centered classroom activities.

Although the current climate of reform in American schools offers exciting new opportunities for those preparing to enter the teaching profession, reform also poses significant *challenges* to prospective teachers, many of whom have never experienced learning or teaching in reform-oriented ways (or with standards-based instructional materials). As teacher educators, we are concerned with preparing these preservice teachers to not only embrace the curriculum standards and theories that we hope will guide their future pedagogical decision-making, but also to effectively utilize the sorts of instructional resources that will be available to them.

This article explores issues emerging from a teacher education activity in which prospective elementary teachers were invited to analyze selected sections of different mathematics instructional materials (i.e. traditional textbooks and reform-oriented curriculum materials)[2]. Although this activity took place in a mathematics class for prospective teachers and involves the exploration of mathematics instructional materials, the outcomes have implications for teacher educators in many other academic areas.

Rationale

The notion that activities related to instructional materials can lead to significant learning by preservice teachers is not new. Recent research has documented ways in which inservice teachers

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[1] The manuscript presented in this chapter has been published in the journal, *Action in Teacher Education* (Lloyd & Behm, 2005)

[2] For the remainder of this article, we will use the term *textbook* to refer to traditional mathematics materials and the phrase *curriculum materials* to refer to newer reform-oriented materials. *Instructional materials* will be used to refer to both textbooks and curriculum materials.

may be compelled to develop new subject-matter understandings and new pedagogical practices as they teach with reform-oriented curriculum materials (Ball & Cohen, 1996; Lloyd, 2002a; Remillard, 2000; Russell et al., 1995). Researchers have also documented teachers' learning during participation in Chinese and Japanese models of textbook analysis and lesson study (Ma, 1999; Stigler & Hiebert, 1999; Watanabe, 2002). Although preservice teachers lack the opportunity and experience needed to participate in curriculum implementation or lesson study, most teacher education programs require preservice teachers to develop, teach from, and reflect on lesson plans. Some teacher educators also offer preservice teachers direct experience with innovative curricular designs by using reform-oriented K–12 curriculum materials as the basis for subject matter learning (Lloyd, 2002b, 2004; Lloyd & Frykholm, 2000). These ways of using lesson plans and instructional resources in teacher education appear to offer fruitful strategies for helping preservice teachers to learn about both pedagogy and subject matter.

This article proposes the guided analysis of instructional materials as another effective teacher education activity. We suggest three possible reasons that the analysis of instructional materials may be a uniquely valuable activity in which to engage preservice teachers. First, teachers may benefit from exposure to reform-oriented curriculum materials so that they can become more familiar with new representations of content and new recommendations for classroom activities. Comparisons between various instructional materials may offer preservice teachers opportunities to reach informed decisions about the relative educational value of different curricular designs. By considering the diverse learning theories on which different instructional materials are based, preservice teachers may be able to improve their ability to predict what types of understandings their students would gain through the use of these materials. Because preservice teachers will one day leave the university to become key curriculum decision-makers in their own classrooms and schools, development of the ability to weigh the advantages and disadvantages of different instructional materials is critically important.

Analysis of instructional materials also requires teachers to consider subject matter and pedagogy together, in relation to one another. Traditionally, the coursework component of teacher preparation has maintained a separation between content (subject matter) and pedagogy. More recent trends have included recognition of the value of integrating content and pedagogy within teacher education courses and programs (Ball & Bass, 2000; Cochran & Jones, 1998;

Edwards, 1997; McArthur, 2004; Thorton, 2001; Wilson, 1994; Yager & Penick, 1990). Because, in the analysis of instructional materials, preservice teachers are asked to consider materials from the perspectives of learners *and* future teachers, they must utilize both subject matter knowledge and pedagogical conceptions. Doing so may help preservice teachers to begin to develop the *pedagogical content knowledge* (Shulman, 1987) they will need for their future teaching.

Finally, as most teacher educators are aware, it is often difficult to establish a context in which preservice teachers are able to access and reveal their often tacitly-held beliefs about teaching (Cooney, 1985; Fenstermacher, 1979). The problems and activities contained within instructional materials can provide very specific topics for discussion and analysis. For example, analysis may include exploration of why one set of instructional materials *begins* by providing a formula, but another *ends* with student development of that same formula to solve a real-world problem. This sort of comparison may compel teachers to explore some of their own unquestioned beliefs about the learning of mathematics.

Context for Preservice Teachers' Analysis of Instructional Materials

The Preservice Teachers and the Course

Participants in this study were 23 preservice elementary teachers in an undergraduate mathematics course titled *Geometry and Computing for Teachers.* The course met once weekly for three hours and took place during the spring semester of the 2002-2003 academic year at a large state university located in the Mid-Atlantic region of the United States. Students in the class were preservice elementary teachers, all female, in either their second or third year of a 5-year elementary education program. The two instructors of the course, a mathematics education professor and a mathematics education doctoral student, designed the analysis assignment and are also the authors of this report.

This mathematics course focused on a variety of two- and three-dimensional geometry and measurement topics. As part of a larger ongoing research project related to teacher learning with K-12 curriculum materials, selected units from reform-oriented middle school curriculum materials were being used as the primary mathematical texts in the course. With the exception of the assignment described in this report, all course activities focused the preservice teachers on using curriculum materials as learners of mathematics. The particular units, chosen from the reform-oriented *Mathematics in Context* and *Connected Mathematics Project* curriculum materials, were selected to correspond to the mathematical emphases typically found in a geometry course for preservice elementary teachers.

The Assignment: Teachers' Analysis of Instructional Materials

Although the teachers worked extensively with the curriculum materials to learn mathematics in the course, the authors were also interested in gaining information about how the teachers might be thinking about *pedagogical* issues related to the reform-oriented curriculum materials. With the dual purpose of attaining this information and offering teachers a chance to reflect on and articulate their views of curriculum and teaching, we designed an activity focused on the analysis of mathematics instructional materials.

During the fifth week of a 15-week semester, the preservice teachers were given copies of selected student pages from two different sets of instructional materials. (These instructional materials are described in the next section of this report). For this assignment, due at the end of the 8th week of the semester, the preservice teachers were asked to first give an open-ended analysis of each set of instructional materials. This part of the assignment was intentionally kept unstructured to offer the preservice teachers a chance to develop their own ideas about what to look for when examining instructional materials. The second part of the assignment was more specific, asking the preservice teachers to respond to 10 questions focusing on the comparison of the two sets of instructional materials. They were asked to analyze the differences between the two sets of instructional materials, describe what they liked more or less about each one, explain which they preferred for students and/or teachers, indicate any changes they might make, suggest what they thought were the main ideas and mathematical understandings that students would gain, and then choose which set they would prefer to use in their future classrooms. The assignment sheet is included in the Appendix of this report.

The Instructional Materials

Selection of the instructional materials that we asked the teachers to analyze was very deliberate. We aimed to find two fairly self-contained sets of instructional materials that dealt with the same mathematical topic but in different ways. Specifically, we wished to find materials that incorporated distinctly different assumptions about teaching and learning. Our search for two such sets of instructional materials was guided, in part, by distinctions between reform-oriented and more traditional mathematics instruction drawn by Simon (1994) and outlined in Table 1. Although Simon's distinctions offer extreme characterizations of the assumptions on which instruction might be based, the distinctions served to structure our decision-making about the qualities of instructional materials that might be productive for teachers to consider. In particular, we sought two sets of instructional materials containing distinctly different opportunities for students to communicate about mathematics, participate in genuine problem-solving and generalization about mathematical ideas, develop and test their own ideas and hypotheses, foster their own sense of mathematical authority, and connect their learning to new ideas and questions.

With these distinctions in mind, the sets of instructional materials selected for the teachers to analyze are as follows:

- Set A: "Measuring Parallelograms" and "Measuring Triangles" from the unit *Covering and Surrounding* (Lappan et al., 1998, pp. 46-59) of the Connected Mathematics Project [CMP], and

- Set B: "Area of Polygons" from the textbook, *Mathematical Connections: A Bridge to Algebra and Geometry* (Gardella et al., 1992, pp. 445-449).

Both sets of instructional materials focused on finding areas of rectangles, parallelograms and triangles. However, they differed greatly in length, presentation, and overall design. Each set of materials is described below.

Set A begins with a brief review of finding the area of rectangles by counting square units, reminding students that although the goal of the activity is to find shortcuts for finding the area of special figures, they could cover a figure with grid squares and count squares to find the area. It then asks students to find the area of several rectangles and parallelograms and explain their methods. Several more problem statements follow, asking students to create various parallelograms that meet certain constraints. The following task is then posed:

> Summarize what you have discovered from making parallelograms that fit given constraints. Include your feelings about what kinds of constraints make designing a parallelogram easy and what kinds of constraints make designing a parallelogram difficult. Have you discovered any shortcuts for finding areas of parallelograms? If so, describe them. (Lappan et al., 1998, p. 49)

Set A goes on to state that, as students have probably discovered in their work, it would be useful to develop an easy way to find area without having to count grid squares. It instructs students to draw and cut out several nonrectangular parallelograms, cut each into two pieces, and try to reassemble them to form rectangles. They record the base, height, perimeter and area of the original parallelograms and the newly formed rectangles and the following question is posed: "What relationships do you see between the measures for the rectangle and the measures for the parallelogram from which it was made?" (p. 50). Students are then asked to use what they have learned to find the area and perimeter of a given parallelogram. It continues, using the same questioning and exploration approach, this time focusing on what students have learned about parallelograms to find a shortcut for finding the area of triangles.

Set B begins by explaining to students how to find the area of a rectangle by counting grid squares. The students are asked to think about a simpler way to find the area of a rectangle, and are then shown a list of formulas and diagrams (for finding the area of squares and rectangles) and an example calculation. The materials illustrate how any parallelogram can be "rearranged" into a rectangle, noting the similarities between the area formulas for rectangles and parallelograms. The formula for finding the area of a parallelogram and an example follows. Next appears an explanation of how to find the area of a triangle by thinking of it as one-half the area of a parallelogram, followed by the formula for finding the area of a triangle and one last example. Set B concludes with a variety of practice problems, some asking students to find the areas of given figures, some fill-in-the-blank questions focused on comparing the areas of various rectangles, parallelograms, and triangles, and some career/application problems. Sample questions follow:

- Make a sketch of a parallelogram with base 8.5 in. and height 6 in. (Gardella et al., 1992, p. 447)
- Find the height of a triangle with area 36 ft^2 and base 8 ft. (p. 447)
- Group Activity: Using a newspaper, find the cost of several types of flooring. Which type is most expensive? Least expensive? Calculate the cost of installing three types of flooring in your classroom. What factors should you consider when choosing a flooring? (p. 449)

These sorts of problems comprise the conclusion of Set B.

The Authors' Bias

Because most claims about instructional materials are reflective of some professional or personal perspective, it is important for the reader to be aware of the authors' bias. Although reform-oriented curriculum materials can be used as the basis for traditional classroom instruction (and vice versa), it is the authors' view that Instructional Set A is considerably more likely to form the basis for reform-oriented instruction (of the type outlined in Table 1) than is

Instructional Set B. As illustrated in the description above, Set A explicitly attempts to have students develop, test, and communicate about their own ideas about ways to find the areas of parallelograms and triangles. In contrast, Set B offers very few opportunities for students to develop or communicate about mathematical ideas – instead, the materials outline all the information that students need to know.

As teacher educators and researchers, we were interested in how the preservice teachers might react to distinctions between these two sets of instructional materials. We recognize that our bias toward reform-oriented curriculum materials may have been shared with teachers because, in our mathematics course, we implemented other materials from the same reform-oriented curriculum series (*Connected Mathematics)* from which Set A was extracted. However, we intentionally never initiated or participated in any explicit conversations about different instructional materials with the preservice teachers. This decision was necessary for the larger research study of which the present report is part.

Interpreting the Teachers' Written Reports

Data for this paper consists of the 23 preservice teachers' written responses to the assignment appearing in the Appendix. To synthesize and interpret the teachers' written analyses of the two sets of instructional materials, we started by reading the entire collection of papers two times. During the first review, we had two goals in mind: to get an initial sense of the types of responses and to create a summary of each paper. The second review was intended to further develop the common ideas that seemed to be surfacing, as well as to improve the information that was recorded during the first review. In particular, our reviews aimed to identify the criterion the teachers seemed to be using for reading and evaluating the instructional materials, as well as those factors that seemed to be primary in their ultimate decisions about which set of instructional materials they preferred. For instance, as elaborated in the next section of the report, many students looked at the instructional materials in search of a clear presentation of rules and formulas. This search was a determining factor in many teachers' preference for Set B over Set A.

After these two large reviews, we examined each of the 23 papers more carefully to confirm the tentative themes developed during initial reviews. In all, each individual paper was reviewed at least four times to develop major themes. All quotes pertaining to a particular theme were compiled electronically and were selected for inclusion in this report on the basis of how clearly they expressed the theme and how representative of the theme they were.

Preservice Teachers' Analysis of the Instructional Materials

In this section, we present themes that were most common to the teachers' papers, followed by a short discussion of less common but very noteworthy themes from a few teachers' papers.

In Search of Familiar (Traditional) Components

Eleven of the 23 preservice teachers specifically cited their own past experiences with traditional mathematics textbooks and lessons as major influences on their interpretations of the two sets of instructional materials. Consider, for example, Erin's comment about Set B: "[Set B] is done in a much more structured fashion than Set A. The way that this lesson plan is structured is more of what I am used to, and what I feel is effective when teaching math to children." Because Erin was more familiar with the traditional form of Set B, she seemed to be more convinced of its effectiveness in the classroom. Allison expressed similar ideas as she discussed Set B. "From a teacher's point of view, I would prefer to use Set B…[This is] the type of lesson that I grew up on as a child, and maybe that is why I am partial to this particular lesson." Allison too emphasized a sense of comfort based on familiar experiences and exposure to more traditional instructional materials.

Most of the preservice teachers (20 out of 23) not only preferred Set B due to its familiarity, but also disliked Set A due to its lack of familiarity. Because they searched each set of instructional materials for familiar traditional features (e.g. rules, examples, practice problems), the teachers tended to comment most about what *was not* in Set A and what *was* in Set B (and less about what *was* in Set A and *was not* in Set B). The following statement made by Sophia illustrates this theme: "Set A did not provide examples or formulas which I think is a bad idea. It is not necessary in this lesson to have them, but it is still a good idea." Sophia communicates, as do many of the preservice teachers, that example problems and formulas of the type appearing in Set B should have been included in Set A. Although Sophia suggested that formulas and examples are not needed in Set A, she still expressed desire to include these elements somewhere in the materials.

Of the 16 teachers who did articulate the goal of Set A, 13 teachers noted its failure to include more traditional mathematical and pedagogical features. Consider Amy's description:

> In Set A they are trying to get the child to come up with their own way of finding area. They don't want to just come out and tell them what the formula is like in Set B. I think it is good for the children to initially investigate and see if they can come up with ways to find area on their own, but I think after some investigation, they should be given the formulas for reference and clarity.

Like Sophia, Amy suggests that formulas should be listed somewhere within Set A. Although she sees some benefits of Set A's design, Amy maintains a desire for instructional materials to present formulas to students.

In general, and perhaps not surprisingly, the preservice teachers' interpretations of the instructional materials reflect the prominent view that students need to be *told* the mathematics they are expected to learn. For instance, it was common for teachers to comment on the value of Set B's clear presentation of important ideas. Consider, the following statement made by Allison when discussing Set B:

> The objectives, terms, and formulas were displayed in boxes so that they were set apart from the rest of the lesson. I think that this is a great idea because then students can look back and review the major concepts briefly if needed…Overall, I prefer Set B because it reinforces the main concepts through clear bulleted format.

The organization and "bulleted format" of Set B were actually cited by Allison as her primary reasons for preferring Set B to Set A. Although not stated, it is quite possible that Allison (and the other preservice teachers who mentioned organization as a key factor in their like or dislike of a particular set of instructional materials) is most concerned with what the boxed and bulleted organization represents throughout the materials: a direct presentation of the concepts, formulas, and ideas needed to complete the task at hand. She seems to be associating the overall mathematical goal of this set of materials with the direct, immediate presentation of information – a hallmark of traditional mathematics instruction.

Using Traditional Expectations to Make Questionable Interpretations of the Instructional Materials

The influence of preservice teachers' familiarity with more traditional instructional material components was, at times, so strong that it led them to inaccurately describe the two sets of instructional materials or to arrive at questionable conclusions about the materials. Certainly instructional materials can be interpreted in many ways. However, 14 teachers' traditional assumptions about what a set of instructional materials should contain actually resulted in descriptions that neglected or misrepresented critical features of each set.

For example, when invited to describe her favorite component of each set of instructional materials, Erin wrote:

> In Set A, I liked how it clearly explains all of the information … My favorite component of Set A is how thorough the lesson plan is. It is lengthy and provides many opportunities for practicing the concepts. This can make unclear students more clear on concepts and lets them learn through repetition, which can be very effective.

Erin describes Set A as providing a clear explanation of the information followed by opportunities for practicing the concepts. Actually, Set A offers very little explanation, instead providing questions that help students to develop a formula for finding area. Considering their guiding nature and placement within the materials, it would seem difficult to categorize these questions as practice (as Erin does). The goal of Set A is not to illustrate a process or procedure and have students practice[3], but to provide an opportunity for the gradual development of the concept through student exploration.

For another example of this theme, consider the following statement made by Allison, as she attempts to describe a problem from Set A:

> Throughout [Set A], there are several characteristics that would help a student better grasp the concept. For example, there are a number of problems that the students are instructed to solve using the formula. Problem 5.1 offers a variety of shapes so that the student learns how to apply the formula to more than one situation.

This description is also rather inaccurate. The problem to which Allison refers does ask students to find the area of several parallelograms, however, it does not ask them to use "the formula" to solve the problems. It instead includes a square grid background and asks students to explain how they found the area of each shape, leaving open the possibility of students developing different methods and ideas about how to find area.

It is possible that these inaccurate descriptions of Set A arose out of a lack of close reading and effort on the part of our preservice teachers. However, both Erin and Allison seemed to have a fairly good understanding of the ultimate goal of Set A. For example, in another part of her paper, Allison states the following about Set A:

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[3] Although the pages chosen for Set A did not include practice problems per se, the *Connected Mathematics* curriculum (from which they were extracted) does contain practice problems at the end of each section of material. Our decision to exclude these practice problems from Set A related to our desire to create a strong conceptual distinction between Set A and Set B.

> Students are asked to explore the notion [of area] themselves, conclude from their findings, and then explain them…This will only benefit the student's understanding of area and will divert him/her from simply memorizing facts and formulas.

Given this description, it seems fair to conclude that Allison, and perhaps many of her classmates, made some quick judgments about problems or activities in Set A based on what she thought *should have been* included in the materials. The use of words such as "explanation" and "practice problems" as highlighted by Allison and Erin are certainly terms and processes with which they are comfortable. However, these terms are simply not accurate descriptors of Set A.

In Search of Non-Traditional Components: More Questionable Analysis

A substantial number of the preservice teachers (15 out of 23) expressed an interest in instructional materials containing cooperative group work, an important component of reform-oriented mathematics instruction. Interestingly, the teachers tended to assume that problems or activities outlined in the two sets of instructional materials would be completed by students individually, unless explicitly indicated in the materials as "group work." Consider a statement made by Erin when discussing Set A:

> Many students need the opportunity to interact with other students to gain a better understanding of the presented concepts. Much of this "individual work" could present a problem for students who are not these types of learners.

Although Set A never specifically indicates group work anywhere within its pages, it also never indicates that the problems are to be completed individually. In fact, successful completion of the open-ended problems of this set of instructional materials would demand extensive student interaction and exploration. However, Erin's statement seems to indicate an automatic default to assuming individual student work when analyzing Set A.

Elizabeth's writing about group work is illustrative of the same assumptions made by Erin (above) and of the theme, discussed previously, of teachers' focus on what is *not* in Set A. Consider Elizabeth's overall descriptions of the two sets of instructional materials:

> Set B was able to offer the students group work, hands-on activities, show how it is relevant in people's lives, wrote a clear objective at the top of the paper and the directions were much easier to understand. Set A did not offer group work, a hands-on activity, a clear objective, show how it is relevant, nor did it have directions that were as easy to follow as Set B.

It may be the case that Elizabeth's and other teachers' comments are reactions to two problems (out of 24) in Set B that indicate potential interaction among students. The question, "How many square inches are in a square foot" (Gardella et al., 1992, p. 447) is labeled "Discussion" and a problem incorporating newspaper advertisements to compare cost of various types of flooring (p. 449) is labeled "Group Activity." Although it is certainly not our intent to discredit the importance and quality of these two problems, it is important to point out here that these indicated interactive problems make up only a small portion of Set B. It is interesting that Elizabeth, in addition to many other preservice teachers, characterized Set B as being more interactive and group-oriented than Set A. As teachers' descriptions illustrate, assumptions about student interaction were based entirely upon indications of such within each set of instructional materials.

Justifying Differences Between the Two Sets of Instructional Materials

Although they were not asked to do so, 14 of the 23 teachers were compelled to discuss why such different sets of instructional materials might exist. In one way or another, most of the preservice teachers communicated a belief that each set of materials had been created for a different type or level of learner. Consider the following statement made by Elizabeth:

> Maybe Set B is targeted to a younger audience and that is why the directions and explanations are much easier to read and understand. Set A could be targeted for an older audience that should already know the material and might not need the explanation to go along with it.

This statement gives us insight into Elizabeth's beliefs about the learning of mathematics. She argues that Set A would only be used with students who have already learned the concepts and formulas associated with area. Elizabeth appears to be either unaware of the purpose of the exploratory nature of Set A or does not believe in its ability to lead students to their own understanding and development of the concepts.

Similar to Elizabeth's reasoning, Helen made the following observation about the two sets of instructional materials and their intended usage by students:

> It seems [Set A] would be best used with a group of students who has a hard time with math, or that is below or on grade level in their math work. This does not mean it is not a good lesson, because it is, however a group of above grade level math students would not find this lesson very challenging…Set A never gives the child the formula for finding the area of any of the shapes used. This bothers me because I believe at some point it is necessary for even the slower math students to have the formula to use with the practice problems.

Helen indicates that Set A was created for students who have "a hard time with math." Although this statement could be interpreted in many ways, Helen's later comment about the problem she has with Set A never providing a formula ("it is necessary for even the slower math students to have the formula") indicates her belief that formulas are the ultimate learning goal to be achieved by students when going through a mathematics lesson. Her critique of Set A does not include an analysis of the kind or quality of problem within the materials, it instead focuses on its exclusion of an explicitly defined formula. Brenda, as do most of the preservice teachers, agrees when she comments: "Set A is more simplified than Set B. Set B takes it to a higher degree using more complicated formulas and word problems."

A few of the preservice teachers were able to identify the different mathematical goals and implied assumptions about mathematics learning within each set of instructional materials. They tended, however, to identify these differences only when describing the students for whom they believed these sets of materials were intended. Take for example a comment made by Shelly when discussing the differences between the two sets of materials:

> I think both sets do a good job of getting the ideas across but for different types of learners. For Set A, people that like to see the problems done visually and learn better by figuring it out themselves will learn better from this lesson. Set B is for students that learn best from memorizing formulas and plugging numbers in to find out the answer.

Mary communicates a similar, albeit more critical, sentiment to Shelly's comment when she states: "Sure this lesson [Set A] may be great for the inventor kids, but not for those already struggling with math and the concept of area."

These comments about the instructional materials and the students for whom they were written provide insight into several notions of mathematics teaching and learning communicated by the preservice teachers. First, and probably most obvious from these statements, is the general belief that those students who would be labeled as slow learners of mathematics by these preservice teachers learn mathematics in different ways than do students who excel in mathematics. Coupled with this idea is the notion that these slower learners work through simple problems without the use of formulas – the formulas are saved for more advanced learners of mathematics.

Less Common Analysis Among a Few Preservice Teachers

Comments made by three of the preservice teachers, although not typical of the larger group of teachers, offer some important themes that are worthy of consideration. These themes suggest possible ways that instructional materials analysis may offer some teachers, who are perhaps at a different place in their development as teachers, opportunities to articulate their conceptions.

Consider, for example, the comments made by Margaret as she discusses Set A:

> I like the fact that Set A gives more of an open-ended opportunity for children to learn rather than Set B, with “right” or “wrong” answers…Set A is better because it involves the students and lets the students come to a mathematical idea without memorizing rules and formulas. I feel as if the students would actually LEARN the concept of area in a parallelogram and triangle rather then memorize a formula…Overall, I like Set A much better. If given the option to choose, I would use Set A in my classroom. I would feel as if the material and mathematical concepts would actually stick with children in the long run, whereas a formula might be forgotten in a week.

Margaret indicates that Set A allows students to explore ideas on their own and come to their own mathematical understandings without having to memorize a formula. Margaret has identified why a formula might not be included in Set A and appears to appreciate the potential benefits of that approach.

Similarly, Jean comments on the role of exploration in students’ growing understanding of concepts and procedures:

> This lesson requires students to explore topics on their own, coming to conclusions about the concepts using what they know and what they learn from experimenting with the problems given in the lesson…Having the students explore the topics on their own makes sure that they have a true understanding of the material and why the formulas work the way that they do.

Jean also relates her own past learning experiences to Set B:

> I remember completing lessons similar to Set B and never learning the information. I would skim through the beginning explanation and then complete the problems, giving little attention to what was actually stated in the reading. I think that Set A would give the students a better thorough understanding of the material.

Although Jean is familiar with instructional materials like Set B, she indicates a belief that Set A would offer students a chance to develop more thorough understandings.

Finally, consider comments made by Teresa when discussing which set of instructional materials is better for students:

> Set A is better for the students. It allows them to explore the concepts themselves so they learn how to find the measurements themselves. By exploring different ways to solve the problems, it gives solutions for many students to understand. They gain a better understanding as to why the solutions work and how they work, so that it will be easier for them to solve the problems and to remember how to do so.

Clearly Teresa has made a connection between the way students engage with mathematics and the resulting nature of their knowledge.

Each of these three teachers points out the importance of the exploratory approach of Set A and how this exploration may allow students to develop deeper, more meaningful and lasting understandings. They also identify the value of letting students develop their own solution methods and assert the importance of this in relation to students understanding why and how solution methods work and make sense. Although these opinions were certainly not in the majority, they highlight very important ideas that can arise as preservice teachers examine instructional materials.

Discussion and Implications

This instructional materials analysis assignment had two primary purposes: (1) to inform us, as researchers and teacher educators, about preservice teachers' conceptions of instructional materials, and (2) to determine if an analysis assignment might be a useful teacher education activity in a mathematics course early in teachers' programs of study. In this section, we revisit those purposes in light of the results of the teachers' analyses.

The results of our instructional materials analysis assignment are consistent with the widely accepted notion that preservice teachers' prior schooling experiences have profound effects on their conceptions of teaching and learning (Ball, 1990; Lortie, 1975). It is not surprising that when our preservice teachers attempted to analyze different sets of instructional materials, their prior experiences in traditional experiences, or the "apprenticeship of observation" (Lortie, 1975, p. 61), played a considerable role.

We were, however, somewhat surprised by the *strength* of the traditional element of the teachers' conceptions of appropriate instructional materials. Many teachers not only conducted their analyses from the perspective of past experiences with traditional instruction – they actually applied their expectations so heavily that they sometimes made faulty interpretations of the instructional materials. This result is particularly interesting in light of the fact that the teachers were using curriculum materials similar to Set A for their own mathematical learning in the course.

Although many teachers used traditional criteria to evaluate the instructional materials and gave little or no credit to more innovative instructional approaches, we remain optimistic about the role of instructional materials analysis in preservice teacher education. In fact, the traditional nature of teachers' conceptions suggests that teachers may benefit from *more* instructional materials analysis. Through this activity, teachers were invited to carefully reflect on and articulate their ideas about what constitutes effective instructional materials. For our students, this activity may have been their first experience viewing instructional materials the perspective of a teacher.

We also recognize that there are many ways that this assignment (and perhaps the course activities surrounding it) might be improved. Based on the results of our attempt at engaging students in the analysis of instructional materials, we propose that improvement be aimed, at least initially, at the following three areas:

- increasing teachers' focus on the depth and type of mathematical understandings that students might gain from different instructional materials,
- improving teachers' analysis of the purpose or quality of student interaction and cooperation in the classroom, and
- developing teachers' sense of themselves as curricular decision-makers.

Suggestions for how we might make such improvements are elaborated below.

The preservice teachers in our course seemed to be more concerned with the clarity of the presentation of information in the instructional materials than with a deeper consideration of the kinds of understandings students might develop through engagement with these particular sets of materials. Teachers seem to have some primitive notions about learning styles, as evidenced by their comments about how certain learners might be more successful with a more (or less) open-ended set of instructional materials. These notions may offer an excellent starting point for teachers to more critically consider their assumptions about learners and learning. Our assignment (see Appendix) may dramatically improve with the addition of one or more questions that draw teachers' attention to the specific mathematical understandings that students would gain from Sets A and B. It may also be the case that teachers would benefit from more extensive reflection on their own specific mathematical understandings before attempting to compare instructional materials. For example, our teachers actually used Set A later in the semester for their own mathematical learning about area. Reversing the order of these assignments could promote the development of deeper mathematical understandings among the preservice teachers. Greater familiarity with Set A might increase teachers' ability to consider its pedagogical merits. It may also be the case that teachers' pedagogical content knowledge would be enhanced as a result of this explicit connection between content and pedagogy (Ball & Bass, 2000).

Teachers' written analyses of the two sets of instructional materials contained little attention to the quality or purpose of student interaction. None of the preservice teachers taking part in this analysis attempted (in writing) to explore which types of problems would be effective for group work or discussion. It is important for teachers to recognize that how mathematics is taught is intimately connected to how it is learned (Carpenter et al., 1999; Hiebert et al., 1997). Although some teachers indicated an interest in cooperative learning, the teachers did not appear to take classroom communication as a serious criterion in their evaluation. As suggested above, this problem may be addressed by the addition of pointed questions to our assignment. It may also be aided by more extensive discussions in class about the different teaching and learning theories that underlie instructional materials.

Many preservice teachers attend teacher education courses with the desire to be told how to teach. The teachers in our course appear to have carried the same perspective into their analysis of the instructional materials. As the example above illustrates, the teachers seemed to view the instructional materials "as is" – they seemed reluctant to make assumptions about and possible modifications to the materials. Teachers will need to learn to view curriculum as adaptable if they are to adopt what Ball (1993) describes as a "bifocal perspective – perceiving the mathematics through the mind of the learner while perceiving the mind of the learner through the mathematics" (p. 159). Attending to students' developing mathematical ideas and the mathematics that students are to learn, the teacher must be poised to make difficult but necessary decisions about what happens in the classroom.

How can we alter our instructional materials analysis assignment to better prepare teachers to play key roles in curricular decision-making? Although teachers were asked about making changes to the instructional materials (Question 7 of the assignment – see Appendix), our questions may communicate a somewhat static treatment of the two sets of materials. Our assignment could be altered to *require* teachers to make changes to the instructional materials, for instance, by asking them to use the two sets of instructional materials as the basis for two lesson plans (or alternatively one lesson plan which incorporates aspects of both sets of materials). Doing so would require teachers to make choices and decisions about the sets of materials – work they will need to do as teachers.

Teacher educators in other content areas are likely to find that their students' interpretations of instructional materials are similarly influenced by prior experiences in traditional classrooms.

We encourage teacher educators in other disciplines to investigate this influence, and moreover to develop and document the effectiveness of course activities that require preservice teachers to critically examine instructional materials. Future research in different content areas may reveal interesting new findings about how preservice teachers' subject-specific experiences impact, and are impacted by, the analysis of instructional materials.

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Table 1

Distinctions between reform-oriented and traditional mathematics instruction

Reform-Based Instruction	**Traditional Instruction**
1. Situations for students to communicate mathematical ideas and engage in negotiation of meaning	1. No situations for students to communicate mathematical ideas and engage in negotiation of meaning
2. Problem solving in a specific context followed by abstraction/generalization of ideas	2. Presentation of an abstract idea followed by application in specific contexts
3. The concepts discussed are developed by students and expressed in their language	3. The concepts discussed are presented by the teacher in his/her own language/the language of the communities in which he belongs
4. The responsibility for determining the validity of ideas resides with the classroom community	4. The responsibility for determining the validity of ideas resides with the teacher or is ascribed to the textbook
5. Application is the exploration of new ideas or extensions of ideas previously developed	5. Application is limited to the practice and use of the general idea presented

Appendix 1

Analysis of Instructional Materials

This appendix presents the specific assignment given to the preservice teachers in this project. Teachers received copies of two sets of instructional materials, Set A and Set B, and the following questions:

Part 1 – Open-Ended Analysis

For this part of the project, you will carefully read through both sets of instructional materials and type up a separate analysis of each. Your analysis should be as long as necessary to adequately describe and analyze all components of the materials. Before reading through the materials, take the time to brainstorm ideas about what to look for during your analysis.

Part 2 – Question-Guided Comparison

1. Upon first glance, what seems to be similar between the two sets of instructional materials? What seems to be different?
2. Look back at the similarities and differences that you listed in Question 1. Why do you think certain components of the instructional materials are different or similar? What is your opinion of the differences and similarities between the materials?
3. What do you like less or more about each set of instructional materials? Why?
4. Which set of instructional materials do you think is “better” for students? Explain your reasoning, making sure to describe what you mean by better.
5. From a teacher’s point of view, which set of instructional materials do you like better? Which set of materials do you think would be easier to use in the classroom? Explain.
6. Which set of instructional materials do you think is more commonly used in classrooms? Why?
7. If you could make changes to any part of either of these materials, what would those changes be? Why?
8. What is your favorite component of these two sets of instructional materials? Explain your reasoning.
9. Go through each set of instructional materials again, trying to imagine yourself as a student working through each set. What do you think are the main ideas that you’d get out of each set of materials? How are the main ideas similar and/or different between the two sets?
10. Overall, which set of instructional materials do you like better? If given the option to choose, which set of materials would you use in your classroom? Why?

Chapter 4. Piloting the Mandated Curriculum Program and Adapting a Supplementary Textbook: A Student Teacher's Varying Relationships with Mathematics Curriculum Materials[1]

Millions of students in the United States use *Standards*-based curriculum materials to learn mathematics (Senk & Thompson, 2003). With substantial federal funding in the 1990s, these curriculum materials were designed to help teachers enact the recommendations of the National Council of Teachers of Mathematics (1989). Although a great deal of research about *Standards*-based curriculum materials has focused on student achievement (e.g., Carroll & Isaacs, 2003; Harwell et al., 2007; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Riordan & Noyce, 2001), an equally important body of research has investigated *teachers'* experiences with these materials. These studies have documented "teachers in transition" as they adopt unfamiliar curriculum materials and struggle to enact the curriculum programs as intended (Keiser & Lambdin, 1996; Manouchehri & Goodman, 2000; Wilson & Lloyd, 2000), highlighted the significant variation in teachers' use of curriculum materials (Herbel-Eisenmann, Lubienski, & Id-Deen, 2006; Lambdin & Preston, 1995; Lloyd, 1999; Remillard & Bryans, 2004; Sherin & Drake, 2004), and portrayed teachers as engaging with, adapting, and learning from *Standards*-based curriculum materials (Collopy, 2003; Lloyd, 2002; Remillard, 2000).

An important emergence from this line of inquiry is a *participation with the text* perspective on research about teachers' curriculum use (Remillard, 2005). Studies that draw on this perspective focus on "relationships that teachers forge with curriculum materials, the factors influencing that relationship, and the effect that relationship has on the teacher and enacted curriculum" (p. 216). As the body of research about teacher-curriculum interactions continues to grow, research about the nature of preservice teachers' use of mathematics curriculum materials and textbooks is in its initial stages. In the past five years, three published reports have addressed student teachers' use of mathematics curriculum resources (Lloyd, 2007, 2008; Van Zoest & Bohl, 2002) In Van Zoest and Bohl's study, curriculum-based discussions between a student teacher and her mentor teacher afforded opportunities for both teachers to learn about mathematics and pedagogy. Lloyd's studies offer preliminary insights into the nature of student

[1] The manuscript presented in this chapter is currently under review for publication in a peer-reviewed journal (Behm & Lloyd, under review).

teachers' interactions with curriculum resources for the design and enactment of mathematics instruction. In particular, these studies raise questions about student teachers' use of different kinds of curriculum resources for their mathematics instruction in varying classroom contexts.

Roth McDuffie and Mather (in press) suggested that teachers may engage in different types of curricular reasoning when they use *Standards*-based curriculum materials and commercially-developed mathematics textbooks. What relationships might student teachers forge with different curriculum materials during their internships? The present report describes one student teacher's use of *Standards*-based mathematics curriculum materials for 10 weeks in a first-grade classroom. In addition, the report describes the student teacher's contrasting use of a commercially-developed textbook for one mathematics lesson. Our decision to provide detailed accounts of one student teacher's use of two conceptually distinct curriculum programs stems from the research need described above and also based on current teacher education practices. Increasingly, student teachers are placed in schools where mathematics textbooks are adopted by districts as a strategy for improving student achievement (Corcoran, 2003). Indeed, some student teachers are asked to use textbooks "widely criticized for their content" or "curriculum that is controlled through objectives and standardized testing" (Ball & Feiman-Nemser, 1988, p. 421). Other student teachers are placed in classrooms where *Standards*-based mathematics curriculum materials are in use (e.g., Lloyd, 2008; Van Zoest & Bohl, 2002). Although mathematics curriculum programs are a common component of student teachers' experiences and some teacher educators have begun to explore the use of mathematics textbooks and curriculum materials as learning tools in teacher education coursework (see e.g., Hjalmarson, 2005; Lloyd, 2006; Lloyd & Behm, 2005; Tarr & Papick, 2004), our knowledge about how preservice teachers' experiences with different curriculum materials might influence their future instruction is quite limited.

We characterize the student teacher's relationships with the *Standards*-based curriculum materials and a commercially-developed textbook in terms of Remillard and Bryans' (2004) broad categories of teachers' curriculum use, shown in Table 2.

Table 2
Teachers' Curriculum Use (from Remillard & Bryans, 2004)

Category	Description of Teachers' Curriculum Use
Thorough piloting	Teachers "tended to read and use all parts of the curriculum guides in their teaching . . . . 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).
Adopting and adapting	Teachers "used the materials as a guide for the general structure and content of their mathematics curriculum, that is, what topics to teach and how to sequence them, as well as many of the tasks they presented to students to work on." They "regularly adopted mathematical tasks from the curriculum guides, but drew on their own strategies and approaches to enact them in the classroom" (p. 374).
Intermittent and narrow	Teachers "used the materials minimally, primarily relying on their own teaching routines and other resources to guide their curriculum map over the year" and who "tended to use the resource narrowly – selecting familiar tasks and using the repertoires they had developed over years of teaching when enacting them in the classroom" (p. 374).

Remillard and Bryans studied eight elementary teachers using *Standards*-based curriculum materials and developed three characterizations of the teachers' curriculum use: *thorough piloting*, *adopting and adapting*, and *intermittent and narrow use*. These categories of use of curriculum materials describe the distribution of responsibility for guiding instructional activity between the teacher and the curriculum materials.

The study also utilizes Remillard's (1999) model for examining teachers' curriculum use throughout multiple arenas in which teachers engage in curriculum decision-making. The *design arena* involves selecting and designing mathematical tasks. Here teachers consult with the textbook and decide whether to adopt, adapt, or invent their own classroom tasks. The *construction arena* involves enacting these tasks in the classroom and responding to students' encounters with them. Finally, within the *curriculum mapping* arena, teachers work with curriculum materials to determining the organization and content of the entire curriculum into which daily events fit. As Remillard (1999) describes, "unlike the first two arenas, the mapping arena is not directly related to daily, classroom events; rather it impacts and is impacted by them" (p. 322). These categories – the *design arena,* the *construction arena,* and the *curriculum* *mapping* arena – highlight the multiple aspects of teachers' curriculum development where teachers make explicit and implicit decisions regarding curriculum use. Utilizing these categories, we are able to highlight the multiple facets of curriculum enactment.

What was the nature of the student teacher's curriculum use in the curriculum design and construction arenas when using *Standards*-based curriculum materials and a commercially-developed mathematics textbook? Careful consideration of this question has potential to help identify ways of supporting preservice and beginning teachers as they use and learn from many different types of curriculum resources for the first time. Information about preservice teachers' experiences with *Standards*-based and commercially-developed mathematics curriculum materials can also contribute to our understandings of teachers' curriculum use at different stages in their careers.

METHODS

Participant and Setting

The student teacher, Heather, completed her internship in the Spring semester of 2004 during her final year in a 5-year teacher education program at a large, public university in the United States. In the Fall semester of 2002, Heather completed one undergraduate mathematics course focused on the subject matter of the elementary curriculum – a course for which the authors of this paper were instructors. Heather also completed an elementary mathematics pedagogy course in the summer of 2003, just before her fifth year in the teacher education program. Because this pedagogy course was offered in the summer, it was taught by the mathematics supervisor for the local school division, Jameson County. The course in which Heather was enrolled focused almost exclusively on teaching and learning with the *Standards*-based *Everyday Mathematics* curriculum (University of Chicago School Mathematics Project [UCSMP], 2001a) which had recently been mandated for use in Jameson County's elementary schools. As Heather expressed, "We learned so much. We spent the whole semester using *Everyday Math*."

Heather's student-teaching placement was in a first-grade classroom at Clayton Elementary, a suburban K-5 elementary school in Jameson County. The school utilized the county-mandated *Everyday Mathematics* [*EM*] curriculum for mathematics instruction in grades K-5. Approximately 2 weeks after her internship began in January 2004, Heather assumed primary responsibility for teaching all subjects, including mathematics (55 minutes per day).

Heather's cooperating teacher, Ms. Greene, had been teaching first grade for 5 years when Heather entered her classroom as a student teacher. Ms. Greene had been using the *EM* curriculum materials since they had been adopted by the county 4 years prior, and had participated in several related summer professional development workshops.

For 10 weeks, Heather worked with the 13 students in Ms. Greene's classroom. During most of this time, Heather used the *EM* curriculum materials for her mathematics instruction. For one of her lessons, Heather used a commercially-developed mathematics textbook (Burton & Maletsky, 1998) to teach about symmetry.

Data Collection

To enhance the validity of the research design, multiple forms of data were collected (Miles & Huberman, 1994). The majority of the data was collected through classroom observations and both informal and semi-structured interviews. Table 3 presents the dates of Heather's interviews and observed lessons.

We observed Heather's classroom 11 times throughout the semester. Most observations took place in 2-3 day consecutive blocks. During observations, we took fieldnotes throughout the entire block of time devoted to mathematics. In the fieldnotes, we recorded information about Heather's instruction, with attention to the enactment of lesson plans. We were particularly interested in the moment-to-moment teacher decisions of lesson enactment as compared to suggestions and ideas written in the *EM* curriculum. As soon as possible after each visit, we created more detailed electronic accounts of our observations.

Heather was interviewed seven times during her student-teaching, both before and after observations. During the first five interviews, Heather described her plans for upcoming lessons and her views about lessons she had already taught. During the final two interviews, Heather reported about her general experiences teaching mathematics during the student-teaching internship and about the specific struggles she identified as central to her curriculum use.

Artifacts and documents that included Heather's lesson plans and student-teaching journals were also collected and photocopied. The lesson plans provided information about Heather's intentions for her lessons. The student-teaching journal offered further insight into how she felt particular mathematics lessons were carried out.

Table 3
Heather's Lessons and Data Collected

Lesson	**Dates Taught (and Data Collected)**
EM "Equivalent Names" (UCSMP, 2001, pp. 492-497)	Feb. 25 (Obs. 1)
EM "Digital Clocks" (pp. 533-538)	Mar. 8 (Int. 1, Obs. 2)
EM "Timing in Seconds" (pp. 539-543)	Mar. 9 (Obs. 3)
EM "Data Landmarks" (pp. 544-548)	Mar. 10 (Obs. 4, Int. 2)
EM "Attribute Rules" (pp. 566-569)	Mar. 18 (Obs. 5)
	Mar. 22 (Int. 3)
EM "Pyramids, Cones, and Cubes" (pp. 588-592)	Mar. 23 (Obs. 6)
Math Advantage "Symmetry" (pp. 141-142)	Mar. 24 (Obs. 7, Int. 4)
EM "Dollars" (pp. 618-623)	Mar. 30 (Obs. 8)
EM "Place Value – Hundreds, Tens, and Ones" (pp. 624-628)	Apr. 1 (Obs. 9)
EM "Application: Shopping at the School Store" (pp. 629-634)	Apr. 2 (Obs. 10)
EM "Equal Shares" (pp. 639-643)	Apr. 6 (Obs. 11, Int. 5))
	Apr. 27 (Int. 6), Apr. 28 (Int. 7)

Analysis

Analysis of data began at the start of data collection for the study. All fieldnotes were typed within 48 hours of each classroom observation, coupled with analytic notes and memos written at the end of each file. Notes primarily consisted of initial thoughts about what was interesting about each lesson and what appeared to be unplanned or problematic for Heather. For example, we made notes when Heather deviated from the recommendations of the *EM* teacher's guide or from her verbal description of each upcoming lesson. We also made notes regarding questions to ask during future interviews about observations, and specific curriculum use to attend to during future observations. To clarify questions and to generate new questions related to areas of interest, each interview was transcribed before subsequent interviews were conducted. Analytic memos were also written after interviews.

More extensive analysis took place following the completion of data collection. We created a chronological file containing fieldnotes, interviews, lesson plans, and Heather's student-teaching journal. This file was reviewed several times with the aim of making sense of the data and making initial notes about recurrent issues in the data. We utilized interview data to help identify pertinent issues (successes and struggles) throughout Heather's teaching experience. For instance, Heather's struggles with lesson pacing emerged as a recurrent theme in our preliminary analysis. During the more intensive data analysis phase of the study, interview and observation data related to Heather's use of the *EM* curriculum program and the commercially-developed textbook were organized according to curriculum design and curriculum enactment. Separate files were created to group this data according to developing themes (e.g., lesson pacing, teacher direction, lesson objectives, curriculum script). As major themes developed, lesson segments and interview quotes that appeared to highlight the major aspects of Heather's curriculum use were selected for inclusion in this report.

RESULTS

Heather's Use of the *Everyday Mathematics* Curriculum Program

In each of the *EM* lessons that we observed, Heather closely followed the recommendations of the *First Grade Everyday Mathematics Teacher's Lesson Guide* (UCSMP2001b). Heather utilized this curriculum guide as her primary resource for decisions about what mathematical tasks to implement and how to structure class activities and discussions. As she planned for instruction in the first-grade classroom, Heather sought to follow the *EM* lessons as suggested. However, due to difficulties fitting the lessons into her 55-minute mathematics period, Heather chose to eliminate certain lesson components and sometimes modified her instructional plans so that she could move students more quickly through the lessons. Because Heather intended to enact the *EM* lessons as suggested in the teacher's guide and made adjustments primarily in response to difficulties with enactment, we characterize Heather's use of the *EM* curriculum during her student-teaching internship as *thorough piloting* (Remillard & Bryans, 2004). This characterization is elaborated and illustrated in the following sections.

Curriculum Design

Each weekend, Heather prepared for the upcoming week's mathematics activities using the *EM* teacher's guide to develop general plans for her lessons: "On the weekend I'll just do an outline for the week and just write down roughly what I'm going to do" (Int. 1). For example, for an *EM* lesson about equivalent names for numbers (for example, 5 + 2 is another name for 7), Heather's lesson notes consisted of the following:

10:30-11:25am Math Section 6.2

- Math Message: write as many addition facts as you can whose sum = 7
- Equivalencies, different names. Use pan balance
- Introduce and explain name collection boxes
- Journal page 135—partners. Use addition/subtraction facts table

Heather explained that she read the teacher's guide for a general sense of the lesson: "I read through this and make notes about the topics or just generally. These [*her handwritten lesson plans*] aren't really detailed, and when I'm teaching, I have the teacher's manual up there with me" (Int. 1). Before mathematics time each day, she briefly reviewed the *EM* book and her notes.

Typically, Heather attempted to conduct her mathematics lessons in the ways recommended by the *EM* guide. When Heather changed the recommendations prior to instruction, her adaptations usually related to the amount of time spent on different components of the lessons. She often expressed that there were too many activities for her to carry out in one 55-minute session: "There's two other sections that they [the authors of the curriculum] think you should get to, apparently, in a math lesson and we're lucky if we get to the second one" (Int. 2). In this comment, Heather referred to the three main sections within each *EM* lesson: (1) the main component of the lesson containing the initial review ("math message") and main activities for the day, (2) review activities based on previous lessons, and (3) options for individualizing the activities (e.g. literature connections and/or additional whole-class activities to extend the main lesson). Parts of the second component of each lesson were completed by Heather's students during their "morning work" when they completed the journal page of review problems. In all the lessons we observed, Heather removed the remaining parts of the second component (the review activities in addition to journal pages completed in small groups or individually during class time) and opted not to extend the main mathematical activities as suggested in the third section of each lesson.

Overall, Heather's use of the *EM* materials prior to instruction involved reading each lesson to develop a general idea of the mathematical content and the recommended activities, and making decisions to remove lesson components that she sensed would not fit into her 55-minute mathematics period.

Curriculum Enactment

During each lesson we observed, Heather placed the *EM* teacher's guide on a stand in the front of the room and accessed information from the book numerous times during the lesson. Heather used the teacher's guide during instruction to keep herself informed of specific tasks and questions to ask students as well as the overall organization of lesson components. In Heather's view, the teacher's guide provided a sort of lesson "script" to which she needed access as she taught:

> I feel like it's a script, so I always have this book with me because I never have it memorized. I'm never really like, "Okay, I know to go from here to here to here." I always have it here so I can remember, "Okay, this is what I wanted to do next." A lot of times, I feel like if I miss a paragraph in the book then maybe that will throw the lesson off. (Int. 2)

As the quote above suggests, Heather felt that *EM*'s script sometimes contributed to difficulties enacting her mathematics instruction. She elaborated this sentiment at the end of her student-teaching:

> The teacher's guide is very scripted. I mean it literally. I thought of it as a play almost. It would say, "Begin the lesson and ask students this question and expect answers like this." And it would give you examples of what the students might say, and then it would say, "Respond with this." You could have not thought for yourself at all if you wanted to. I mean you could have really just read out of the book. . . . I didn't like to pay so much attention to it that I was reading from it, just regurgitating everything that was in the book, but I would forget, you know? Where did they want this to go next? Because it was good – it would really set the questions up and the activities so that it really went where it needed to go. So it was important to follow it. But I didn't want to be reading from the book either. Literally you could read from the beginning of the lesson until the end. (Int. 6)

Before the start of student-teaching, Heather had been excited to be placed at a school in which she would use the *EM* curriculum materials. She quickly came to realize, however, that using the materials was more complicated than she had anticipated:

> When I started out I thought, "I'm going Clayton County for student teaching – Great, math will be planned. I don't have to worry about it. I'm just going to have to be working on all the other lesson plans that aren't laid out for me." And, it's just been ironic because I think I've struggled the most with the scripted program. (Int. 2)

As she taught with the *EM* materials, Heather experienced difficulties related to two main issues: lesson pacing and lesson objectives.

Lesson pacing. During instruction, Heather often struggled carrying out her lessons in the timeframe she had allotted. As a result, she sometimes felt she had to identify ways to "make up time" (Int. 4). Heather began most lessons, as suggested in the teacher's guide, with a short review of past material. These initial lesson reviews (titled "Math Message" in the *EM* materials) typically took much longer than the 10 minutes Heather had planned and then "got [her] all messed up for the rest of the lesson" (Int. 1).

For example, during the *Equal Shares* lesson, students responded to the "Math Message" ("Which would you want, a candy bar or half a candy bar?") with more enthusiasm than Heather had anticipated: "It could make you fat!", "It is so good!", and "Think about it people!" (Obs. 11). Heather expressed how difficult it was for her to end the students' discussion:

> It kills me to just cut them off and only let a couple of them share, and so they all get so excited and I want to hear everything they have to say, but then there's not time. I was thinking, "We're spending too long on this, we're spending too long on this!" but then I just couldn't ignore them. (Int. 5)

In general, Heather felt uncomfortable devoting only a small portion of class time to the introductory questions and problems in *EM* lessons, despite her awareness that the philosophy of the curriculum was to "spiral" or build on concepts through repeated exposure:

> The spiral was a big part of my troubles. When you start off a lesson and you're reviewing something, it was very hard to just move on and say, "Well, that was just review and they'll get it again." (Int. 6)

Because Heather often extended the time spent on introductory discussions, she had less time available for the main parts of her *EM* lessons.

When Heather recognized that she was behind her intended timeframe in a lesson, she typically offered more direction to students as a way to move them quickly through the main part of the lesson. For example, after the candy bar discussion described above, Heather directed students' work on the remainder of the lesson – in contrast with her initial plan to have students discuss the problems in small groups. As Heather expressed:

> I looked at the clock and we had spent half the lesson on that beginning part, on talking about candy and on dividing our slates. And so I'm like, "Okay, we only have 15 minutes to get through this page." That was a big part of it for me, because I was like, "Okay, they've got them in 2 pieces, they've got their halves on their papers. They've said 'halves,' so then I'm like, 'Okay, on to the next one.'" I think I would have felt better about it if we had gotten to discuss it more. (Int. 5)

As this comment illustrates, Heather wished to have her students explore and discuss *EM* problems, but she felt she had to help students move through the problems quickly in the interest of time.

During some of Heather's lessons, she used teacher direction as a way to make up time even when introductory activities did not run overtime. For example, during a lesson titled *Data Landmarks*, one piece of the *main* activity of the lesson took much longer than Heather had anticipated. In this lesson, students had difficulty with "calculator counting" and Heather was surprised: "It threw me when they were doing their calculator counting, that they were not getting it…they just weren't getting it" (Int. 2). Heather spent an extensive amount of time leading students through the calculator counting activities, compiling the class data after three trials, but then discarding the data and repeating the timed trial for a fourth time when students answers were more varied than she wanted. When Heather shifted students' attention to a set of questions about the results of the tallied class data, she directed students' work on the questions. For example, rather than allowing students to discuss and develop their own methods, she told students how to find the range. As she described later,

> We spent so long doing the calculator counting and then when we figured out the range, I felt like I really rushed through it. I was like, "Subtract the smallest from the biggest, what is it?" And they knew it, so I was like, "Okay, just fill that in." (Int. 2)

During a subsequent part of this lesson, for which Heather had initially intended to have students "act out" finding the middle number of the data, she instead directed students through the process of figuring out which student (and their corresponding number) occupied the middle position. She expressed her disappointment in rushing and directing students through this activity:

> With the middle number, I really had wanted to spend more time on that. I really wanted them to do that, because I wanted to get them out of their seats. That really engages them and I just wanted them to be able to really see it and act out finding that middle number. . . . I was feeling the time crunch and just feeling pressured to get it all in. (Int. 2)

The "time crunch" Heather felt as she taught her *EM* lessons contributed to her tendency to use teacher direction to move students quickly through activities that she would have preferred to allow students to explore.

Interestingly, although Heather decided to use whole-class, teacher-directed instruction as a strategy for moving students quickly through activities like those described above, she expressed concern about the amount of whole-class instruction suggested in the *EM* teacher's guide:

> The program is focused on whole-class instruction. It's so hard when I'm up there giving whole-class [instruction] and I can see that some of them are catching on and some of them are bored and there are others who I know I still need to be working with. I'm having concerns about how much of it is whole class. (Int. 2)

Even when activities were not designated specifically as whole-class activities (as in the case of the questions for the *Data Landmarks* lesson), Heather directed students' work on activities in order to maintain (or catch up to) her intended lesson pace.

Lesson objectives. As Heather taught her *EM* lessons, she was sometimes uncertain or unaware of the objectives or goals of particular lessons. To some extent, this difficulty related to Heather's uncertainty about how her lessons fit into the larger curriculum program. For example, before teaching the *Data Landmarks* lesson, Heather explained, "I'm a little unsure about it. It's with graphing. It's calculator counting and graphing and I don't know how that fits into everything" (Int. 1). Heather's lack of familiarity with the first-grade *EM* curriculum also made it difficult for her to determine what language and ideas she should emphasize in her lessons. As she expressed after teaching a lesson about fractions,

> I know there are a lot of lessons on fractions and this is just the first one, so maybe it's okay for an introductory lesson, I don't know. I was thinking, "I was supposed to teach them fractions today," and I'm like, "They don't know it." I know that this is just a beginning lesson but I noticed myself wanting to mention equivalences and stuff, and I'm like, "Well that is later, that's just going to confuse them," and so I was not sure where to stop teaching. What's the minimum that they're supposed to learn here before I'm going into other lessons and more complicated things? (Int. 5)

At times, Heather seemed to gain understanding of the goals of *EM* lessons while she taught them. For example, consider Heather's teaching of an *EM* lesson focused on timing in seconds. The goals and activities were stated in the *EM* teacher's guide as follows:

> Children establish that there are 60 seconds in 1 minute. They practice timing in second-intervals, and then time each other on various activities. . . . The second hand movement is easy to see. As a group, practice reading seconds by watching the clock and calling out 5-second intervals to 60 seconds. Tell children that today they will do several different activities that involve timing in seconds. The timing method used will depend on the timing tools available. (p. 539)

As suggested in the teacher's guide, the majority of mathematics time was spent with students performing and timing activities such as holding their breath and standing on one leg, blinking repeatedly, etc. However, because there were no stopwatches available, Heather decided prior to the lesson to use the second hand of the clock on the classroom wall. Heather worried that not all of the students could see the clock, so she faced the clock herself and counted out the seconds (by fives) as the students performed the activities. During the lesson, Heather realized that the students were not engaged with the main ideas of the intended lesson (counting in second-intervals). As she explained after the lesson,

> They're listening to *me* counting by fives, and all they're getting out of it is how many times they can blink their eyes. They were not getting that the point of the lesson was to use the second hand to time yourself. It was bothering me when I was doing it, and I was like, "*I* am the only one getting practice timing anything." And they're just getting practice doing these different things that I'm asking them to do, which have no relevance to math. (Int. 2)

After realizing that the lesson objectives were not being met, Heather adjusted her plans so that pairs of students used the clock to keep track of the time required to perform certain acts. However, very little class time (about 8 minutes) remained for Heather to help students with difficulties that emerged as they attempted to use the second hand of the clock.

After teaching her *EM* lessons, Heather often identified aspects of her instruction that she wished had been different. In a few cases, she also attempted to think of alternative approaches. For instance, after teaching the *Timing in Seconds* lesson, Heather identified ways she would change her plans if she were to teach it again:

> I would do whatever I could to hunt down clocks for them to use or maybe call 3 or 4 students over at a time and counted with them for a minute. I think that would have worked. I would have maybe let them do more with partners just to give them more practice with *them* counting, instead of listening to me count. Because I don't think that really meant anything to them. They were just excited to see how long we could do everything. (Int. 2)

However, more typically, Heather expressed uncertainty about how she might adapt *EM* lessons to feel more successful in the future.

Heather's Use of an Alternative Textbook Lesson

Towards the end of her student-teaching, Heather was given the opportunity to create one lesson without the use of the *EM* curriculum materials. Because Heather's cooperating teacher, Ms. Greene, had experienced difficulties with an *EM* lesson about symmetry, she suggested that Heather create her own lesson about symmetry. Heather expressed excitement about the opportunity "to write [her] own lesson" (Int. 3), and spent several days locating and then adapting lessons focused on symmetry. As described below, Heather selected a lesson from a commercially-developed textbook (Burton & Maletsky, 1998) and made adaptations to the lesson – both before and during instruction – in accord with her pedagogical goals for her first-grade students. We characterize Heather's use of this textbook lesson as *adopting and adapting* (Remillard & Bryans, 2004).

Curriculum Design

Ms. Greene offered Heather several textbooks and teacher's guides, all from commercially-developed textbook series (not from *Standards*-based curriculum programs). Heather described her choice of one textbook's symmetry lesson: "I looked through them, and one of them had an idea that I liked, so I went with that one—but I sort of changed it a little" (Int. 3). The change Heather described involved converting a whole-class lesson from the textbook into a set of small-group activities. Before teaching the symmetry lesson, Heather explained her evolving ideas about the lesson:

> Each group is going to get a sheet of paper and it's going to be divided into two columns and one's going to be symmetrical and one's going to be not symmetrical. I'm going to give each group a bag of shapes. Then, as groups, they glue them on the right column and then we'll just talk about it and talk about what symmetry—actually I think we'll start off talking about what symmetry is. If there is time, which I think there probably will be—and I haven't decided if I'm going to start with this or let it be an ending activity to make sure that there's time for it—I will give them paper and scissors and say, "Fold it and cut and make something that is symmetrical and make something that isn't symmetrical." It will be a very hands-on day. I'm excited. (Int. 3)

In contrast to her planning with the *EM* materials, Heather's planning for the symmetry lesson included making decisions about the substance, order, and purpose of lesson components. In addition, Heather's notes about the symmetry lesson were more detailed than her notes for *EM* lessons that she taught. For the symmetry lesson, she wrote the following:

> 1) We will begin the lesson by having a whole class discussion about symmetry. Students will be given a sheet of paper and a pair of scissors and asked to fold the paper in half and cut out a pattern. When they open it up, they will see the line of symmetry (the crease).
> 2) Next, students will be asked to work in small groups according to their table arrangements. Each group will be given a chart divided into two columns ("symmetrical" and "not symmetrical") and a baggie of shapes. Their task will be to take each shape and glue it in the correct column.
> 3) After all groups have completed this assignment, we will have a brief discussion about which shapes belong in each column. If time permits, students can cut out another shape of their own and add it to the appropriate column.
> 4) After this activity, students will be given a worksheet that shows several different figures and asks them to draw the line of symmetry on each figure. (Symmetry lesson plan)

Unlike her hand-written notes regarding *EM* lessons, Heather's typed plans for the symmetry lesson included specific lesson details and notes regarding lesson pacing (e.g. "if time permits…"). These notes served as Heather's lesson organization and enactment guide.

Curriculum Enactment

As indicated in her lesson plan, Heather decided to start the symmetry lesson with a discussion about symmetry followed by a brief paper-cutting activity. Heather moved quickly through these introductory activities, for example prompting students to "quickly just cut something out because we're going to throw them out in 2 minutes anyway" (Obs. 7). Later Heather explained her rationale for keeping the introductory activities brief:

> I rushed through the introductory part of the lesson, which usually takes up a good amount of the lesson. I was conscious of this as I was teaching, and for a minute I thought maybe I should slow down but then I quickly decided that I wanted them to get the bulk of their knowledge in this lesson from the group activity. That was one of the best impulse decisions I have ever made! The students were excited to begin their group work. (Journal entry)

Heather's "impulse" decision at the start of the symmetry lesson to move quickly through an introductory activity appeared to help her pace the remainder of her lesson.

After introducing the group-work with "symmetry charts" to the class, Heather circulated among the groups and, while teaching, decided to add a new component to the lesson. She explained her new lesson component during a subsequent interview:

> I decided to have [the students] come up and talk about [their symmetry posters]. There were different things in each group that were unique to that group. So, I was like, "Well, we'll let them share that." And we had time for it. And we *still* had time to do the worksheet. (Int. 4)

One group and one student's comments in particular seemed to have influenced Heather to incorporate group sharing as the lesson progressed. Heather explained:

> A lot of [the groups] put the shamrock on the symmetrical side and I looked at it yesterday and it's not [symmetrical] because of the way the stem curves out. There was one group who pointed that out and I asked them, "Why did you put that there?" *Roger* was like, "Well, because the stem curves, you can't do it." I was like, "Oh my gosh, that was very observant of him." I wanted him to be able to share that. That was such a moment for me because there've been problems and concerns with him, and that was just — I loved it. (Int. 4)

After teaching the lesson, Heather explained, "I thought it went great. I had fun with it and I was so relaxed. It was probably the best math lesson I've had this semester. I kept checking the clock and I'm like, 'We're okay on time, everything's great!'" (Int. 4). Overall, Heather felt that this was "one of the best lessons, especially the best math lesson" (journal entry) that she taught.

Different from her use of the *EM* curriculum during instruction, Heather made several pacing decisions while enacting the symmetry lesson. She also altered the structure of student presentations from her original plans as she noticed important mathematical ideas evolving in each group of students.

Because the symmetry lesson occurred at the end of student-teaching, Heather did not have an opportunity to create another lesson utilizing alternative resources, although she expressed interest in doing so. She also suggested that her experience creating the symmetry lesson might contribute to a more adaptive stance toward her future use of the *EM* curriculum:

> I would definitely look more into doing my own things, or maybe taking some of the *Everyday Math* stuff out and putting more of my stuff in – even if we kind of followed along with this [pointing to the *EM* guide]. It is definitely something I would want to do cause I feel like it went a lot better than some other lessons. (Int. 6)

DISCUSSION

Herbel-Eisenmann, Lubienski, and Id-Deen (2006) described how the expectations of students and parents contributed to one teacher's strikingly different mathematics pedagogy as she used the materials of two different curriculum programs, one *Standards*-based and one commercially-developed, in two eighth-grade classes. The researchers highlighted the importance of the different *curricular contexts* as influences on the teacher's instruction with each curriculum. The notion of curricular context is also helpful in understanding Heather's use of curriculum materials. In Heather's case, the *EM* curriculum was advocated by her university methods course instructor, mandated for use in her first-grade classroom, and accepted and adhered to by her cooperating teacher and the other teachers in the school. It is not particularly surprising then that Heather's use of the *EM* materials consisted primarily of *thorough piloting* (Remillard & Bryans, 2004) toward the *EM* curriculum. In contrast, when Heather was explicitly invited to design her own lesson about symmetry, choosing from a number of textbooks as resources and replacements for the mandated curriculum program, her use of a supplemental textbook could be characterized as *adopting and adapting* (Remillard & Bryans, 2004).

Heather's use of the *EM* curriculum for 10 weeks and an alternative textbook for one lesson provide much needed illustrations of a student teacher's interactions with curriculum materials for the design and enactment of mathematics instruction. Although it is important not to over-generalize from Heather's use of a commercially-developed textbook for the design of just one lesson, differences between her experiences with the *EM* curriculum and the commercially-developed textbook's symmetry lesson raise important issues for discussion. As illustrated in the previous sections, Heather used the different curriculum materials in different ways – piloting the *EM* curriculum but adapting the textbook's symmetry lesson. Moreover, the nature of her resulting instruction differed – during her *EM* lessons she tended to struggle with lesson pacing and lesson objectives and to direct students' activities to a greater extent than she did during the symmetry lesson.

Thorough Piloting of the EM Curriculum

Like the student teachers and beginning teachers in other studies (Kauffman, Johnson, Kardos, Liu, & Peske, 2002; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004), Heather drew heavily upon the *EM* teacher's guide for the design and enactment of mathematics instruction. As she planned and taught with the *EM* materials, Heather focused much of her attention on using the suggestions presented in the *EM* teacher's guide. Heather's preservice course experiences with the *EM* materials – experiences that were led by a strong advocate for the series – might have impacted her efforts to implement the curriculum materials closely. It may be the case that Heather perceived that close implementation of *EM* was the "correct way" to teach mathematics. Such a view would likely contribute to an inclination to adhere to the recommendations of curriculum materials.

Heather expressed excitement about having been placed in a county that used EM because she assumed that "math would be planned." Two recent studies suggested that beginning teachers, lacking curricular repertoires of their own, seem to appreciate the guidance of textbooks and curriculum materials (Kauffman et al., 2002; Remillard & Bryans, 2004). Similar to the beginning teachers in these studies, Heather seemed to appreciate the guidance of the *EM* curriculum. The scripted nature of the teacher's guide also proved helpful in terms of minimizing mathematics planning time. However, the teacher's guide also appeared to be constraining as Heather used the script to lead her through lessons. Heather's focus on learning how to be an effective deliverer of a detailed and scripted curriculum program echoes findings from two studies of student teachers implementing the National Literacy and Numeracy Strategies in England (Edwards & Protheroe, 2003; Twiselton, 2004). Like Heather, the student teachers in these studies focused on delivering pre-designed mathematics lessons and activities. Heather's case highlights aspects of the affordances and constraints of curriculum materials apparent in all three studies – although the *EM* curriculum materials seemed quite scripted to Heather, they also might have helped her to stay afloat during her student-teaching.

Heather not only appreciated the guidance of the *EM* materials, but also found that the *EM* activities and games aligned well with her views of mathematics instruction. As she taught her *EM* lessons, one of Heather's greatest struggles was with lesson pacing. Because introductory activities took longer than she had originally anticipated, Heather found herself rushing through the main activities, even those she was most excited about having her students explore. During the last 10-15 minutes of mathematics class, Heather conducted activities at a substantially increased pace in order to complete all components of her lessons. Student teachers' and beginning teachers' struggles with lesson pacing, the organization of lesson components, and classroom management have been documented many times in the literature (Feiman-Nemser & Buchmann, 1987; Fuller, 1969; Moore, 2003; Veenman, 1984; Zeichner & Tabachnick, 1981). Struggles with time and lesson organization have also been reported in studies of teachers using *Standards*-based materials for the first time (Keiser & Lambdin, 1996; Manouchehri & Goodman, 1998). Extended experience using *Standards*-based curriculum materials may alleviate struggles with lesson pacing (Keiser & Lambdin, 1996), but Heather's relatively short student-teaching internship did not afford her the time to resolve this struggle.

Although Heather faced difficulties with individual lesson pacing, Heather's cooperating teacher and the structure the *EM* curriculum supported her overall *curriculum mapping* (Remillard & Bryans, 2004). The spiraling *EM* curriculum program dictated the scope and sequence of lessons and therefore supported Heather in her organization of daily content over the year. However, due in part to the nature of her internship (which began halfway through the school year), Heather lacked knowledge of the first-grade *EM* program as a whole. Heather often did not know whether a certain mathematical topic had yet been addressed or to what depth it had been covered earlier in the year. *EM*'s "spiral" design may have made it even more difficult for Heather to grasp the general scope and sequence of the curriculum materials.

Despite and quite possibly in light of support provided by the overall curriculum mapping, Heather often faced difficulties related to understanding daily *EM* lesson objectives. Heather tended to develop general rather than detailed plans for her *EM* lessons and to access the detail provided in the *EM* materials immediately before and during mathematics class. As a result, she sometimes did not fully understand lesson objectives until she was in the middle of teaching her lessons. In a well-known study that compared novice and expert teachers' planning, teaching, and reflecting, Borko and Livingston (1989) found that novice teachers conducted only short-term planning and seldom planned at the chapter or unit level. Like these teachers, Heather planned her lessons on a weekly basis, a practice that limited her ability to see how lessons in one particular unit fit together. Although some *EM* units required up to 16 days of class time to complete, Heather focused primarily on how lessons for one particular week (5 days) fit together.

Heather's experiences bring to mind the account of Heaton (2000), who encountered numerous struggles as she worked to follow a scripted curriculum program. Heaton expressed, "In theory, making use of the CSMP textbook seemed like a safe and sure way to begin my journey of change. In practice, however, efforts to make use of this new text quickly led to frustration" (p. 19). Like Heather, Heaton initially relied upon the textbook lessons to plan her instruction, but frequently found herself in the midst of instruction and unsure about the mathematical goals of her lessons:

> I had trusted that the teacher's guide was going to help me through it. It was letting me down. It was, at once, too much and not enough of a guide. It had given me enough guidance to lead me to believe we could do this activity even though I failed to acquire any broader sense of its purpose. In the midst of teaching, I found myself lost with a guide (p. 28).

For both Heather and Heaton, following a textbook seemed like a reasonable way to enact lessons as beginners – Heather, a beginning teacher, and Heaton, an experienced teacher challenged by new ways of guiding students' mathematical learning. For student teachers, relying heavily upon a curricular guide might constrain opportunities to move moment to moment. For example, Heather made more decisions about pace and the structure of lesson activities based upon her students' work when enacting the symmetry lesson as compared to her instruction with the *EM* curriculum. However, as Heaton emphasized, even for more experienced teachers, utilizing curriculum materials that align with teachers' ideas about teaching and learning seems like a safe and secure way to begin a journey of change. Perhaps student teachers' use of detailed, *Standards*-based curriculum materials not only provides support and structure, but might also constrain certain aspects of learning to teach.

Adapting the Commercially-Developed Textbook Lesson

Heather's planning and teaching of the symmetry lesson contrasted greatly with her more frequent teaching of *EM* lessons. Heather's planning before teaching the symmetry lesson involved making modifications to the textbook lesson in accord with what she knew worked well for herself and her particular students – namely small-group instruction. As she taught the symmetry lesson, she made additional modifications to the lesson in response to her students' developing understandings. As Lampert (2001) pointed out in a book devoted to her own teaching experiences:

> Lesson preparation involves figuring out how to connect particular students with particular mathematics. The work involved moving back and forth between mathematics and the structure of the task I could assign. That task would have to relate the particular students I was teaching with the particular mathematics I wanted them to study and learn…. The problem I am working on is how to engage *this* class, with *its* particular variation of skills and understanding, in the study of ideas surrounding *this* piece of mathematics. (p. 117)

Heather's lack of apparent difficulty with pacing as the symmetry lesson progressed and her mid-lesson decisions to modify her plans represented a markedly different teaching experience — one focused more on teaching mathematics to her particular group of students than on teaching mathematics from a particular set of curriculum materials.

For Heather, the opportunity to create a lesson utilizing alternative resources not only felt successful, but also shed light on her more frequent use of the *EM* materials. For example, Heather reported more time spent planning and rethinking the activities she chose for her particular students when she adapted an alternative textbook lesson as compared to time spent planning with the mandated *EM* program. This difference in planning time highlights the support the detailed *EM* materials provided Heather, but also alludes to differences in preparedness related to time spent planning. Heather's deviation from her symmetry lesson plans, prompted by students' developing ideas during group work, also highlighted her lack of flexibility while working within the *EM* curriculum. Even as Heather attempted to move away from the details within the *EM* teacher's guide, she rarely felt she had sufficient time to allow other potential solution strategies to emerge or her students' developing ideas to guide the pacing and direction of lessons. Although she taught the symmetry lesson at the end of her student-teaching, the experience prompted Heather to consider how she might use the mandated curriculum program in a more flexible and creative way in the future.

Differences between Heather's use of the *EM* materials and the lesson from a commercially-developed textbook bring to mind Lloyd's (1999) description of teachers who appeared to be reluctant to make changes to the *Standards*-based curriculum materials they were using because the materials' philosophy aligned closely with the teachers' views about mathematics pedagogy.

As Lloyd suggested,

> When a reform-minded teacher uses traditional materials in the classroom, he or she may be afforded more room for personalization because the goals of the materials are so different from his or her own goals. Because reform-oriented curriculum designers accomplish much of the alteration of mathematical content and activity in their production of materials, teachers with strong and innovative visions may experience a profound loss of previously held opportunities to personalize their instruction. (p. 246)

When student teachers are required to use *Standards*-based curriculum materials, they may focus more on figuring out how to successfully use that specific curriculum program – especially when the curriculum program aligns well with their philosophies about teaching and learning—than on how to personalize instruction for their particular students. Even as Heather expressed concern about the scripted nature of the *EM* curriculum guide, she found value in the questions posed, the set-up of the activities, and the overall direction of each lesson; she felt it was important to follow the curriculum as written. Perhaps like the teachers in Lloyd's study, Heather's view that the *EM* materials were well-constructed made it difficult for her to adapt them.

IMPLICATIONS FOR TEACHER EDUCATION

Heather's experience learning to teach with a detailed, *Standards*-based curriculum program echoes the experiences of more seasoned teachers "relearning the dance" (Heaton, 2000). Like Heather, Heaton struggled to identify lesson objectives and master lesson pacing while using new curriculum materials. The experienced teachers in Lloyd's (1999) study refrained from personalizing or adapting lesson ideas because the ideas within the new curriculum program closely aligned with their philosophies of mathematics teaching and learning. What distinguishes studies focused on student teachers, however, are the *curricular contexts* (Herbel-Eisenmann et al., 2006) surrounding their learning and the conclusions and recommendations that emerge to better inform preservice teacher education.

Whereas experienced teachers relearning to teach with new curriculum materials in their own classrooms are influenced by their administrators and peers, student teachers' experiences are impacted and influenced by their university instructors and cooperating teachers. Heather's close use of the *EM* curriculum materials appeared to be influenced by her cooperating teacher and university instructor's support of the materials. This raises questions about what would have happened if Heather's cooperating teacher did not support use of the curriculum materials. How might Heather's curriculum use and her opportunities for learning have changed? The notion of curricular context remains critical as we consider placement opportunities for student teachers and create purposefully structured learning experiences related to those placements both prior to and during student teaching (see Lloyd, 2007).

Whereas teachers at all levels find themselves teaching while learning new strategies and using new resources to teach, student teachers have the unique opportunity to teach with multiple support systems in place. One responsibility of teacher educators is to help preservice teachers learn to use mathematics curriculum materials and textbooks effectively. If student-teaching internships are to focus on more than just curriculum delivery, we need to consider ways to prepare student teachers to engage in a dynamic relationship with curriculum materials (Lloyd, 1999). As Heather's case highlights, it can be difficult for student teachers to learn how to use a new curriculum program while at the same time attending to the particular needs of a new group of students. In order to help preservice teachers develop an understanding of mathematics curriculum materials, some researchers have suggested providing preservice teachers with extensive opportunities to engage with curriculum resources before student-teaching (e.g., Ball & Cohen, 1996; Ball & Feiman-Nemser, 1988; Ben-Peretz, 1990; Lloyd, 2006; Remillard & Bryans, 2004). Although Heather gained familiarity with the *EM* materials during one course of her teacher education program, she was not challenged to view the *EM* program from a critical perspective – for example, by comparing the *EM* materials with other elementary curriculum resources or observing teachers' use of the materials with specific groups of students.

Zeichner and Liston (1987) suggest that preservice teachers ought to be prepared to view knowledge and situations as problematic rather than certain and fixed. It is important, of course, to consider the implications of prematurely pushing teachers to lesson adaptation and refinement. It would be irresponsible, as Ball and Feiman-Nemser (1988) point out, to prepare teachers who reject textbooks and teacher's guides. As Kauffman (2002) suggests, however, "one could also argue that the beginning years are the best time to allow a beginning teacher to be creative, before they are fixed in their ways and less susceptible to change and improvement" (p. 22). As we plan preservice coursework and facilitate student teaching placements, we need to help teachers learn from many types of curriculum resources as they evaluate and use lessons for their particular students' learning. Helping preservice teachers identify ways to use the supports embedded in curriculum materials for their own learning and their students' learning is critical as they engage in first-time mathematics teaching.

More studies are needed that focus on preservice teachers' use of mathematics curriculum materials and textbooks during student-teaching. Heather's preservice education and specific student-teaching experiences afforded her opportunities to use curriculum materials in different ways. Under what circumstances is *thorough piloting* educative for student teachers? Under what circumstances is *adapting* curricular resources educative for student teachers? Comparison studies focused on elementary and secondary student teachers' use of different types of curriculum resources (for example, *Standards*-based curriculum materials and commercially-developed textbooks) in a variety of school contexts would also add much needed detail to our understanding of preservice teachers' curriculum use and implications of such use. Finally, given the similarity between Heather's curriculum use and that of more experienced teachers, teachers' initial encounters with new curriculum programs at all levels of experience warrant further investigation.

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Chapter 5. Factors Influencing Student Teachers' Use of Mathematics Curriculum Materials[1]

> *I feel like the teacher's guide is a script, so I always have it with me because I never have it memorized. I just feel like if I miss a paragraph in the book then that will throw the lesson off. It's too much information.* - Heather, 1st grade student teacher
>
> *It's brief what they [the authors of the curriculum materials] tell you to do, so it's a lot of make up your own approach. Sometimes I write myself notes, but otherwise, I just get it in my head and can go from there.* - Anne, kindergarten student teacher
>
> *I had to use the workbook that you saw the students using. I needed to use that for every new thing that I did…. The truth is, I have to use what they're giving me, but I add to it where I think it's lacking.* - Bridget, kindergarten student teacher

In this chapter, we describe three elementary student teachers' uses of mathematics curriculum materials and propose potential factors that may have worked together to contribute to their ways of using the materials. As the above quotes highlight, student teachers' ways of using mathematics curriculum materials can vary tremendously. Heather aimed to follow closely the suggestions of her *Standards*-based curriculum materials, Anne made adaptations to her *Standards*-based materials, and Bridget followed selected components and supplemented her commercially-developed textbook. What factors might have influenced these student teachers to use their curriculum programs in different ways? Attention to this question has potential to expand our current understandings of teachers' relationships with mathematics curriculum materials by focusing on curriculum use at the beginning of teachers' professional lives. Consideration of factors influencing student teachers' initial ways of using curriculum materials can also inform the ways teachers are prepared for their first mathematics classroom experiences. Because teachers' early classroom experiences are likely to involve mathematics textbooks or curriculum materials intended to guide the design of mathematics instruction, understanding the nature of and the factors influencing teachers' first use of curriculum materials to teach is undoubtedly important.

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Teachers' Use of Textbooks and Curriculum Materials

Over several decades, researchers have set out to define, characterize, and understand teachers' work during various phases of the teaching career – from novice teachers to mid-career teachers to experienced and expert teachers (Berliner, 1986; Steffy, Wolfe, Pasch, & Enz, 2000). Yet, within the realm of teachers' use of mathematics textbooks and curriculum materials, research about the professional continuum is in its infancy. Two recent studies reported that beginning teachers appear to appreciate and rely on the explicit guidance about what and how to teach that mathematics textbooks can offer (Kauffman, Johnson, Kardos, Liu, & Peske, 2002; Remillard & Bryans, 2004). These studies suggest that beginning and experienced teachers may use mathematics textbooks and curriculum materials differently. For instance, Remillard and Bryans noted that the beginning teachers in their study

> tended to read and use all parts of the curriculum guides in their teaching . . . . 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, most of the experienced teachers in the study "regularly adopted mathematical tasks from the curriculum guides, but drew on their own strategies and approaches to enact them in the classroom" (p. 374). The field is in need of additional studies that investigate the particular ways that teachers at different points on the professional continuum use curriculum materials for mathematics instruction. We also need to understand how and why differences in teachers' use of mathematics curriculum materials develop.

In the present chapter, we briefly describe three student teachers' ways of using curriculum materials for the design and enactment of mathematics instruction. Then we propose multiple factors that may have contributed to these student teachers' use of mathematics curriculum materials. We suggest that these factors warrant further examination by researchers interested in understanding the influences on teachers' initial use of mathematics curriculum materials.

Preservice Teachers and Mathematics Curriculum Materials

Most teachers view the student-teaching internship as the most valuable and beneficial part of their preparation (Feiman-Nemser, 1983; Guyton & McIntyre, 1990), claiming that much of what they know comes from first-hand teaching experience (Feiman-Nemser & Buchmann, 1985). Preservice teachers' interactions with curriculum materials are an important aspect of their first mathematics teaching experience. Twenty years ago, Ball and Feiman-Nemser (1988) discussed the experiences of teachers who emerged from teacher education programs with the impression that good teachers do not follow textbooks or rely upon teacher's guides. The authors described this finding as "a significant dilemma for preservice teacher education" created by the following two competing facts:

> On the one hand, textbooks are widely criticized for their content, their biases, and their implicit views of teaching and learning. Logically, this suggests that new teachers should not be encouraged to use them. On the other hand, many beginning teachers are hired by school districts where such textbook materials are mandated. (p. 419)

Two decades later, teacher education faces some similar dilemmas as well as new ones. Increasingly, student teachers are placed in schools where mathematics textbooks are adopted by districts as a strategy for improving student achievement (Corcoran, 2003). Indeed, some student teachers are asked to use textbooks "widely criticized for their content" or "curriculum that is controlled through objectives and standardized testing" (Ball & Feiman-Nemser, 1988, p. 421). Since the publication in the 1990s of over a dozen mathematics curriculum programs claiming to be aligned with the *Standards* (National Council of Teachers of Mathematics, 1989), many student teachers are currently placed in classrooms where *Standards*-based mathematics curriculum materials are in use (e.g., Van Zoest & Bohl, 2002). Although mathematics curriculum programs are a common component of student teachers' experiences and some teacher educators have begun to explore the use of mathematics textbooks and curriculum materials as learning tools in teacher education coursework (see e.g., Hjalmarson, 2005; Lloyd, 2006; Lloyd & Behm, 2005; Tarr & Papick, 2004), our knowledge about how preservice teachers' experiences with curriculum materials might influence their future instruction is quite limited.

Investigating student teachers' uses of mathematics textbooks and curriculum materials is critical to understanding teachers' curriculum use across the professional continuum and to improving teacher education. This chapter aims to (a) briefly describe student teachers' use of the mathematics curriculum materials of their internship sites and (b) propose a set of factors that may have contributed to the student teachers' ways of using their curriculum materials.

Research Context

The participants in this study were three white, undergraduate preservice elementary teachers in their early twenties, Heather, Anne, and Bridget[2]. Data collection occurred during the last 7 weeks of Heather, Anne, and Bridget's 10-week student-teaching internships when they were teaching mathematics full-time in Spring 2004. The majority of the data were collected through classroom observations and informal and semi-structured interviews. All data were organized into case study databases for analysis during and after data collection. Due to space limitations, methodological details are not included in this chapter but can be accessed in reports of the individual teachers (Behm & Lloyd, 2006; Lloyd, 2007, 2008). Our focus in this section is on the context in which the study took place.

The university that these preservice teachers attended is located in the Mid-Atlantic region of the United States in a small town in Jameson County. Heather and Anne completed their student-teaching internships in Jameson County at a school approximately 3 miles from the university. The area surrounding the school contains rural and suburban regions and has a predominantly white student population. The *Standards*-based *Everyday Mathematics* [*EM*] curriculum program (University of Chicago School Mathematics Project [UCSMP], 2001) was used in all elementary schools in Jameson County. Heather was placed in Ms. Greene's first grade classroom and, Anne worked with Ms. Roy and Ms. Jones in their combined kindergarten classroom across the hall.

Bridget completed her internship at Walnut Street School in the urban Coopersburg Schools, located 45 miles from the university. Bridget was placed in Ms. Barrett's kindergarten classroom, which was composed of 13 African American students and 1 Asian student. During the 2003-04 academic year, 93% of the students attending Walnut Street were eligible for free or reduced-cost lunch programs. For mathematics instruction, the teachers utilized materials from the commercially-developed *Silver Burdett Ginn* [SBG] (Fennell et al., 1999) textbook series. In addition, administrators and teachers at Bridget's school viewed the state mathematics framework as a critical curriculum guide to be followed closely.

The Student Teachers' Ways of Using their Curriculum Materials

In this section, we briefly describe Heather's, Anne's, and Bridget's use of their mathematics curriculum materials for the design and enactment of instruction during their student-teaching internships.

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[2] All names for teachers, schools, and counties are pseudonyms.

Heather's Use of Standards-Based Curriculum Materials

Each weekend Heather prepared for the upcoming week's mathematics activities using a copy of the *EM* teacher's guide to develop general plans for her lessons: "On the weekend I'll do an outline for the week and write down roughly what I'm going to do. . . . These [*handwritten notes in her planning book*] aren't really detailed." Heather explained that she looked at the teacher's guide again each morning before teaching: "During specials or snack time, I'll just review the lesson for that day." Heather felt that detailed lesson plans were unnecessary because when she taught, she had "the teacher's manual up there." Although Heather typically planned on her own as she read through the lessons in the teacher's guide, she also occasionally consulted her cooperating teacher: "I would ask [Ms. Greene] about any questions that came up when I was planning, like about different games or just questions that come up. . . . She's really helpful with that."

Typically, Heather attempted to conduct her mathematics lessons in the specific ways recommended by the 4 to 5 page lesson plans found in the first grade *EM* teacher's guide. She used the guide during instruction to refer to specific tasks and questions to ask students as well as the overall organization of lessons. Heather explained that she tended to rely on the book during instruction because of the detailed, scripted nature of the information contained in the teacher's guide: "I feel like the teacher's guide is a script, so I always have it with me. A lot of times, I feel like if I miss a paragraph in the book then maybe that will throw the lesson off." When Heather adapted the recommendations, her changes usually related to the amount of time to spend on each lesson component. She often experienced difficulty carrying out her lessons in the timeframe she had allotted and, as a result, she sometimes changed the nature of the activities to "make up time." For example, during a lesson titled *Data Landmarks*, students spent the majority of class time collecting and recollecting data, taking more time than she had planned. After the data was collected, Heather asked the students to "act out" the process of finding the range of the data, an activity she was initially excited to allow students to explore and discuss. However, with limited time remaining in class, Heather "really rushed through [it]. I said, 'Subtract the smallest from the biggest. What is it?' And they knew it, so I said, 'Okay, just fill it in.'" Heather commented, "I would have felt much better if we had gotten to discuss it more." Although after teaching this lesson and most others Heather identified aspects of her instruction that she wished had been different and attempted to think of alternative approaches, her future lesson plans were typically driven by the presentation of the next lesson in the *EM* guide.

Anne's Use of Standards-Based Curriculum Materials

During mathematics time in Anne's large kindergarten classroom, each teacher (Ms. Roy, Ms. Jones, Anne, and another student teacher) taught one-fourth of the students. Groups of 8 to 10 students rotated between the four teachers so that each child saw each teacher, and did each mathematics activity, once during a 4-day period. Because Anne taught each *EM* lesson four times, she had the opportunity to adapt her lessons multiple times and to consult with Ms. Roy and Ms. Jones between lessons to develop instructional ideas. (Due to the classroom structure, however, neither Ms. Roy nor Ms. Jones was able to observe Anne's mathematics instruction directly.)

Each week, Anne met with Ms. Roy and Ms. Jones to decide what activities from the *EM* curriculum program would be taught and by whom. During planning meetings, the cooperating teachers offered short commentaries about their previous experiences teaching particular lessons. After each planning meeting, Anne was given (or made herself) photocopies of the pages that she needed from the *EM* kindergarten teacher's guide – a book with half-page lessons that Anne described as "activity ideas, briefly written so you can quickly grab it and see, 'Oh, here's what I need to do today.'"

As Anne used the photocopied pages to plan her lessons, she began to make adaptations to *EM*'s written suggestions. She explained, "It's a lot of make up your own approach. I make notes to myself, sometimes just underlining and sometimes it's actually writing out what I'm going to need to do." For example, when she read the *EM* recommendations for a lesson titled "Bead String Name Collections," she felt that the lesson was "pretty simple" and "wouldn't take a whole half hour in the way it's written." For this particular lesson Anne planned to alter the physical materials (to make bracelets using pipe cleaners and beads instead of using buttons and string) and the mathematical emphasis (to introduce number sentences involving addition instead of continuing exploration of equivalent names for numbers). These changes to extend the duration of the proposed activities and increase the mathematical sophistication of the children's work were apparent in many of Anne's lesson adaptations.

During instruction, Anne rarely consulted her plans or pages from the *EM* book. Prior to instruction she concentrated on learning details that would allow her to conduct her lesson without a book or notes: "I try to remember little hints [from the lesson plan], but otherwise I tend to wing it and do what feels right and go wherever the kids are going with it." Most adaptations that Anne made during instruction were related to student behavior after students had completed or lost interest with an activity or game. For example, during her first time teaching the "Disappearing Trains" lesson (an addition and subtraction game with linking cubes), Anne spent a fair amount of class time redirecting students who were off-task. She commented, "There will definitely be a modification tomorrow. I need to find a new thing to do."

When making adaptations, Anne sometimes addressed classroom management issues that had emerged during her first attempt at teaching a lesson (as was the case in the "Disappearing Trains" lesson described above), but she more frequently made adaptations to the *mathematical content* of the lesson – she emphasized key ideas more explicitly and emphatically in subsequent lessons. For example, we observed that, in contrast to her first time teaching it, Anne emphasized addition to a greater extent in her second and third iterations of "Bead String Names Collection" by introducing addition number sentences that were not part of the *EM* lesson description. After teaching one of her lessons four times, Anne remarked that there were "lots of adjustments, but it got pretty good by the end for having them think deeply."

Bridget's Use of a Commercially-Developed Textbook

During her internship, Bridget used the workbook component of the SBG curriculum program and supplemented the workbook with additional tasks and activities. Each week, Bridget met with three other kindergarten teachers to plan for upcoming lessons. The focus of these planning meetings was on the selection of SBG workbook pages and worksheets: "I've been told several times that I needed to make sure that [the students] are getting plenty of paperwork." Bridget perceived that the other components of the SBG curriculum did not "fit" the school and she described that the teachers "never used any full lessons" from the SBG guide. Instead, the teachers used a year-long curriculum plan to identify which pages of the SBG workbook could be used to address the state curriculum standards. Bridget explained that "the principal likes to know what [state standards] we're covering which day."

Although Bridget found the planning meetings to be helpful, she consistently made her own plans after the meetings. As Bridget explained, "The truth is, I am trying to use what they're giving me and add to it where I think it's lacking." For each lesson, Bridget evaluated the SBG workbook offerings according to her informal assessment of students' knowledge, the objectives presented in the state curriculum framework, and her own visions of mathematics instruction. Typically, Bridget extended workbook lessons to allow students to “move around” and use physical materials or manipulatives. To develop new mathematics activities for use in conjunction with the SBG worksheets, Bridget first consulted the state curriculum framework to identify specific mathematical content, and then tapped other resources for instructional ideas that would address the needs of her students.

For example, after teaching with some of the SBG worksheets related to coins, Bridget created her own additional worksheets: “I was actually really disappointed with how they did money in the book. So I made a few sheets and we did a lot of that together because I didn’t feel like the book really did it at all.” The sheets Bridget created were based on pictures of coins and activities that she found in “stuff from *Everyday Math* that [she] copied from teachers in [Jameson] County” and were intended to address mismatches she identified between students’ understandings and the emphases of the SBG worksheets. Later in her internship, Bridget was responsible for reviewing “shapes” with her kindergarten class – a topic for which students had already completed the relevant SBG workbook pages. As in the previous example, Bridget designed her lessons about shapes using the state curriculum framework and her informal assessments of students’ knowledge. Although she created some new worksheets to satisfy the expectations of her school, the majority of her lessons about shapes involved helping students to organize and play games with shapes on a large Venn diagram made from hula hoops – an activity that Bridget developed based on her memory of a similar lesson from her mathematics pedagogy course at the university.

Student Teachers’ Use of Mathematics Curriculum Materials

These descriptions suggest that student teachers’ ways of using curriculum materials can vary a great deal from teacher to teacher. Whereas Heather read and used all parts of the *EM* curriculum guide to structure daily mathematics lessons, Anne consistently made adaptations to the recommendations of her *EM* materials and Bridget used her SBG materials minimally. The variation we observed across the student teachers’ curriculum use, as well as many characteristics of their use, are consistent with reports of inservice teachers’ use of curriculum materials (Remillard & Bryans, 2004).

However, some aspects of the student teachers’ use of curriculum materials appeared to be distinctly different from that of inservice teachers. When the student teachers in our study used their curriculum materials, they did not draw upon "their own strategies and approaches" or "the repetoires they had developed over years of teaching" (p. 374), as did the inservice teachers described by Remillard and Bryans (2004). Instead the student teachers tapped both human and material resources, including their cooperating teachers, peers (other student teachers), their own subject matter knowledge and preservice teacher education experiences, and alternative instructional materials. This finding draws attention to the potential importance of such resources in preservice and beginning teachers' early use of curriculum materials. It also raises the question of whether differences in the availability of human and material resources might contribute, in part, to differences in student teachers' ways of using their curriculum materials.

Potential Factors Influencing Student Teachers' Use of Curriculum Materials

In this section, we propose factors that may have contributed to the student teachers' ways of using of their mathematics curriculum materials. As presented in Table 4, these factors include each student teacher's curriculum program, mathematics teacher education coursework, mathematics content knowledge and confidence in teaching mathematics, school accountability status and context, and cooperating teacher.

Table 4
Factors Influencing Student Teachers' Use of Curriculum Materials

	Heather	**Anne**	**Bridget**
Curriculum Program	Detailed multi-paged teacher's lesson guide *(EM)*	Half-page teacher's lesson guide *(EM)*	Student workbook (*SBG*)
Mathematics Teacher Education Coursework	1 mathematics course (used a textbook for prospective teachers) 1 mathematics pedagogy course (focused on the *EM* curriculum materials)	2 mathematics courses (used units of *Standards*-based curric. materials) 1 mathematics pedagogy course (emphasized an investigative approach)	2 mathematics courses (used units of *Standards*-based curric. materials) 1 mathematics pedagogy course (emphasized an investigative approach))
Content Knowl./ Confidence	Medium / Low	High / High	High / High
Accountability Status of School	Fully accredited	Fully accredited	Provisionally accredited
Cooperating Teacher	5 yrs teaching experience (4 yrs using *EM*), close relationship with student teacher	Veteran (5 yrs using *EM*), good relationship with student teacher, no teaching observations	4 yrs teaching (no prior experience in kindergarten), little curricular guidance for student teacher

In the following sections, we suggest ways that each factor in Table 4 may have influenced (together with other factors) the student teachers' use of curriculum materials. The purpose of proposing these factors and discussing their potential influences on the three student teachers' use of curriculum materials is (a) to offer a tentative set of factors to be explored in future research and (b) to suggest aspects of teacher preparation that might be adjusted to support teachers' initial use of mathematics curriculum materials.

It is important to point out that, although we discuss each proposed factor individually in the sections that follow, our view is that these factors (and likely other factors as well) worked together to influence the student teachers' use of their mathematics curriculum materials. Heather's efforts to follow closely the recommendations of the *EM* materials were likely influenced by interactions among a variety of factors that may include the detailed nature of the curriculum materials, her focused experiences with *EM* in her teacher education coursework, her lack of confidence about teaching mathematics, the alignment of her received curriculum with the state curriculum standards, and her cooperating teacher's influence. In Anne's case, the brevity of *EM's* kindergarten lesson descriptions, her experiences with a variety of *Standards*-based curriculum materials in university coursework, her high confidence in teaching mathematics and mathematical content knowledge, the alignment of her received curriculum with the state curriculum standards, and her opportunity to teach mathematics lessons independently and multiple times with the support of her cooperating teacher might have contributed to her tendency to make adaptations to *EM's* recommendations. Finally, Bridget's use of the SBG program may have been impacted by the limitations of the SBG workbook as an instructional resource and Bridget's perception of a lack of "fit" of the materials, her past experiences in university courses advocating a variety of resources for mathematics instruction, her explicit attention to the state curriculum standards, her high level of confidence in and content knowledge for teaching mathematics, and her cooperating teacher's minimal guidance.

Curriculum Materials in Use

In her review of research about teachers' uses of mathematics curriculum materials, Remillard (2005) suggested that the "materials themselves matter in teachers' interactions with curriculum materials" (p. 240). Similarly, in a study of four beginning elementary teachers, Kauffman (2002) found that characteristics of the curriculum materials in use were "central to how. . . teachers approach[ed] their lesson planning and instruction" (p. 21). Qualities of

Heather, Anne, and Bridget's received curriculum programs – together with additional factors – may have contributed to the ways they used their curriculum materials during student teaching.

Heather's use of the first grade *EM* curriculum materials may have been influenced, in part, by her sense that the materials were detailed and what she referred to as "scripted." She described being faced with a great deal of information in the curriculum materials, the majority of which was new to her. Because she focused on enacting the details of the *EM* lessons, and seemed to understand the "big picture" of her lessons only after teaching them, it may have been difficult for Heather to make adjustments to the written suggestions in the materials. Heather also had a favorable view of the extensive information in the materials. She appreciated and agreed with the pedagogical approaches of the *EM* materials. This view may have contributed to her inclination to try to follow closely the recommendations of the materials. Only when she experienced difficulty enacting *EM*'s recommendations in her allotted class time did Heather make adjustments to the curriculum materials.

In contrast to Heather, both Anne and Bridget made adaptations to curriculum materials that were either brief or limited as instructional resources. Although Anne used the same curriculum program as Heather, the *EM* materials for kindergarten consisted of brief lesson descriptions typically spanning half a page. It is possible that the brief nature of Anne's curriculum materials offered opportunities for her to gain a general sense of *EM* lessons and to make decisions about adjusting the specific activities and mathematical emphases of lessons. Anne's *EM* lesson pages were not only brief, but they also described lessons that were generally consistent with her own instructional philosophy. Bridget's lessons too were based on relatively brief written information – pages from the workbook component of SBG's commercially-developed curriculum program. However, this curricular resource failed to meet either her own goals for mathematics instruction or the objectives of the state curriculum framework. These mismatches likely contributed to Bridget's tendency to adapt and supplement the SBG program.

We remind the reader that it is not our intention to argue that the nature of the curriculum materials, as we have described, can explain some particular aspect of the student teachers' curriculum use. Instead, our aim is to propose ways that the nature of the curriculum materials may have contributed – most likely through interaction with other factors – to the student teachers' curriculum use. For example, we are doubtful that Heather would have adapted the brief *EM* kindergarten materials in the ways that Anne did, if Heather had been placed in Anne's classroom. Other factors, such as Heather's teacher education experiences and lack of confidence about teaching mathematics, may have contributed to Heather attempting to follow closely the recommendations of the kindergarten materials (as she did with her first-grade materials), unlike Anne. On the other hand, perhaps Heather would have made adaptations to the recommendations of her curriculum materials if she had the opportunity to teach each lesson multiple times in the kindergarten classroom, as Anne did. Because the student teachers' curriculum use was probably influenced by the contextual and situational characteristics of their internship sites *as well as* personal factors, we would not expect the student teachers to exhibit the same type of curriculum use across different internship sites. We emphasize that, in all likelihood, the factors discussed in this section – as well as others that we have not identified – worked together in complex ways to shape the student teachers' ways of using curriculum materials.

Teacher Education Coursework

A recurring question in teacher education is whether the effects of university coursework are "washed out" by classroom experiences (Ebby, 2000; Raymond, 1997; Steele, 2001; Zeichner & Tabachnick, 1981). In our study, the preservice teachers' internships did not appear to eliminate the impact of prior course experiences – in fact, as we describe below, the student teachers' coursework, in conjunction with other factors, may have contributed to their tendencies to use curriculum materials in particular ways during their internships.

Heather's experiences in mathematics education courses were quite different from those of Anne and Bridget. Anne and Bridget completed two undergraduate mathematics courses for preservice elementary teachers. In these courses, they used a variety of units from different *Standards*-based curriculum programs and worked through the mathematics in these units as learners. Two years later, Anne and Bridget completed a graduate-level mathematics pedagogy course that emphasized an investigative approach to mathematics teaching and learning. The preservice teachers enrolled in this course were introduced to the *EM* curriculum program during one 3-hour class session.

In contrast, Heather enrolled in one mathematics course for preservice teachers. In that course, she used a college mathematics textbook written for preservice elementary teachers. Less than one year later (during a summer term), Heather's graduate-level mathematics pedagogy course was taught by the mathematics curriculum supervisor of Jameson County (where use of *EM* was mandatory). The course focused almost exclusively on learning how to implement the

EM program effectively. As Heather expressed, "We learned so much. We spent the whole semester using *Everyday Math*."

Heather's preservice course experiences with the *EM* materials – experiences that were led by a strong advocate for the series – might have impacted her efforts to implement the curriculum materials closely. For instance, she initially expressed excitement about having been placed in a county that used *EM* because she assumed that "math would be planned." Anne and Bridget, on the other hand, were more inclined to make adaptations to their curriculum programs. Prior exposure to the mathematics embodied in *Standards*-based curriculum materials (in their mathematics courses) and an investigative approach to teaching and learning (in their pedagogy class) may have contributed to Anne's tendency to make adaptations to her *EM* materials and Bridget's decision to supplement the SBG workbook pages. Moreover, Anne and Bridget's pedagogy course did not explicitly advocate the use of any one curriculum program in particular, whereas Heather's pedagogy course had a specific focus on implementation of the *EM* curriculum program. It may be the case that Heather perceived that implementation of *EM* was the "correct way" to teach mathematics. Such a view would likely contribute to an inclination to adhere to the recommendations of curriculum materials.

Unlike Heather and Anne who used a *Standards*-based curriculum program during their student teaching, Bridget was expected to use only the workbook component of a commercially-developed curriculum program. Bridget's visions for mathematics instruction, which were likely influenced by her experiences with *Standards*-based curriculum materials at the university, appeared to contribute to her dissatisfaction with the SBG worksheets and her decisions to adapt and use alternative resources. Recall that, in the design of several mathematics lessons during her internship, Bridget drew upon activities in the *EM* materials and from activities she remembered from her mathematics pedagogy course. In Bridget's case, teacher education coursework may have influenced not only her interpretations of the curriculum program in use at her student-teaching site, but also her selection of the alternative resources she used for her design of supplemental mathematics activities.

Student Teachers' Content Knowledge and Confidence About Teaching Mathematics

The influence of teachers' conceptions of mathematics on classroom instruction has been widely documented. In the case of student teachers, Borko, Livingston, McCaleb, and Mauro (1988) found that differences in subject matter knowledge and confidence in that knowledge were associated with differences in student teachers' planning and teaching. Those teachers who had strong content knowledge and confidence in their knowledge were more responsive to students while teaching. Similarly, Kahan, Cooper, and Bethea (2003) found that student teachers' mathematical content knowledge affected their preparation and instruction across a wide variety of elements of teaching. Below we propose ways that the student teachers' content knowledge and confidence may have influenced their use of mathematics curriculum materials.

In their mathematics content course for elementary teachers, Anne and Bridget were considered by the course instructor to be two of the strongest mathematics students. Anne described herself as "a math person" and explained, "Math is a thing I was always good at. I was one of those students that it clicked for me. I always liked math." The following year, Heather also performed well in her mathematics course, however she was not considered to be one of the strongest students mathematically. Moreover, her confidence in teaching mathematics appeared to be significantly lower than that of Anne and Bridget. Heather expressed that she was not confident in her ability to understand the topics or to teach elementary mathematics. She commented on her apprehension about teaching mathematics: "You never know if [the students] are going to get it, or if you are going to be able to explain it."

These differing levels of confidence in teaching mathematics and mathematical abilities may have contributed to Heather, Anne, and Bridget's use of their curriculum materials. For example, Heather was observed using her curriculum guide as a resource during most of our observations, holding and reading the book throughout her instruction. In contrast, Anne and Bridget did not use their teacher's guides or lesson notes while they taught. This difference may be related to the varying amounts of information provided in the three student teachers' materials. It may also be related to the student teachers' differing levels of confidence in teaching mathematics and mathematical content knowledge. Although it would be difficult, based on our data, to speculate about the primary influences on Heather's tendency to follow the curriculum program closely and make minimal adaptations to lessons, Anne's inclination to adapt lessons to increase the mathematical sophistication of lessons, and Bridget's decisions to supplement the SBG worksheets with exploratory activities, the student teachers' confidence about teaching mathematics appears to be one of several contributing factors.

School Context

There are many aspects of school context that influence teachers' work with curriculum materials and textbooks. Because our study took place in a state where a detailed curriculum framework specifies standards in four core content areas (including mathematics) and at a time when teachers faced increasing pressures from mandated state testing, we found it interesting to consider how the accountability status of each internship site might have impacted the student teachers' ways of using their curriculum materials.

Kauffman (2002) identified ways that local expectations about teachers' use of mathematics textbooks can be tied closely to school and district-level implementation of accountability policies. In the case of two of the beginning teachers in his study, "Their principals and curriculum coordinators expect them to adapt and supplement the textbook materials regularly, using them as resources for teaching the state standards rather than relying on them to determine the curriculum" (p. 17). In contrast, two other beginning teachers perceived that "they are expected to use their textbook regularly. The materials themselves constitute the *de facto* curriculum. There is also an expectation that they supplement the materials, but in clearly defined ways and in a limited fashion" (p. 18). Student teachers also receive such messages about curriculum from authority figures, including their cooperating teachers. (See the next section for our discussion of cooperating teachers.)

Bridget's student teaching took place in a school that was identified as "low performing" on state tests. During the year of Bridget's student-teaching internship, as well as the previous year, the school's mathematics test scores were below the passing rate for both third and fifth grades. Bridget received strong messages from teachers and administrators about the importance of addressing the state curriculum objectives to prepare students for state tests. Bridget frequently adapted and supplemented the SBG worksheets that she felt did not adequately address the objectives of the state curriculum framework. The mismatch between the SBG worksheets and the mathematical goals of the state curriculum framework (as well as her personal instructional goals) likely contributed to Bridget's minimal use of the SBG curriculum materials.

Heather and Anne, on the other hand, were placed in a school that was labeled by the state as "Fully Accredited." Teachers at their school used a pacing guide that identified how each state standard was addressed in the *EM* curriculum program. As Heather's cooperating teacher pointed out, "More times than not, *EM* has a higher expectation than the [state curriculum framework].

We're meeting the [state curriculum framework] needs by using this curriculum." Because students at their school were successful on state mathematics tests and teachers and administrators were assured that the *EM* curriculum addressed the state curriculum standards, Heather and Anne were positioned to place greater trust in their curriculum programs than was Bridget. In Heather's case, the school's endorsement of the *EM* curriculum program was underscored by her cooperating teacher's support and by her prior experience with *EM* at the university.

For the student teachers in our study, alignment between curriculum programs, the expectations of their internship sites, and their own instructional goals appeared to impact their use of curriculum materials. The student teacher who experienced the greatest curricular alignment, Heather, attempted to adhere to the recommendations of her curriculum materials. The student teacher who experienced the least curricular alignment, Bridget, used her curriculum program minimally as she attempted to meet state objectives, satisfy her school's expectations, and fulfill her own goals for teaching mathematics.

Cooperating Teachers

An essential ingredient of a student-teaching experience is a mentor teacher's guidance (Britzman, 1991; Fairbanks, Freedman, & Kahn, 2000; Feiman-Nemser, 2001; Frykholm, 1998). In this section we consider how the expectations, instructional practices, and mentoring styles of the cooperating teachers might have impacted the student teachers' use of curriculum materials.

Heather's efforts to follow the EM materials closely may have been influenced by the practices of her cooperating teacher. Ms. Greene reported that she used the *EM* teacher's guide to structure mathematics lessons and suggested that the teacher's guide "has so many good questions so I always have [the guide] up there with me. They have some really good examples and stories. . . and the book really does help." Heather observed Ms. Greene's mathematics instruction for two weeks at the beginning of her internship. When Heather began teaching mathematics full-time, Ms. Greene observed all of Heather's lessons and offered regular feedback. Ms. Greene spoke to Heather frequently about the difficulties she and other teachers faced in learning how to pace *EM* lessons. The close relationship between Ms. Greene and Heather, and Ms. Greene's close adherence to the recommendations of the *EM* materials, likely influenced Heather's use of the materials and her focus on lesson-pacing.

Anne, on the other hand, worked with Ms. Roy in a unique classroom situation in which each of the four teachers taught one-fourth of the students each day. This structure allowed Anne the opportunity to revise and adapt her lessons extensively as she taught each lesson four times. However, because Ms. Roy and Ms. Jones taught mathematics at the same time that Anne did, Anne's mathematics instruction was never directly observed by her cooperating teachers. Yet Anne's inclination to make adaptations to *EM* seemed to be supported by Ms. Roy and Ms. Jones. Their lunchtime conversations offered occasions for Anne to receive assistance in addressing problems she encountered during the lessons. Perhaps their conversations with Anne, encouraging her to modify tasks between each lesson iteration, influenced Anne's more adaptive use of *EM*. It may also be the case that the classroom structure, in which Anne taught her lessons on her own and unobserved, afforded Anne the freedom to make extensive adaptations to the content and organization of lessons.

Relative to Heather and Anne, Bridget received less guidance from her cooperating teacher regarding her mathematics lessons. Typically Ms. Barrett's guidance related to Bridget's classroom management strategies. Bridget offered that it might have been difficult for Ms. Barrett to make suggestions about mathematical content or student learning because of her lack of familiarity with the kindergarten curriculum. (Ms. Barrett had no prior experience teaching kindergarten). With the limited curricular guidance from her cooperating teacher, Bridget turned to a range of alternative resources for instructional ideas.

Conclusions and Implications

Like Silver, Mills, Ghousseini, and Charalambous (this volume) and Christou, Menon, and Philippou (this volume), in this chapter we have discussed teachers' use of mathematics curriculum materials at a particular point on the professional continuum. We have offered preliminary information about how student teachers' use of curriculum materials compares to that of more experienced teachers. Whereas Remillard and Bryans (2004) found that the beginning teachers in their study tended to follow closely the recommendations of their curriculum materials, we found significant variation in curriculum use across our three student teachers – variation that is similar to that across the eight teachers in Remillard and Bryans's study. However, in contrast to the teachers in Remillard and Bryans's study who drew upon their own instructional repertoires as they interpreted and used their curriculum materials, the student teachers in our study turned to their cooperating teachers, peers, teacher education experiences, and other textbooks and materials. This finding suggests that resources such as these may be critical supports, or safety nets, for student teachers when they use curriculum materials for mathematics instruction for the first time. The potential importance of such resources is underscored by Kauffman et al.'s (2002) portrayal of beginning teachers as "lost at sea" during their initial use of mathematics curriculum materials and textbooks.

We have also proposed and discussed five factors that may have worked together to influence the student teachers' ways of using their curriculum materials. Although we cannot claim to have identified the primary influences on the student teachers' use of their curriculum materials or the key factors that might explain other student teachers' curriculum use, our tentative set of factors can be used to inform the focus and design of future studies. The factors we discussed, and relationships among them, are promising candidates for further investigation of how and why student teachers develop particular ways of using curriculum materials. Understanding the personal and contextual factors that jointly shape teachers' initial use of mathematics curriculum materials may also help teacher educators to provide productive experiences for preservice teachers. Even those factors that are not easily adjusted within teacher preparation programs deserve awareness and attention from those involved in student teachers' experiences.

Drawing on the five factors we have proposed, we put forth the following questions for consideration by researchers and teacher educators:

(1) How do *characteristics of mathematics curriculum materials* affect student teachers' initial teaching experiences? How might teacher education activities prepare student teachers to read and interpret the suggestions of different kinds of mathematics curriculum materials and textbooks?

(2) How might *preservice teacher education coursework* prepare student teachers to use a variety of curriculum materials and frameworks for the design and enactment of effective mathematics instruction? How might preservice teacher education experiences prepare teachers to identify and use human and material resources available for instructional support?

(3) What are the relationships between *mathematical content knowledge and confidence* and student teachers' use of curriculum materials? How might teacher education activities prepare teachers to use curriculum materials for their own learning of mathematics and to increase their confidence in teaching mathematics?

(4) How do *policy mandates for state testing and curriculum frameworks* impact student teachers' initial experiences using mathematic curriculum materials for instruction? What can teacher educators do to prepare teachers to engage in productive relationships with state curriculum frameworks?

(5) What is the influence of *cooperating teachers* on student teachers' use of curriculum materials? How might teacher educators collaborate with cooperating teachers to purposefully support student teachers' initial interactions with mathematics curriculum materials?

Although our study suggested a number of important factors that may influence student teachers' use of curriculum materials, there are additional factors that we have not addressed. For example, in their review of research on learning to teach, Wideen, Mayer-Smith, and Moon (1998) called for more focused attention on how *all* players affect the landscape and process of learning to teach, including supervising teachers, teacher educators, students, and parents themselves. The effects of parents on teachers' use of curriculum materials (Gellert, 2005; Lubienski, 2004) and the role of university supervisors are certainly important considerations (Frykholm, 1998). In addition, longitudinal studies of teachers – from preservice experiences to the early years of teaching – are greatly needed. What factors seem to have the greatest impact on teachers' use of curriculum materials as they gain experience? Investigating these questions will not only provide clearer understandings about teachers and teaching, but might also suggest ways that preservice coursework and internship experiences can be adjusted to support teachers' early encounters with mathematics curriculum materials in the classroom. Because student teachers' experiences have potential to influence the nature of subsequent professional learning, we must identify and provide supports for teachers' initial curriculum use so that productive interactions with curriculum materials can continue to develop in the future.

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Chapter 6. Conclusions

In 1996, Ball and Cohen asked a critical question: what is, or might be, the role of curriculum materials in teacher learning? In this final chapter, I synthesize issues and findings from Chapters 3, 4, and 5 to help answer this question for the specific case of preservice teachers.

As new *Standards*-based mathematics curriculum materials were developed, teacher learning was considered an important component of the design (e.g., Davis & Krajcik, 2005; Remillard, 2000; Van Zoest & Bohl, 2002). Ball and Cohen (1996) suggested that turning curriculum materials into a site for teacher learning requires a reconceptualization of curriculum design: the curriculum as a whole, including student books and teacher's guides, would have to provide a terrain for teacher learning. *Standards*-based curriculum materials have come to be thought of as *educative* materials intended to promote teacher learning of subject matter, help teachers anticipate and interpret learners' understandings, and support teachers' design capacity as they make decisions about curriculum adaptation (Davis & Krajcik, 2005).

Growing numbers of teacher education courses engage preservice teachers in textbook analysis and adaptation, as well as in the use of *Standards*-based curriculum materials (Frykholm, 2005; Lloyd, 2006; Lloyd & Pitts Bannister, accepted for publication; Tarr & Papick, 2004). Moreover, many student teachers are placed in school settings where the use of *Standards*-based curriculum materials has been mandated (e.g., Lloyd, 2008; Van Zoest & Bohl, 2002). As Ben-Peretz (1984) points out, however, "The ability to grasp the full meaning of curriculum materials is a prerequisite for their professional use in classrooms. This ability has to be developed in pre- and inservice teacher education programs" (p. 11). If teacher education is to play a pivotal role in helping teachers learn from the use of mathematics curriculum materials, it is important to examine carefully the typical experiences and learning opportunities embedded in preservice programs. The descriptions of preservice teachers' experiences with mathematics curriculum materials in Chapters 3, 4, and 5 not only add detail to what we know about teachers' interactions with and uses of curriculum materials, but also have the potential to offer insight into the role of teacher education in guiding and supporting teachers' ongoing learning with these materials. To frame these results and suggest opportunities for learning, I use Feiman-Nemser and Buchmann's (1985) critical analysis of experience in teacher education.

Pitfalls of Experience in Teacher Education

Although a trust in firsthand experience in learning to teach is common, Feiman-Nemser and Buchmann (1985) examine early experiences in teacher education with a critical eye. The authors ask, "Is experience as good a teacher of teachers as most people are inclined to think?" (p. 53). To explore this question, Feiman-Nemser and Buchmann discuss teacher learning in the moment as well as the "potential learnings – insights, messages, inferences, reinforced beliefs – about being a teacher, about pupils, classrooms, and the activities of teaching" (p. 54). These "pitfalls" of teacher education, or particular types of "inappropriate learning" as described by the authors, are outlined in Table 5.

I use these frames to help highlight three important ideas from my manuscripts: (a) what was learned by preservice teachers in my studies, (b) how teachers were given opportunities for that learning (i.e. the nature of their experiences), and finally, (c) other opportunities and resources that we might provide preservice teachers bearing in mind the importance of teacher learning with curriculum materials amongst the pitfalls of experience in teacher preparation.

Table 5: Pitfalls of Experience (from Feiman-Nemser and Buchmann, 1985)

Pitfall	**Description of experience**
Familiarity pitfall	The familiarity pitfall stems from the tendency to trust what is most memorable in personal experience…. Ideas and images of classrooms and teachers laid down through many years as a pupil provide a framework for viewing and standards for judging what [is seen] now (p. 56).
Two-worlds pitfall	The two-worlds pitfall arises from the fact that teacher education goes on in two distinct settings and from the fallacious assumption that making connections between these two worlds is straightforward and can be left to the novice (p. 63).
Cross-purposes pitfall	The cross-purposes pitfall arises from the fact that classrooms are not set up for teaching teachers (p. 63). The legitimate purposes of teachers center on their classrooms, which generally are not designed as laboratories for learning to teach (p. 62).

Learning to Challenge what is Familiar about Curriculum during University Coursework

Research indicates that teachers teach in the ways in which they were taught (Ball & Feiman-Nemser, 1988; Lortie, 1975). Feiman-Nemser and Buchman's (1985) "familiarity pitfall" highlights this idea. The authors suggest that *unquestioned* familiarity is a pitfall in that it "arrests thought and may mislead it" (p. 56). The authors further emphasize, "People do not recognize that their experience is limited and biased, and future teachers are no exception. The 'familiarity pitfall' stems from the tendency to trust what is most memorable in personal experience" (p. 56).

The preservice teachers in my studies experienced the familiarity pitfall. Many brought ideas and images from their own schooling experiences to their teacher education coursework. As described in Chapter 3, when we asked our preservice teachers, early in their programs, to evaluate and compare mathematics lessons – two fairly self-contained sets of instructional materials that dealt with the same mathematical topic but in different ways – many of their views about what should be in a lesson related very closely to what they had experienced as students themselves. Their past experience not only limited their view of what could possibly be incorporated into a mathematics lesson, but the strength of their conceptions also tended to cloud their interpretations of some qualities of the less familiar lesson activities.

Most teachers require extensive experiences and time working with and learning from new curriculum materials, especially *Standards*-based curriculum materials. Calls have been made to incorporate curriculum materials into methods courses and professional development practices to help teachers develop an understanding of and familiarity with these new materials (Ball & Cohen, 1996; Lloyd, 2002, 2006; Manouchehri & Goodman, 1998). The familiarity pitfall suggests the need for activities such as the mathematics lesson comparison. The selection of the instructional materials that we asked teachers to analyze for this lesson comparison was very deliberate – material sets with distinctly different conceptions of teaching and learning, but also sets of materials that were familiar and comfortable as opposed to materials that were unfamiliar and more closely aligned with the current reform movement in mathematics education. Contrasting familiar materials with newer, more innovative materials not only provided insight into the *strength* of the apprenticeship of observation (Lortie, 1975) as preservice teachers found traditional elements even when they were not there, but also created an entry point for discussion related to the power of past experience. Our preservice teachers not only had opportunities to learn about *Standards*-based materials during university coursework, but they were also given a chance to compare lesson structures and uncover tacitly-held beliefs about teaching and textbooks. Chapter 3 contributed to the very limited knowledge base about preservice teachers' learning from innovative curriculum materials and the connection to prior conceptions regarding the teaching and learning of mathematics.

Teacher Learning about Curriculum Materials across Two Distinct Settings

Feiman-Nemser and Buchman (1985) also describe the "two-worlds pitfall" in teacher preparation. As suggested by the authors, preservice teachers will need guidance in recognizing how what they have learned as university students can help shape their perspectives and practices as teachers. Making these connections are not necessarily easy or automatic.

In Chapter 5, I examined the experiences of three elementary student teachers who taught in different classroom contexts and utilized different instructional resources to teach mathematics. I found that, in contrast to the inservice teachers in Remillard and Bryans' (2004) study who drew upon their own instructional repertoires as they interpreted and used their curriculum materials, the student teachers in my study turned to their cooperating teachers, peers, teacher education experiences, and other textbooks and materials. This finding suggests that resources such as these may be critical supports for student teachers when they use curriculum materials for mathematics instruction for the first time. Bridget, for example, relied heavily on her teacher education experiences – she pulled in activities from her mathematics methods courses and from the instructional resources she had come to believe were more innovative and closely aligned with her new views of mathematics teaching and learning. In addition to relying on ideas from her teacher education coursework, Bridget also needed to use the mathematics instructional resources mandated by her placement school – materials she felt were inappropriate for her students learning. She was caught in the "two-worlds pitfall" as she taught with mathematics instructional materials for the first time. Bridget worked hard to fulfill the requirements of her internship site by using the required workbook, but also needed to find ways to incorporate new instructional ideas she had learned throughout university coursework.

In this setting, Bridget was given an opportunity to learn how to balance school expectations about mathematics curriculum with the curricular strategies she felt were appropriate for children's learning. She needed to reach compromises between her university experiences and her internship site. *Standards*-based curriculum materials were an important resource for Bridget as she came to realize the shortcomings of the traditional workbook she was mandated to use.

Classrooms as Sites for Teacher Learning about Curriculum Materials

As preservice teachers first enter classrooms, they are confronted with the responsibility of teaching while still learning how to teach. Feiman-Nemser and Buchman (1985) describe this experience as the "cross-purposes pitfall." This pitfall suggests the frequent disconnect between the responsibility of teaching and the need for critical reflection on teaching. It also highlights the idea that classrooms are not set up for teaching teachers.

During her student teaching experience, Anne was given the opportunity to learn about a specific *Standards*-based curriculum program. Anne typically extended activities and increased the mathematical emphasis of many of her lessons. Because Anne worked with only a small group of children each day, she also participated in extensive lesson adaptation and extension as she modified her lessons for the next group of students she was to teach. Anne became familiar with these new, innovative materials and was then given the unique opportunity to teach each of her mathematics lessons four times. Because of the unique setup of her student teaching classroom, Anne not only became familiar with the materials, but she was also able to reflect on and then adapt lessons based on her experiences. Anne most often focused on increasing the mathematical sophistication of each of her lessons, and on the classroom management necessary to make it through her lessons four times on her own. Although mathematical sophistication and classroom management strategies are important in regard to teacher learning with curriculum materials, Anne seemed to miss opportunities to think about the overall goals of the curriculum program she was teaching with. Anne was caught in the "cross-purposes pitfall" as her cooperating teacher was naturally focused on the learning of her students, and was not as critically involved in Anne's learning to teach. Although Anne had opportunities to consider and adapt *Standards*-based curriculum materials, the setup of the classroom was not ideal for Anne to get feedback and guidance from her cooperating teacher regarding the use of mathematics curriculum materials.

Heather was also caught in the "cross-purposes pitfall" as she found herself placed in a classroom with a cooperating teacher who had set routines and guidelines for students, and who used a detailed, *Standards*-based mathematics curriculum for instruction. When Heather entered her student teaching experience in the middle of the year, she easily assimilated into the order already established in her cooperating teacher's classroom. Heather was able to observe her cooperating teacher teach with the detailed mathematics curriculum, and was then able to step in to the already established instructional routine. Heather was afforded an opportunity to consider and learn about the complicated nature of *Standards*-based curriculum program enactment as she worked to understand how to use a particular set of curriculum materials well.

Feiman Nemser and Buchmann (1985) talk about the differences between practicing teachers' and student teachers' ability to create their own classroom and make curricular decisions:

> Moving children through the daily schedule is, of course, part of the teacher's responsibility, but a real teacher also has to decide what that schedule will be, how the children should be grouped, and what assignments to put on the board. The point is that student teaching occurs in somebody else's classroom; this makes the requirements for action and thought in student teaching fundamentally different from those for the teacher. (p. 60)

Heather's experience with classroom norms and curriculum use was, of course, limited to the situation in which she was placed. For Heather, the ability to enact lessons and work on fitting lessons in a predetermined amount of time was her goal, as also emphasized by her cooperating teacher. For student teachers, relying heavily upon a curricular guide or on predetermined classroom norms might limit opportunities to move moment to moment and constrain certain aspects of learning to teach. For example, Heather made more decisions about pace and the structure of lesson activities based upon her students' work when enacting her symmetry lesson – a lesson structure created by Heather – as compared to her instruction with the detailed *Standards*-based curriculum materials she had observed her cooperating teacher use. Heather's experience with a *Standards*-based curriculum provided her an opportunity to understand the complicated nature of curricular resources, but also limited her chances to reflect critically on other aspects of curriculum enactment.

Teacher Learning with Mathematics Curriculum Materials

The preservice teachers in the three studies presented here found themselves immersed in professional development with mathematics curriculum materials, textbooks, and state curriculum guides during coursework and fieldwork experiences. To respond to Ball and Cohen's (1996) question, curriculum materials indeed played substantial role in preservice teacher learning in my studies. Preservice teachers had the opportunity to:

- develop an understanding of the variety of mathematics instructional resources available for teaching *that were different from what was familiar and comfortable*;

- *negotiate balance* between university experiences and personal expectations for instructional resources and the expectations of schools in regard to mathematics curriculum;

- consider and learn about the *unexpectedly complicated nature* of *Standards*-based curriculum program enactment; and

- make decisions regarding lesson *adaptation* from a variety of mathematics instructional materials for particular students and for particular classroom contexts.

The results from these chapters not only illustrate teacher learning with and about curriculum materials, but also point out opportunities within teacher education for preservice teachers to question well-established beliefs and practices regarding mathematics teaching and mathematics instructional resources. In other words, the opportunities for learning afforded to these preservice teachers as they interacted with mathematics curriculum materials display a common theme of *disequilibrium*. These chapters also highlight possible missed opportunities for learning and the importance of *human resources* within teacher education as it relates to preservice teachers' encounters with disequilibrium. These ideas are explored further below.

The Role of Disequilibrium

As Wheatley (2002) describes, disequilibrium among preservice and inservice teachers is caused by a challenge to teachers' beliefs about their existing practices. Wheatley further suggests, "The psychological need to resolve such disequilibrium often pulls teachers into learning and change" (p. 9). It was when our preservice teachers encountered materials and practices different from what they were expecting or accustomed to that opportunities for learning seemed to arise. For example, for many of the preservice teachers who participated in the lesson analysis assignment (Chapter 3), exposure to new curriculum materials allowed them to consider the methods in which they were taught mathematics. Many of the preservice teachers examining the curriculum materials encountered disequilibrium as they questioned prior certainties about effective lesson structures for the teaching of mathematics. This lesson analysis assignment, and the recommended modifications, positions teachers to encounter disequilibrium and confront tacitly-held beliefs about teaching built on what is inherently familiar and comfortable.

The student teachers described in Chapters 4 and 5 also encountered disequilibrium as they engaged with mathematics curriculum materials in the classroom. For example, Bridget encountered disequilibrium when she was placed in a school system with curricular expectations that differed from her newly developed views about teaching and learning. Trying to make sense of the "two-worlds" pitfall, Bridget found herself making modifications to the curriculum materials she was required to use and also drawing on curriculum materials and activities from her teacher education coursework. Unlike student teachers placed in classroom in which the philosophies of the university and of the classroom align, Bridget had to make sense of her new ideas of mathematics teaching and learning and how those ideas might be modified to fit the vision of her placement site. Confronting and managing this sort of curricular disequilibrium may be an increasingly necessary skill for novice teachers in these times of high-stakes testing and teacher accountability.

Heather too encountered disequilibrium as she utilized *Standards*-based mathematics curriculum materials during student-teaching. Quite the opposite of what she expected, Heather discovered how difficult it was to plan and teach with what she described as a detailed, scripted mathematics curriculum. What Heather thought she knew as she entered student-teaching – that mathematics would be planned – was challenged as she discovered the work and reflection necessary to use the curriculum materials effectively. Further, when Heather was encouraged to plan from alternative instructional resources for just one lesson, she felt more attuned to her students and the overall learning objectives. Heather's feeling of disequilibrium when using the *EM* curriculum, coupled with the opportunity to plan a lesson using different curricular resources, helped Heather to evaluate more critically her understanding of a *Standards*-based curriculum program prior to beginning full-time teaching.

The Role of Human Resources

Bumping up against disequilibrium when using mathematics curriculum materials for teaching and learning is not surprising. There is potential for learning when preservice teachers are asked to consider materials different from what they are used to, teach with methods and materials different from their philosophies about teaching and learning, and teach with complicated and detailed curriculum materials. For example, Heather's encounter with disequilibrium regarding curriculum materials allowed her the opportunity to consider the complicated nature of *Standards*-based curriculum materials. This reflective experience, however, was somewhat hindered by issues of "cross-purposes." To return to the initial question of the role of curriculum materials in teacher learning, as preservice teachers encounter disequilibrium amongst the pitfalls of experience in teacher education, it is important to articulate the role of *human resources* in this learning. As our understanding of the role of curriculum materials in teacher learning matures, it is important to reconsider the role of teacher educators, cooperating teachers, university supervisors, and all others connected to preservice teacher learning with curriculum as it relates to pitfalls of experience in teacher education.

The familiarity pitfall stems from teachers' tendency to trust what is most memorable from past schooling experiences. Left unaddressed, preservice teachers may have a hard time viewing other alternatives as valid possibilities for their future teaching. This common pitfall within teacher education emphasizes further the importance of *many* instructional activity comparison assignments designed to enhance and challenge curricular knowledge, and the critical role of teacher educators in both the design of and facilitation of reflection surrounding such activities. As described in Chapter 3, comparison activities might be designed to (a) increase teachers' focus on the depth and type of mathematical understandings that students might gain in comparison to their own school experiences in mathematics, (b) improve teachers' analysis of the purpose of student interaction, again as compared to their own experiences, and finally (c) develop teachers' sense of themselves as curricular decision-makers as *teachers*, and not just as prior students. Teacher educators need to help preservice teachers make sense, in a deep and conceptual way, of the variety of curriculum resources available to them both before and during student teaching experiences. They need to help preservice teachers realize that what they have experienced with mathematics curriculum materials and instructional resources as students is only one option amongst many possibilities in their future use of mathematics curricular resources.

To address the two-worlds pitfall, teacher educators might position themselves as critical supports, or safety nets, for preservice teachers as they make the transition from university coursework to classroom-based fieldwork. Helping teachers make connections between philosophical beliefs and actual classroom practice with mathematics instructional materials and pushing them to "act with understanding" (Feiman-Nemser & Buchmann, 1985, p. 64) is critical. For example, Bridget may have benefited from more help from her university instructors in analyzing different curricular resources. What if Bridget's university professors and supervisor had pushed her to reflect on the different strategies she was using for mathematics instruction? What if university personnel helped her to consider the learning outcomes of her students in relation to the curricular strategies attempted? For mathematics curriculum materials and instructional resources to play a role in teacher learning throughout student-teaching, teacher educators and university supervisors might need to expand their support and redefine their roles to stretch far beyond the walls of university classrooms.

Cooperating teachers might also reconsider their role in the education of preservice teachers. If cooperating teachers viewed themselves as teacher educators rather than model teachers, they might be better positioned to help preservice avoid the "two-worlds" pitfall as it relates to developing curricular knowledge. For example, Bridget's cooperating teacher might have helped her reflect critically on her use of both *Standards*-based and more traditional mathematics curricular resources. Bridget may have additionally benefited from help in analyzing her lesson choices and use of instructional resources and what her initial curricular choices, mid-lesson decisions, and post-lesson reflection might have suggested for future teaching actions.

In light of the "cross-purposes" pitfall, cooperating teachers might also search out ways to support novice teachers to move beyond mere imitation towards purposeful and reflective decision-making with curriculum materials. For example, if Anne's cooperating teacher had been teaching with her, or observing Anne's lessons and adaptations, their conversations might have broadened to include students' mathematics communication, ideas about genuine problem solving in mathematics, and children's sense of mathematical authority as they worked through problems from innovative curriculum materials. Heather's cooperating teacher might have also reconsidered her role in Heather's student teaching experience. In addition to supporting Heather in her quest to learn how to use a particular set of *Standards*-based curriculum materials well, she might have also encouraged Heather to consider and experiment with her *own* uniquely designed lesson activities and classroom structures. Critical examination and use of many types of instructional resources during student teaching might help us work towards a compromise between the necessary responsibility of a preservice teacher to teach and his or her ultimate goal of learning about teaching. Although these modified roles might create new challenges within current teacher education practices, we must not underestimate the importance of human resources as we consider opportunities for teachers to learn with mathematics curriculum materials.

Final Thoughts

In order to position curriculum materials as tools for teacher learning, we need to move beyond mere exposure to specific materials and on curriculum use strategies, towards a focus on the critical analysis of curriculum materials and their use. Helping preservice teachers to (a) understand the philosophies that underlie curriculum materials, (b) make sense of their use of materials both before and during student teaching as they transition from the university to school settings, and (c) navigate the pitfalls of experience as they encounter learning opportunities in real classrooms is critical. As we design opportunities for preservice teachers to engage with mathematics curriculum materials, we must position all players in the preparation of teachers as critical supports amongst the pitfalls of experience within teacher education. With these human supports in place, engaging preservice teachers in activities and learning opportunities with the potential to create disequilibrium and reflection has the potential to position mathematics curriculum materials as clear tools for teacher learning and as vehicles for renewal and innovation in the teaching of mathematics.

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