LEARNING TO ASSESS AND ASSESSING TO LEARN: A DESCRIPTIVE STUDY OF A DISTRICT-WIDE MATHEMATICS ASSESSMENT IMPLEMENTATION

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ABSTRACT

CATHARINA WIN RINGER: Learning to Assess and Assessing to Learn: A Descriptive Study of a District-Wide Mathematics Assessment Implementation
(Under the direction of Susan N. Friel and Karen Erickson)

In today's mathematics education, there is an increasing emphasis on students' understanding of the mathematics set forth in standards documents such as the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000) and, most recently, the *Common Core State Standards for Mathematics* (National Governors Association for Best Practices & Council of Chief State School Officers, 2010). Widespread adoption of the *Common Core State Standards for Mathematics* (CCSSM) within the United States establishes, for the first time, a common set of coherent, focused standards built on "research-based learning progressions detailing what is known today about how students' mathematical knowledge, skill, and understanding develop over time" (NGA Center & CCSSO, 2010, p. 4).

The CCSSM sets grade-specific standards for the majority of the nation's teachers and students, standards that students are expected to achieve with understanding. This requires that teachers assess whether students have developed an understanding of the mathematics set forth in these standards. Although the standards are well defined within the CCSSM, methods of identifying and meeting the needs of students who do not meet or who exceed these grade-specific expectations are not defined, and therefore it is left for individual teachers to identify ways to do so.

This embedded multiple-case study explores the individual and collective experiences of a group of third-grade teachers as they worked to implement a district-initiated mathematics formative assessment and intervention process. The yearlong investigation focused on third-grade teams in two schools, their implementation of the process, and its impact on student learning. This study was designed within the context of engaged scholarship, a participative form of research that leverages the different kinds of knowledge of key stakeholders in studying complex problems. Teacher and administrator interviews, student assessment results, and professional development documents were analyzed to better understand experiences of the implementation process, influences on instructional practice, and impact on student understanding. Findings from this study suggest that these teachers faced at least eight challenges as they implemented the formative assessment practices. These challenges are described with reference to barriers identified by Cizek (2010) and clearly must be addressed in order for teachers to embrace the type of formative assessment increasingly called for in research, policy, and practice.

Study findings have several implications for efforts to support teachers' implementation of a formative assessment and intervention process. These findings are discussed along with directions for future research.

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I have come to find that I much prefer the scenic route – or it much prefers me. Either way, as in most things, this has been a long and winding path. Many have been on this journey with me from the beginning and others have joined along the way. There are no words for the gratitude I feel for each of you and the journey we have shared. I know that during no part of this have I traveled alone, and though this work bears my name, it is through our relationships along the way that it has been constructed.

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Finally, to Bruce: there are no words. You Know . . .

DEDICATION

To all the women who have served as examples of strength, inspiration, and gumption along the way . . .and to the men who love us just the way we are.

For Kate . . .

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CHAPTER 1

INTRODUCTION

> The most effective way to meet standards is to work toward them by beginning wherever the child is. If we are to truly teach children, we must meet them at their level of understanding. Any other strategy simply wastes the child's time and prevents the development of the essential foundational understandings and skills needed for future success. (Richardson, retrieved from www.didax.com/AMC/index.cfm)

Teaching has traditionally been a profession of autonomy. In mathematics, this meant that individual teachers decided what mathematics to teach, how long to focus on specific content, and how much time to devote to mathematics each day (Fernandez & Cannon, 2005; Putnam, Heaton, Prawat, & Remillard, 1992). As a result, on a daily basis, teachers access any number of resources to plan and implement lessons and assess student learning, using their own knowledge, experiences, and beliefs to decide what mathematics takes place in their classrooms.

Mathematics Achievement in the United States

Over the last several decades, the work of teaching has been under increasingly intense public scrutiny, in large part prompted by the release of *A Nation at Risk* (National Commission on Excellence in Education, 1983). This report indicated that the education students were receiving in the U.S. resulted in persistent underperformance in mathematics compared with students in other countries. Nearly three decades after *A*

Nation at Risk, students in the U.S. consistently underperform on international assessments compared with their peers in other countries. The most recent international assessment data show a modest increase in the performance of some students across the U.S. but they also indicate that those gains occur at only at the fourth-grade level. On the 2011 administration of the Trends in International Mathematics and Science Study (TIMMS), the average score of U.S. fourth graders rose 12 points compared with 2007, whereas those of eighth graders remained statistically unchanged. On the 2009 Program for International Student Assessment (PISA), a measurement of mathematics literacy in 15-year-old students, the average score of U.S. students fell below the average for all participating countries. Of the 65 participating countries, 29 countries had lower average scores than the U.S., 23 had higher average scores, and 12 had average scores that were not measurably different (Fleischman, Hopstock, Pelczar, & Shelley, 2010). Looking at large-scale assessments in the U. S., *The Nation's Report Card: Mathematics 2011* reported that 40% of students in grade 4 and 35% of students in grade 8 scored at or above proficient on the National Assessment of Educational Progress (NAEP), both of which were higher than in earlier assessment years (National Center for Educations Statistics, 2011). These results indicate that roughly 60% of U.S. students are not proficient in mathematics beginning in grade 4. Although modest gains have been made, as U.S. students matriculate through school, the scores at eighth and tenth grade indicate our students are losing ground.

Focusing on Important Mathematics

In responding to the *A Nation at Risk* report, The National Council of Teachers of Mathematics (NCTM) developed *Curriculum and Evaluation Standards for School*

Mathematics (1989), *Professional Standards for Teaching Mathematics* (1991), and *Assessment Standards for School Mathematics* (1995). These documents outlined a striking change in the ways that educational stakeholders should think about the content, instruction, and assessment of mathematics in classrooms from kindergarten through grade 12. Focusing particularly on what had become common practice in the early elementary grades, the 1989 *Curriculum and Evaluations Standards for School Mathematics* stated:

> The need for curricular reform in K-4 mathematics is clear. Such reform must address both the content and emphasis of the curriculum as well as approaches to instruction. A long-standing preoccupation with computations and other traditional skills has dominated both *what* mathematics is taught and *the way* mathematics is taught at this level. As a result, the present K-4 curriculum is narrow in scope; fails to foster mathematical insight, reasoning, and problem solving; and emphasizes rote activities. Even more significant is that children begin to lose their belief that learning mathematics is a sense-making experience. They become passive receivers of rules and procedures rather than active participants in creating knowledge (p.15).

Through this document, as well as with the later *Principals and Standards for School Mathematics* (2000) and *Curriculum Focal Points* (2006a), NCTM called for a mathematics curriculum that is, “coherent, focused on important mathematics, and well articulated across the grades,” (NCTM, 2000, p. 14), a call for focused coherence that has been echoed in the Common Core State Standards for Mathematics (CCSSM). These standards suggest a progression of mathematics topics from kindergarten through grade

12. Such a curriculum of “important mathematics” must be grounded in core topics—those foundational concepts that, when gained, make other ideas accessible. Each of these core topics is composed of essential understandings that mark significant transitions in students’ understanding of that core concept. Essential understandings are those critical learning phases that serve as milestones or hurdles as children deepen their understanding of core topics. Comprehension of concepts within these essential understandings must be in place to ensure that children are not just imitating procedures or saying words they do not really understand, but are able to think with numbers and, in turn, to use those numbers to solve problems.

Such a progression illustrates the continual building of foundational understandings that underpin the more complex mathematics students will encounter in later years. It is imperative, then, that tools used to assess mathematical understanding in young children, and the instructional decisions based on that understanding, be focused on foundational understanding of mathematics. It is also essential that such assessments reveal student thinking rather than an ability to simply mimic procedures to produce a “correct” answer, which might be referred to as an “illusion of learning” (K. Richardson, 2002). In other words, assessments should help teachers move beyond the procedural (what a child can do) and focus instead on the conceptual (what a child understands). Additionally, assessment tools in the early grades must be designed such that teachers can draw upon them in response to students’ learning, either based on a student’s demonstration of new understanding, a persistent misunderstanding, or a need to make instructional decisions about upcoming learning.

Changing Perspectives on Mathematics Assessment

The reauthorization of the Elementary and Secondary Education Act, more commonly known as the *No Child Left Behind Act of 2001 (NCLB)*, ushered in an era of increased accountability based primarily on student performance on high-stakes tests. Standardized tests, currently the most widely used assessments, are administered to all students at the same time, typically at the end of the year or the end of the course, and evidence is elicited primarily through the use of multiple-choice items. As a summative assessment, the information garnered from these tests may show what a student learned or did not learn and indicate where improvement is needed, while simultaneously serving as an accountability measure for educational stakeholders interested in indicators of school quality. Such large-scale assessments are limited in the knowledge representation they offer, doing little to indicate next steps for students in addressing areas of strength or weakness in order to move forward. In addition, the current administration of these assessments provides a retrospective view of knowledge gained over the course of the previous year, doing little to indicate at what point a student's misunderstanding or struggle with a concept began. Assessment of student progress is needed throughout the school year while there is still time to implement interventions that have the potential to increase student learning.

Although standardized testing provides results about large numbers of students within the same grade or course in a very short time period, most educators would argue that the information provided is neither particularly useful nor focused on important mathematics. For some students, the assessment is either too difficult or too easy, not matching their demonstrated level of understanding and, as such, giving limited information about what they really know or are able to do mathematically. Thus, these assessments provide little useful evidence regarding students' thinking about the concepts presented on the assessment.

Despite the current uses and limitations of standardized tests, these types of summative assessments could serve as one part of a more equitable approach used to make instructional decisions. In its position statement regarding such high-stakes testing, NCTM acknowledges the potential of using large-scale tests as part of a broader assessment approach but advocates for a greater balance in the assessment practices currently being used:

> The National Council of Teachers of Mathematics recognizes the importance of measuring the learning of students and the effectiveness of instruction. Large-scale tests can and should be among several measures that are used to make significant decisions about students and instruction. However, such critical decisions about students and instruction must involve more than the results of any single test. We strongly support a balance of day-to-day classroom assessments, which help teachers improve instruction, and external tests that track progress and provide for national comparisons. (NCTM 2006b)

Reviews of mathematics research and policy recommendations indicate clearly the critical importance of assessment in effective mathematics instruction (National Council of Teachers of Mathematics, 2000, 2006a; National Mathematics Advisory Panel, 2008; National Research Council, 1989). This is reflected in the Common Core State Standards for Mathematics as follows:

> These Standards define what students should understand and be able to do in their study of mathematics. Asking a student to understand something means

> asking a teacher to assess whether the student has understood it. (NGA & CCSSO 2010, p. 3)

Although the CCSSM elaborate what is meant by "understanding mathematics," they do not address assessment beyond the previous statement. Therefore, the question of what types of assessments to use to best support student learning must be considered. We can only measure students' understanding of what they are learning through assessment opportunities that provide teachers with valuable information about what and how students are learning what is being taught.

In contrast, through the *Assessment Standards for School Mathematics* (1995) and the later *Principals and Standards for School Mathematics* (PSSM), NCTM specifically addresses the role of assessment in mathematics. The PSSM states

> Assessment should be more than merely a test at the end of instruction to see how students perform under special conditions; rather, it should be an integral part of instruction that informs and guides teachers as they make instructional decisions. Assessment should not merely be done to students; rather, it should also be done for students, to guide and enhance their learning. (p. 22)

What the Assessment Principle refers to here is assessment *for* learning, or formative assessment. Formative assessment is defined as those activities that teachers and students undertake to gather information that can be used diagnostically to alter teaching and learning. It is only when "the evidence is actually used to adapt the teaching to meet students needs" (Black & Wiliam, 1998b) that an assessment is considered formative. In their meta-study of research on formative assessment, Black and Wiliam clearly convey the potential of using formative assessment to improve student learning:

> There is a body of firm evidence that formative assessment is an essential component of classroom work and that its development can raise standards of achievement. We know of no other way of raising standards for which such a strong prima facie case can be made. Over the last three decades, the evidence supporting the use of formative assessment as a means for improving student learning has only grown, documenting the impact of classroom assessment practices on student learning. (p. 140)

Despite this promise, several challenges to implementing formative assessment exist. Seven such challenges are found in the context of the classroom: purpose, resources, preparation, validity, accommodations, compliance, and time (Cizek, 2010). Cizek points out:

> Although formative assessment represents one of the current best hopes for further increases in student learning, many challenges face this form of assessment, and the eventual efficacy of formative assessment initiatives is not certain. (p. 8)

As Cizek clearly articulates, barriers in place make it difficult for teachers to embrace the type of formative assessment for learning increasingly being called for in research, policy, and practice. In spite of these barriers, some teachers are successfully using formative assessment to understand how and what their students are thinking about important mathematics in order to make instructional decisions (Cizek, 2010; Heritage, 2007; Popham, 2011). Understanding how these teachers have been successful and what impact their success has had on student learning is an important step toward ensuring the widespread, successful implementation of formative assessment across our schools.

One District's Approach to Impact Student Learning

In the summer of 2011, based on the performance of elementary students on state and local mathematics assessments over several years, Piedmont School District[1] (PSD) began to consider ways to strategically address both a persistent achievement gap and lack of student growth. In the spirit of community-engaged scholarship (Carnegie Foundation for the Advancement of Teaching), I was employed by the PSD to co-construct and implement a solution that could later be sustained independently by the district. Our mutual focus on ways to impact teachers' instructional practice and students' opportunity to learn resulted in a partnership centered around implementing a formative assessment and intervention process in second and third grades.

Purpose of the Study

The purpose of this study was to (a) investigate the ways in which third-grade teachers in one school district implement a formative assessment and intervention process focused on the core topic of place value, and (b) the impact of this implementation process on student learning of that core topic.

To that purpose, this study was guided by the following research questions:

1. How does a group of third-grade teachers, individually and collectively, implement a formative assessment process?
2. What sense does a group of third-grade teachers implementing a formative assessment process make of the assessment data individually and collectively?
3. How does a group of third-grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?

[1] Names of school and location have been changed and pseudonyms have been used.

4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?

Summary

Mathematics reform efforts over the last several decades have pointed to a need to focus increasingly on important mathematics and the ways students think about and apply mathematical understandings. Recent education policy in the United States has focused almost entirely on summative assessments that provide single-context views of what students know as demonstrated through narrowly focused, multiple-choice assessments. If we are to collectively improve the mathematics performance of students in the United States so that they are prepared to engage with increasingly advanced mathematics, our collective focus on assessment must be broadened to include formative assessment approaches that guide instructional decisions based on demonstrated student needs. The current investigation was designed to shed light on this process by studying the ways in which one group of third-grade teachers implemented a formative assessment process, made sense of and used the data, and thereby supported students' developing understanding of place value.

CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this study was to investigate the ways in which third-grade teachers in one school district implemented a formative assessment and intervention process focused on the core topic of place value and the impact of this implementation process on student learning of that core topic. Specifically, the questions that guided this study are

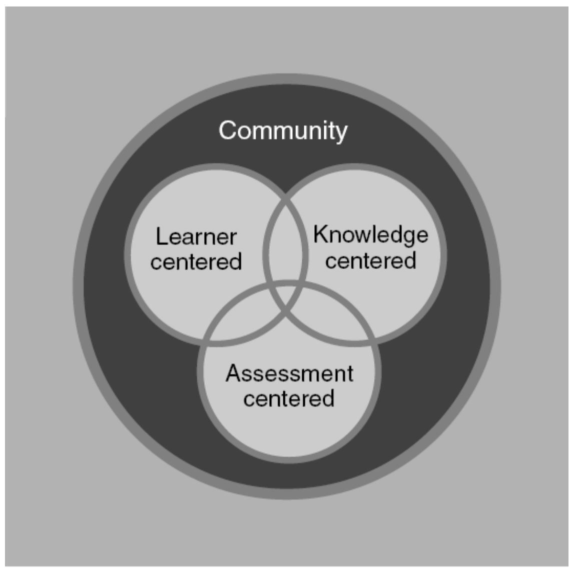
1. How does a group of third-grade teachers, individually and collectively, implement a formative assessment process?
2. What sense does a group of third-grade teachers implementing a formative assessment process make of the assessment data individually and collectively?
3. How does a group of third-grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?
4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?

The importance of the study is grounded in literature relating to formative assessment, learning trajectories, essential understandings, and the development of place value understanding. Each helps establish both the importance of the research questions and the choices of research methods proposed to study those questions.

The Nature and Purpose of Assessment

In *How students learn: Mathematics in the classroom,* Donovan and Bransford (National Research Council, 2005) set out a framework for identifying and designing effective learning environments consisting of four interrelated components (see Figure 2.1). In addition to including knowledge-, learner-, and community-centered components, an effective learning environment must also be *assessment-centered*.

Figure 2.1: Components of effective learning environments
(National Research Council, 2005, p. 13)



Donovan and Bransford (2005) describe what an effective learning environment that balances these four components looks like:

> The instruction described is learner-centered in that it draws out and builds on student thinking. It is also knowledge-centered in that it focuses simultaneously on the conceptual understanding and the procedural knowledge of a topic…, and the learning paths that can lead from existing to more advanced understanding. It is assessment-centered in that there are frequent opportunities for students to reveal their thinking on a topic so the teacher can shape instruction in response to their learning, and students can be made aware of their progress. And it is

community-centered in that the norms of the classroom community value student ideas, encourage productive interchange, and promote collaborative thinking. (National Research Council, 2005, p. 242)

Assessment-centered classrooms require teachers to continuously monitor students' thinking and understanding and provide constructive feedback to drive further understanding. To do this, teachers must be able to implement assessment tasks that provide evidence of students' learning, coordinate purposeful classroom discussions, use questions to elicit student thinking, and offer meaningful feedback intended to engage students in the learning process and move learning forward (Wiliam, 2007). Establishing and maintaining an assessment-centered mathematics classroom requires specific teacher knowledge that most teachers currently do not have.

Supporting teachers as they move toward more formative assessment practices includes developing better understanding of (a) what to assess and (b) how to assess (Magnusson, Krajcik, & Borko, 1999). In mathematics, teachers need to assess students' conceptual as well as their procedural development using methods with which they have little experience.

> To teach [and assess] in a way that supports both conceptual understanding and procedural fluency requires that the primary concepts underlying an area of mathematics be clear to the teacher or become clear during the process of teaching for mathematical proficiency. Because mathematics has traditionally been taught with an emphasis on procedure, adults who were taught this way may initially have difficulty identifying or using the core conceptual understandings in a mathematics domain. (National Research Council, 2005, p. 233)

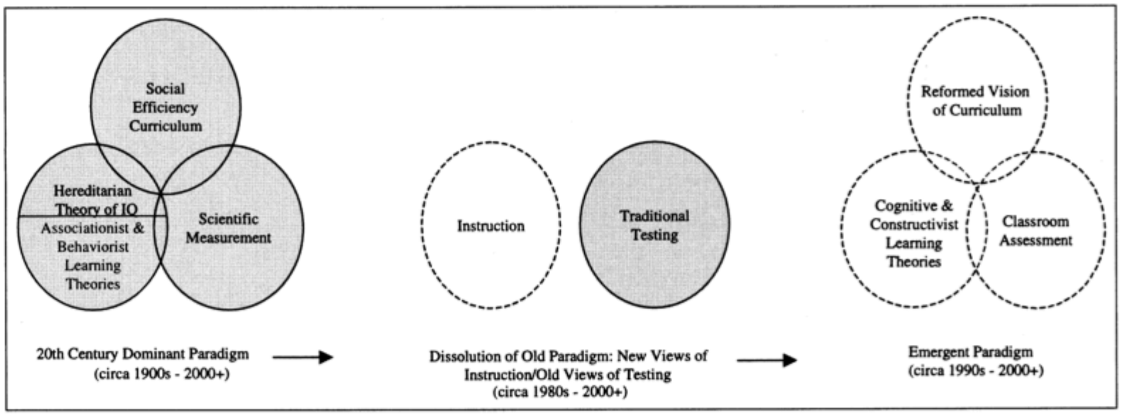
As teachers develop a better understanding about *what* to assess, they also need to consider *how* they assess student learning in order to accurately inform instructional decisions.

Assessment is essential to effective teaching and learning. In defining the intended purpose of assessment, Mokros, Russell, and Economopoulos (1995) wrote

> Assessment should be the servant of teaching and learning. Without information about their students' skills, understanding, and individual approaches to mathematics, teachers have nothing to guide their work. . . . By building student assessment into their teaching as much as possible, teachers can use the information garnered from that assessment to guide their classroom practice (pp. 84–85).

Unfortunately, recent educational policy ("*No Child Left Behind Act of 2001*," 2002) has focused almost exclusively on summative assessment for the purpose of accountability rather than as a guide to classroom practice. Yet, assessment as it is widely understood in this current form has not resulted in an increase in student achievement in mathematics. In fact, for standardized tests the effect size is essentially zero (Slavin, 1987). So why, even with the current reform-based efforts, do these types of summative assessments continue to dominate educational policy? Shepard's (2000) historical perspective (see Figure 2.2) helps conceptualize the current disconnect between assessment and instruction.

Figure 2.2: An historical overview illustrating how changing conceptions of curriculum, learning theory, and measurement explain the current incompatibility between views of instruction and traditional views of testing. (Shepard, 2000, p. 5)



The 20th Century Dominant Paradigm, represented by interlocking rings on the left side of the framework, highlights the interconnection of social efficiency curricula, behaviorist learning theories, and scientific measurement. These views have formed the basis of what has served as the dominant paradigm of teaching and learning throughout much of the 20th century. It is from this paradigm that traditional views of testing emerged in which assessment is used to measure achievement and ability, primarily through the use of objective tests. These views continue to influence current assessment policies and practices and form the foundation of what most teachers, parents, and policymakers have experienced, understand, and believe about assessment.

The Emergent Paradigm illustrated on right side of the framework shows the intersection of constructivist learning theories, reform curricula, and classroom assessment. In this emergent paradigm, assessment is an ongoing process integrated with instructional practice, which draws on student self-assessment, peer feedback, and teacher evaluation of both student learning and teaching. This form of assessment focuses on student understanding and addresses both learning process and learning outcomes.

The current state of instruction and assessment is represented in the middle of the figure. As instruction has moved away from social efficiency curriculum toward more reform-oriented instructional practices, assessment practices have continued to be drawn from the Dominant Paradigm. Although theories of the past continue to influence current policies and perspectives of assessment, teachers are asked to embrace and implement instructional practices drawn from the Emergent Paradigm. This has created a disconnect within education such that "assessment and instruction are often conceived as curiously separate in both time and purpose" (Graue, 1993, p. 291).

In their meta-analysis of assessment, Black and Wiliam (1998b) specify three important difficulties with the current state of assessment: (1) they do not guide effective learning, (2) they have a negative impact on teaching and learning, and (3) assessments have a managerial role. Each of these issues is described in more detail in Table 2.1.

Table 2.1
Three Difficulties with Assessment

Effective Learning	▪ The tests used by teachers encourage rote and superficial learning even when teachers say they want to develop understanding. Many teachers seem unaware of the inconsistency. ▪ The questions and other methods teachers use are not shared with other teachers in the same school, and they are not critically reviewed in relation to what they actually assess. ▪ For primary teachers particularly, there is a tendency to emphasize quantity and presentation of work and to neglect its quality in relation to learning.
Negative Impact	▪ The giving of marks and the grading function are overemphasized, while the giving of useful advice and the learning function are underemphasized. ▪ Approaches are used in which pupils are compared with one another, the prime purpose of which seems to them to be competition rather than personal improvement; consequently, assessment feedback teaches low-achieving pupils that they lack "ability," causing them to believe that they are not able to learn.
Managerial Role	▪ Teachers' feedback to pupils seems to serve social and managerial functions, often at the expense of the learning function. ▪ Teachers are often able to predict pupils' results on tests because their own tests imitate them, but at the same time teachers know too little about their pupils' learning needs. ▪ The collection of marks to fill in records is given higher priority than the analysis of pupils' work to discern learning needs; furthermore, some teachers pay no attention to the assessment records of their pupils' previous teachers.

Adapted from Black & Wiliam (1998, pp. 141–142).

Making assessments more useful requires careful consideration of these three issues as well as the purpose for which an assessment is used. Educational assessments can be classified into three forms: (1) formative and support learning; (2) summative and certify the achievements or potential of individuals; or (3) evaluative and evaluate the quality of educational programs or institutions (Wiliam, 2007, p. 1056). In K–12 mathematics, the Assessment Principle of the *Principles and Standards for School*

Mathematics (NCTM, 2000) clarifies that "Assessment should support the learning of important mathematics and furnish useful information to both teachers and students (p. 22)." In this call for assessment to support and communicate student learning, NCTM endorses the use of formative assessment, but this principle also raises some important questions. What is the "important mathematics" that should be assessed? When should it be assessed? And how should it be assessed?

Assessment can take a variety of forms and serve a variety of purposes (Wiliam, 2007, 2008), yet of these various forms of assessment, research has shown formative assessment to have the greatest impact on student learning (Black & Wiliam, 1998a, 1998b; Schroeder, Scott, Tolson, Huang, & Lee, 2007). As Shepard clearly illustrates in Figure 2.1, despite this research and the current push for reform-based instruction, summative assessment continues to be privileged in policy and practice.

Summative Assessment

Summative assessment has dominated most classroom assessment work for generations, with the bulk of teachers' assessment time spent creating tests, marking wrong answers, and assigning grades. Summative assessment is most commonly used retrospectively to discover what a learner has achieved and is normally carried out at or toward the end of a course or school year. It is a formal process used to see if learners have acquired the skills, knowledge, behavior, or understanding the teacher intended. Within the summative assessment process there is a strong emphasis on comparing students with national and international standards, and feedback to learners is in the form of grades that give an overall picture of performance. Used in this way, these kinds of tests provide little direction for improvement or advice for next steps. Results give an illusion of mastery of particular ideas or concepts because the test content is generally too limited and the scoring too simplistic to represent the broad range of skills and knowledge inherent in the content area assessed.

Research reveals several criticisms of the use of summative assessments in current large-scale, standardized systems. Within such systems, results of students' performance is typically made available weeks or months after the assessment has been completed (Popham, 1999). Such a delay does not allow teachers to make instructional adjustments based on students' demonstrated needs. In addition, a disconnect between the content of the assessment and classroom practice (Shepard, 2001) means that instruction does not inform assessment and, conversely, makes it more difficult for assessment results to be used to inform instruction. Because of the nature of such large-scale assessments, they suffer from "construct underrepresentation" (Messick, 1989), meaning a narrow focus on easily measured content. This narrow focus, in turn, often results in a narrowing of instruction to address the content of the assessment. The manner in which results of many large-scale summative assessments are used, attaching such high stakes as teacher evaluation to student performance, employs these assessments for accountability purposes for which most of these assessments were not designed (Baker & Linn, 2004). Such inappropriate use results in a lack of "consequential validity" (Messick, 1989).

Summative assessments provide information at the student, classroom, and school levels. They can be used effectively to provide information about students' overall learning and broadly indicate the quality of classroom instruction, especially when they are accompanied by other sources of information and used to inform practice rather than for accountability. Defining characteristics of effective summative assessment include a clear alignment between assessment, curriculum, and instruction, as well as the use of assessments that are both valid and reliable. When objectives are clearly specified and connected to instruction, summative assessment can provide information about a student's achievement of specific learning objectives.

Use of assessment that is not reliable or valid to label, track, or otherwise sort young children is not developmentally appropriate practice. Although this is true at any age, it is well understood that the type of large-scale, standardized testing widely used in grades 3 through 12 is not an appropriate assessment tool to use with young children, particularly prior to the end of grade 3 (National Association for the Education of Young Children, 2009). The reliability and validity of results from standardized tests are compromised by rapid developmental changes in young children, unfamiliarity with assessment situations, and unreliable focus and interest during the assessment itself (Meisels, 2006; Powell & Sigel, 1991). Young children are unreliable test takers. Even over relatively short time periods, results from one test administration typically cannot accurately predict results on the next , so it is difficult to be sure that a child's performance this year will reveal anything about their performance next year. This presents a distinct challenge for third-grade teachers, who begin the school year with no such results from the previous year but are held accountable for their students' end-of-year results through the use of such summative assessments. In mathematics, the use of standardized assessments in the upper elementary grades but not in the primary grades presents a challenge that can be attributed to the lack of an assessment continuum focused on the important foundational understandings constructed in the primary grades. It is these foundational understandings that underpin the increasingly complex mathematics students study in the intermediate grades and beyond.

It is not the concept of summative assessment that is problematic, but rather the practice of using tests that are neither valid nor reliable that carry such drastic consequences for students and the curriculum. If the goal of assessments is to promote learning, with evidence of students' current understanding to guide instruction, then it is important that such assessments in mathematics (1) be focused on important mathematical concepts, (2) are able to be used flexibly to guide instructional decisions, and (3) can be used in such a way as to uncover a student's conceptual knowledge and strategies rather than procedural facility alone. Summative assessments happen too far down the learning path to provide information at the classroom level and to make instructional adjustments and interventions during the learning process.

Formative Assessment

In spite of major federal initiatives in the United States (*No Child Left Behind Act of 2001*, 2002), mathematics scores of fourth graders, eighth graders, and 15-year-olds on the National Assessment of Educational Progress (NAEP) and the Programme for International Student Assessment (PISA) have shown limited improvement in recent years, calling into question the validity of the strategic emphasis on standards, testing, and accountability favored by No Child Left Behind (NCLB) (Aud et al., 2012; Fuller, Wright, Gesicki, & Kang, 2007). By contrast, where formative assessment is implemented effectively, achievement is raised across the board, particularly for low achievers, with the potential to reduce the achievement gap while raising expectations for everyone (Black & Wiliam, 1998a). Where students are given the quality support and feedback that are hallmarks of formative assessment and are encouraged and empowered to take more responsibility for their own learning, they learn more effectively.

The reform movement in mathematics has articulated expectations about assessment (Mokros et al., 1995; NCTM 2000). Teachers are expected to examine students' mathematical work, use questions to probe for student understanding, and elicit strategies for solving complex problems. "The deeper probing of the progress in students' thinking lies at the heart of a constructivist approach. Assessment and teaching depend on the same critical ingredient: a solid understanding of students' mathematical thinking," (p. 84).

Grounded in constructivist models of learning linked directly to Vygotsky's ideas on scaffolding (Vygotsky, 1978), the formative assessment process requires teachers to play a critical role in extending children's conceptual understanding as it develops. Formative assessment provides teachers a more effective way of understanding and responding to children's thinking, scaffolding the learning process, and more actively engaging students in that process.

Definitions of Formative Assessment

Defining formative assessment, the State Collaborative on Assessment and Student Standards (SCASS), a part of the Council of Chief State School Officers (CCSSO) states,

"Formative assessment is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes (National Governors Association for Best Practices & Council of Chief State School Officers, 2010). Central to this definition is the view of formative assessment as a process, not a particular test or event, used by both teachers and students for the purpose of providing evidence to make decisions about instruction and learning (Popham, 2008). Formative assessment is an integral part of instruction and learning, providing frequent feedback to both teachers and students throughout the instructional process. Ranging from informal observations and conversations to purposefully planned instructional opportunities, these strategies are embedded within instructional practice to gather evidence of student learning with the purpose to inform and adjust instruction. Such feedback allows teachers and students to make adjustments that will improve students' learning.

Black and Wiliam (2009) describe formative assessment by focusing on the process and outcomes of the effort. They state that assessment is considered formative:

> . . . to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decision they would have taken in the absence of the evidence that was elicited (p. 6).

Formative assessment places emphasis on teachers supporting students to achieve success through their own efforts, developing and using techniques that work for them, and positioning them to play a more active role in their learning. Being wrong, making mistakes, and struggling to understand or do something is viewed as a necessary and integral part of the learning process. Three central questions outline what teachers and students should consider during instruction and form the basis of formative assessment practice: (1) Where are you going? (2) Where are you now? (3) How are you going to get there? (Furtak, 2006). Answering these guiding questions, teachers and students clearly identify their learning goals and construct a plan for working toward them, which creates a continuous cycle of learning that results in enduring understandings.

Various approaches to formative assessment can be placed along a continuum that describes the extent of planning that precedes the assessment. Informal and unplanned formative assessment usually occurs spontaneously in response to observations of student work during instruction. This type of classroom-based formative assessment can be defined as "the process used by teachers and students to recognize and respond to student learning in order to enhance student learning, during the learning, (Cowie & Bell, 1999)." Although this immediate response can be very effective, many teachers, particularly novice teachers, find it difficult to adapt their instruction rapidly or to be able to respond appropriately to these spontaneous opportunities in the moment. Fortunately, formative assessment can also be more planned without interrupting the flow of classroom interactions and instruction. Such planned formative assessment might take the form of teacher questioning using predetermined prompts embedded within class lectures and discussions. The most formal and planned formative assessments are embedded within curricula to check whether students have met certain learning goals before instruction moves forward (Shavelson et al., 2008).

Formative assessment can also encompass a variety of cycle lengths, as illustrated in Table 2.2. Although the time between assessments often distinguishes formative assessment from other types of assessments, it is the extent to which the results inform the direction of future student learning that truly determines whether an assessment is considered formative (Wiliam & Thompson, 2007).

Table 2.2
Cycle Lengths for Formative Assessment

Type	Focus	Length
Long cycle	Across marking periods, quarters, semesters, years	4 weeks to 1 year
Medium cycle	Within and between instructional units	1 to 4 weeks
Short cycle	Within and between lessons	Day by day: 24 to 48 hours Minute by minute: 5 seconds to 2 hours

Research on Formative Assessment

The evidence shows that high-quality formative assessment significantly impacts student learning. Studies of formative assessment show an effect size on standardized tests between 0.4 and 0.7, which is larger than most known educational interventions (Black & Wiliam, 1998a). Formative assessment is particularly effective for students who have not done well in school, thus narrowing the gap between low and high achievers while raising overall achievement.

Research on frequency of formative assessment use by classroom teachers indicates that use of even a single formative assessment practice in a 15-week unit of study resulted in an effect size gain of 0.34, with more frequent use of the practices resulting in greater effect size (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). Teacher use of formative assessment two times per week resulted in an effect size of 0.85 (Fuchs & Fuchs, 1986). The positive effects of using formative assessment have not been found to be specific to any one formative assessment approach. Black and Wiliam (1998a) found that ". . . irrespectively of the particular approach adopted, we have not come across any reports of negative effects following an enhancement of formative assessment practices."

Research on Formative Assessment Practice. Formative assessment has been shown to result in significant increases in student learning (Black & Wiliam, 1998a; Schroeder et al., 2007). With the emerging awareness of the potential impact of formative assessment on student understanding and achievement, a number of research groups have studied formative assessment practices extensively. Studies were conducted in a variety of locations and educational settings with students of various ages. The studies have employed quantitative and qualitative approaches to examine the effects of different types of interventions. Research on formative assessment consistently states that assessments are formative only if results are used to influence the teaching and learning in some way (Black & Wiliam, 2009). To do this, information that teachers gain during a formative assessment sequence needs to be used to modify what might have been done had the information not been available: an assessment cannot be defined as formative assessment if the teacher does not use the information to inform further instructional decisions (Black, Harrison, Lee, Marshall, & Wiliam, 2003; Black & Wiliam, 2009; Cowie & Bell, 1999; Sadler, 1989; Wiliam & Thompson, 2007).

To conduct this form of assessment, teachers must understand how to integrate the tools of formative assessment into their regular classroom practice (Wiliam, 2006). Professional development may show teachers how to use a formative assessment tool, but formative assessment practice is not impacted unless the teacher implements it and learns how to use that information to adapt instruction. For teachers, this means knowing what action to take based on the evidence they have obtained so they can "adapt the teaching work to meet the learning needs" (Black et al., 2003, p. 2). Therefore, research needs to examine the ways in which teachers use the data they gather from formative assessment about student learning.

Social constructivist theory provides an important grounding for research regarding the successful implementation of formative assessment. Teachers have to engage in the socially mediated act of working with students to effectively learn and construct their own understandings of students' thinking about important mathematics. Because formative assessment occurs in a social environment, individual teacher and student knowledge is socially mediated, at least partially, as teachers strive to understand students' "zones of proximal development," ability to express understandings with and without social support, and their individual instructional needs (Torrance, 1993; Torrance & Pryor, 1998, 2001).

Formative assessment is rooted in the social constructivist tradition and is considered divergent assessment (Torrance & Pryor, 1998, 2001). Divergent assessment focuses on what students understand about a concept and usually involves students engaging with more open tasks to reveal student strategies and misconceptions. In contrast, convergent types of assessment are rooted in a behaviorist tradition and focus on whether students have mastered conceptual information. Convergent assessment tends to be curriculum driven, evaluates students relative to the number of correct responses, and treats students as passive absorbers of knowledge. Although both convergent and divergent assessments can be formative, divergent assessment holds truer to most researchers' notions of formative assessment and is considered to be more powerful (Torrance & Pryor, 1998, 2001).

Formative assessments can also be classified based on whether they are planned or interactive (Cowie & Bell, 1999). For both types there must be a clear purpose for conducting the assessment. In planned assessment, the purpose is generally to engage the entire class in identifying progress toward learning goals and is often used to identify areas in which students are struggling so that instruction can be designed accordingly. Alternately, interactive formative assessment focuses on individual students or groups and involves assessment of student learning as students are working on specific learning activities. Because interactive formative assessment responds to demonstrated student needs, interactive formative assessment is less curriculum driven than planned formative assessment, which measures how well students are progressing toward the required understandings (Bell & Cowie, 2001). Although interactive formative assessment is more immediately responsive to student needs, the teacher must be present for the formative assessment opportunity to be realized.

Professional Development and Formative Assessment

Within the context of professional development, teachers who developed individualized action plans for improvement in formative assessment practices saw gains in student achievement (Black & Wiliam, 1998b). Specific strategies that teachers incorporated into their action research plans included increasing and improving questioning of students, using student self-assessment opportunities, feedback in the form of comments with no letter or numerical grades, and making learning goals explicit and visible to students (Wiliam, Lee, Harrison, & Black, 2004). This work does not point to any one strategy as being most productive in impacting student learning, but does indicate that the intentional use of formative assessment strategies benefits students.

Torrance and Pryor (2001) conducted a study of 45 elementary-grade teachers and administrators through interviews and classroom observations to learn about teachers' classroom assessment practices. Within the professional development process, teachers engaged in discussions about assessment and learning issues, conversations about action research, and presentations of progress and emerging data. Teachers analyzed their own teaching practices and developed strategies to improve their existing pedagogy with respect to formative assessment. Many teachers identified a need to involve more divergent assessment rather than the convergent assessment that was so prevalent in their classrooms. They also identified the importance of establishing the purpose for classroom activities and expectations for quality work, as well as the need to use a variety of questioning and feedback approaches.

Professional Development and Teacher Changes

The intent of any implementation process is to initiate a change in teachers' instructional practice using professional development as a catalyst for that change. Within that process, research has indicated that teacher concerns about the implementation can impact the extent to which an innovation is implemented. It is useful, then, for teacher educators involved in an implementation process to anticipate and identify concerns teachers experience throughout that process.

The Concerns Based Adoption Model (CBAM) (Hall & Hord, 2001), developed in 1973, can be useful in describing, measuring, and explaining the process of change through which teachers progress while engaged in an implementation (Anderson, 1997). CBAM includes three diagnostic tools related to teachers' Stages of Concern, Levels of Use, and Innovation Configurations, which can be used by implementation leaders as a means of identifying the needs of teachers as they engage in the process of change and matching appropriate resources with those needs (Hall & Hord, 2001). Although all of the diagnostic tools can be used together, they may also be used individually or in pairs (Anderson, 1997).

The first component of CBAM is the Stages of Concern, which focuses on how teachers perceive the educational innovation they are asked to implement (Willis, 1992). The three phases and seven stages of the Stages of Concern are presented in Table 2.3, along with a description of how each stage is typically expressed. These stages range from little concern with or knowledge of the implementation process to a desire to collaborate with others or explore modifications of the original process (Hall & Hord, 2001).

Table 2.3
Concerns Based Adoption Model – Stages of Concern

Phase	Stage	How Concern Is Expressed
Impact	5. Refocusing	I have some ideas that might work better.
	4. Collaboration	How do I relate what others are doing to what I'm doing?
	3. Consequence	How is my use of this affecting learners? How do I refine my use to increase impact?
Task	2. Management	I seem to be spending all my time getting ready.
Self	1. Informational	I want to know more.
	0. Awareness	I'm not concerned about this.

Widespread adoption of an innovation does not happen instantaneously; therefore, the CBAM model presents change as a process (Hall & Hord, 2001), not an event, taking into account that ongoing resource and teacher support is necessary for the implementation process to be sustained (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Unlike more linear views of change concerns, CBAM acknowledges that although the focus of a teacher's concern may have shifted to another stage, it does not necessarily indicate that the previous stage of concern has been diminished (Willis, 1992).

Assessment Focused on Important Mathematics

Mathematics reform efforts over the last few decades have focused increasingly on student mastery of core conceptual understandings and procedures in the early grades. This requires that teachers be able to accurately assess for student understanding and plan instruction based on the results of that assessment. Until recently, education policy in the United States has relied almost entirely on results from summative assessments that provide single-context views of what students know, demonstrated through narrowly focused, multiple-choice assessments, to provide indicators of student learning and growth.

The current accountability focus established by the No Child Left Behind Act of 2001 (NCLB, 2002) has greatly influenced what and how we teach mathematics (Seeley, 2006). Traditionally, large-scale standardized assessments have focused on procedural fluency and conveniently assessed knowledge and skills. Teachers, who are increasingly evaluated based on their students' scores, are often forced to make instructional decisions based on what will be on those tests. This is in direct contrast to the greater focus on conceptual development and problem solving that the standards movement has called for, a movement that began with the *Curriculum and Evaluation Standards* (NCTM, 1989).

Supporting students' conceptual development requires tools to assess mathematical understanding and provide data that can form the basis for instructional decision making that is focused on important mathematical ideas. Such assessments should reveal student thinking rather than an ability to mimic procedures or produce a "correct" answer. Teachers should be able to use those assessments flexibly, whether based on a student's demonstration of new understanding, a persistent misunderstanding, or a need to make instructional decisions about upcoming learning.

Teachers' knowledge about how learning progresses in a domain, how ideas within the domain are inter-related, and how instructional planning and formative assessment can be mapped onto that progression aid in their use of formative assessment and the effectiveness of their instructional decision making. Learning trajectories reinforce the concept of learning as a continuous and coherent process that "is not viewed as a series of discrete events, but rather as a trajectory of development that connects knowledge, concepts, and skills within a domain" (Heritage, 2007).

Learning Trajectories

The purpose of formative assessment is to provide feedback to teachers and students throughout the learning process about the gap between students' current and desired performance so that action can be taken to close the gap. To effectively accomplish this purpose, teachers need to have in mind a continuum of how learning develops in any particular knowledge domain so that they can determine students' current learning and make instructional decisions about next steps to move that learning forward.

Over 100 years ago, Piaget's research into how children learn revealed typical ages at which particular conceptual understanding seemed to occur—what he called *stages*. Piaget's work identified a series of stages, loosely associated with a child's age, through which children typically progressed, moving toward greater levels of sophistication in what they knew and were able to do. Much more recently, research in early childhood mathematics has begun to articulate natural developmental progressions in learning and development for young children.

A learning trajectory is a "carefully sequenced set of building blocks that students must master en route to a more distant curricular aim. The building blocks consist of subskills and bodies of enabling knowledge" (Popham, 2007, p. 83). Various terms have been used in the literature to define and describe the idea of learning trajectories, yet each one incorporates the idea that learning progresses in relatively predictable ways from less to more sophisticated levels of understanding.

Simon's (1995) *hypothetical learning trajectory* takes into account a teacher's anticipation of the progression of the learning path, providing a basis on which to design instruction. Included in this construct is the teacher's prediction of student reasoning and the flexibility for the hypothetical learning trajectory to shift as students engage in learning opportunities, resulting in the *actual learning trajectory*. This differs slightly from Brown and Campione's (1996) *developmental corridor*, which represents the process over time as children revisit and revise their ideas with ever-increasing sophistication. Inherent in this construct is the purposive nature of this refinement as children incorporate their developing understandings into their prior experience.

According to Clements and Sarama (2004), a *learning trajectory* comprises a mathematical goal, domain-specific developmental progressions through which children advance, and activities corresponding with those progressions. Sequences of critical tasks are used to support students' understanding and use of particular mental structures and patterns of reasoning that serve to reveal student [student _____?]. Catley et al. (2005) posit that learning should be viewed as the process of developing key conceptual structures, or *big ideas* (Schifter, Russell, & Bastable, 1999), which serve as a scaffold to integrate isolated conceptual components. Instruction should focus on core ideas to direct teaching and assessment around a few foundational concepts. These concepts should be the primary focus of instruction in the early grades.

Learning trajectories clearly articulate a progression of learning that frames student learning, supports teachers in their instructional planning, and serves as a structure for formative assessment (Heritage, 2008). In the absence of such learning trajectories, teachers typically turn to content standards to help guide and structure instructional expectations. However, the exclusive use of standards to guide expectations for student learning falls short of the specificity needed for teachers to make meaningful instructional decisions.

> It is fair to say that if the standards do not present clear descriptions of how students' learning progresses in a domain, then they are unlikely to be useful for formative assessment. Standards are insufficiently clear about how learning develops for teachers to be able to map formative assessment opportunities to them. This means that teachers are not able to determine where student learning lies on a continuum and know what to do to close the gap between current learning and desired goals (Heritage, 2008, p. 2).

Clear connections between what comes before and after any particular point in a learning trajectory is an opportunity for teachers to adjust instruction to address a students' demonstrated needs. It is this issue of planning for next steps, based on data gathered through assessment to plan instruction, which proves most difficult for teachers. Well-articulated learning trajectories provide detail and connections among mathematical concepts that serve as a reference for teachers to determine how to respond to students and make decisions about appropriate next steps.

By understanding a learning trajectory in early childhood mathematics, it is possible to use assessment to locate where a child is along a continuum and to anticipate and plan for the next phase of concept development. Purposeful assessments focused on these learning trajectories are capable of helping educators locate where on the learning trajectory a student might be at a given time, identify areas of strength and weakness, anticipate next steps in a student's developmental progression, and plan meaningful opportunities for students to move forward based on their current levels of understanding.

Learning trajectories are powerful maps that lay out natural progressions students typically follow within a domain as they build conceptual understanding in mathematics. Research reports on early mathematics learning point out that more instructional time should be focused on the number domain than on any other topic (Committee on Early Childhood Mathematics, 2009; National Governors Association for Best Practices & Council of Chief State School Officers, 2010). Understanding the domain of number and its significance in mathematics understanding is important in understanding how learning trajectories can be used to inform formative assessment practice and impact student learning.

The Importance of Number

Number sense refers to the general understanding of number and operations (Reys et al., 1999) as well as the relationships between quantities and numerical symbols (S. Griffin, 2004) and requires that students construct a rich set of relationships among quantities, counting numbers, and formal symbols (Griffin, 2004). The study of number and operations is a major emphasis in the elementary grades. According to the *Principles and Standards of School Mathematics* (NCTM, 2000), all mathematics, from prekindergarten through grade 12, is grounded in number. Although it is just one of many strands, number is an essential and dominant component of mathematics, particularly in the elementary grades. Number and operations are the tools that enable students to work in several other strands of mathematics, including measurement, data analysis, and algebra. For example, the principles for solving algebraic equations are the same as the structural properties of systems of numbers; geometric and measurement attributes are described using number; data analysis focuses on making sense of numbers; and problem solving leads to exploring and solidifying understandings of number (NCTM, 2000; K. Richardson, 2002, 2012). Knowledge of number also facilitates the ability of students to symbolically represent many real-life situations and abstract concepts.

In some cases, lack of understanding or fluency with number does not appear until upper elementary or even middle school (Richardson, 2012), which is precisely the time that high-stakes testing is there to point out such students' shortcomings. The continuous nature of the development of number concepts as well as the foundation number sense provides for much of subsequent mathematics (Copley, 2000) and places it in a unique position in mathematics learning.

Recently, the National Research Council Committee on Early Childhood Mathematics published their findings in *Mathematics Learning in Early Childhood* (2009). The focus of this committee was to review and summarize current research regarding mathematics development for children ages 2 through 6 years (about first[t] grade). Acquisition of number knowledge is a complex process that occurs over time with increasing levels of sophistication. Children must coordinate four components of number to "know" number. These components are cardinality, number word sequence, one-to-one correspondence, and symbolic representation. Cardinality and number word sequence are typically the first to develop, but they develop in isolation of one another. For instance, children might be able to say the number word sequence up to three and may be able to recognize the pattern on a die as three, but they are not able to use these two ideas of "three" to assign the number names "one,", "two," and "three" to those same dots. In addition, young children are unable to generalize the idea of three as a characteristic of items in the world around them, not understanding that three elephants is the same quantitatively as three doughnuts. It is when children begin to correlate these two separately developing numerical foundations, at about 2 or 3 years of age for very small numbers, that true number knowledge begins to occur. At about the same time, young children begin to form ideas about one-to-one correspondence, although they have difficulty coordinating the process of pointing at one object at a time, progressing accurately through the number word sequence and retaining the final number counted. The final component to be developed is symbolic representation. Eventually, though, children are able to coordinate all four components, working with larger numbers (up to about 10) by approximately age 4, with teen numbers as 10 and some ones by about age 5, and by first grade up to 100. As children encounter larger numbers, however, they need to progress through the process of integrating these same four components within the larger number range. This process becomes less protracted if they have been given the opportunity to gain a deep understanding of number in the ranges that have come before.

Knowing a student's level of understanding of number can provide markers to assess progress or point out areas of need (Reys et al., 1999) and can influence how we look at what should be taught and when it should be taught to students (S. Griffin, 2004). Richardson and others (Copley, 2000; Heritage, 2007) point out that

> Teachers can maximize what children learn if they know what level of thinking they have developed, and what they still need to understand regarding a particular concept. Teachers will be able to recognize the difference between getting their student to do or say something that gives the appearance of knowledge and evidence that show they really know. (K. Richardson, 2012, p. vi)

There are three key instructional processes in learning and teaching that help maintain focus on matching instruction with student needs: (1) establishing where the learners are in their learning; (2) establishing where they are going; and (3) establishing what needs to be done to get them there (Ramaprasad, 1983). In considering these key processes through the interaction of formative assessment and instruction, teachers' use of the core topics and essential understandings that make up the learning trajectory for number enable them to more efficiently and effectively address the needs of their students in a purposeful way. When domains are described in terms of core topics and supporting essential understandings, teachers are more easily able to map formative assessment and make instructional decisions.

Core Topics and Essential Understandings

Mathematics assessments have typically been based on state standards, often described as "a mile wide and an inch deep." These standards varied widely from state to state. In some cases, the standards were too broad and provided little guidance about what students need to know and be able to do. In other cases, the standards were so explicit that assessments based on them came to resemble checklists of disconnected skills and procedures. Recently, a majority of states adopted the Common Core State Standards for Mathematics (CCSSM), replacing the haphazard state standards that had been in place across the country with a set of common learning goals for students. In addressing the question about what "important mathematics" should be taught and assessed, the CCSSM lays out a continuum along which most students progress mathematically based on learning trajectories backed by a rich research base, like those described above. Although two multistate consortia are currently developing assessments based on the CCSSM, those assessments are set to begin in third grade. For teachers in the primary grades, guidance about what and how to assess is still needed.

Kathy Richardson (2012), in her research on young children's number development, identifies six *core topics* through which children progress from kindergarten through approximately third grade: (1) counting, (2) number relationships, (3) addition and subtraction: parts of numbers, (4) place value: numbers as 10s and ones, (5) numbers as 100s, 10s, and ones, and (6) multiplication and division. Core topics, also called big ideas or key topics, link numerous mathematics understandings into a coherent whole and are those concepts students must know and understand deeply to gain full access to later mathematics (Baroody, 2004; Fosnot, 2008; K. Richardson, 1999d). Therefore, it is important to determine how students are progressing toward understanding these core topics. To do that in a meaningful way, teachers need to focus on the essential understandings that constitute these core topics.

Core topics are composed of several major ideas, a "sequenced set of subskills and bodies of enabling knowledge that . . . students must master en route to mastering a more remote curricular aim" (Popham, 2008, p. 24). Variously referred to as *key developmental understandings* (KDU), *critical learning phases, developmental transitions,* or *essential understandings*, the term used here, these subunits mark critical transitions that are essential for students' mathematical development (Baroody, 2004; Friel, Gunter, & Ringer, 2009; K. Richardson, 2012; Simon, 2006). Such transitions are identified with qualitative shifts in the ability of students to think about and perceive particular mathematical relationships.

> I am not referring to a missing piece of information that affects students' performance; rather, I am emphasizing that without completing a developmental process, the students lack a particular mathematical ability. (Simon, 2006, p. 364)

Essential understandings are important concepts whose development take place over time. They are (1) essential ideas that are milestones or hurdles in children's growth of understanding; (2) developments that determine the way a child is able to think with and use numbers to solve problems; and (3) understandings that must be in place to ensure that children are not just imitating procedures or saying words they do not really understand (illusions of learning) (Kathy Richardson, Retrieved 10/1/09).

In early number work, cardinality, composite units, and conservation of number are examples of such essential understandings that involve "a conceptual advance on the part of students . . . a change in the students' ability to think about and/or perceive particular mathematical relationships" (Simon, 2006, p. 362). Knowledge of composite units includes the ability to think in 10s and 1s. It turns out that this knowledge of composite units and 10s and 1s provides the basis for the development of a deep conceptual understanding of place value.

Place Value as a Core Topic

Our base-10 number system makes use of 10 distinct symbols—0, 1, 2, 3, 4, 5, 6, 7, 8, and 9—known as digits. The base-10 system uses place value to represent larger and larger numbers, meaning that "the quantity that a digit in a number represents depends – in a very specific way – on the position of the digit in the number" (Beckmann, 2011, p. 4). A group of objects can be combined to create a new composite group, for example, a group of 10 ones can also be one group of 10. Our place value system relies on grouping by 10s, such that groups of 100 are composed of 10 groups of 10, groups of 1,000 are composed of 10 groups of 100, and each of these larger units can also be decomposed into 10 of the next-smaller unit (Committee on Early Childhood Mathematics, 2009). The key idea of place value is that the value of each place is 10 times the value of the place immediately to the right.

Place value understanding impacts the way students think about mathematical relationships. It is essential that students develop a conceptual understanding of the structure of number, including the concept that numbers can be decomposed into smaller numbers or combined to create larger numbers. Arguably the most difficult aspect of the number system is its base-10 structure, which students encounter as place value in the primary grades. Within the larger concept of number, the core concept of place value plays an essential role in the ability of students to acquire other mathematical concepts. For students to meaningfully engage with addition and subtraction of multidigit numbers, decimal operations, algebraic expressions and equations, scientific notation, and exponents, an understanding of place value is an essential prerequisite (Baroody, 2004; T. Carpenter, Franke, & Levi, 2003; Fuson, 2004; Sharma, 1993; Sowder, 2002; Wearne & Hiebert, 2002). Coming to really understand the base-10 system is difficult but essential for all children, as students leverage this conceptual knowledge to make ideas within other domains accessible.

The foundation for place value begins in kindergarten and continues to build through elementary school until, by the end of fifth grade, students are expected to "recognize that in a multidigit number, a digit in one place represents 10 times what it represents in the place to its right and 1/10 of what it represents in the place to its left" (CCSSM, 2010, p. 35).

Development of Place Value Understanding

A major focus in the primary grades should be providing a variety of experiences that promote the construction of 10 as a composite unit (K. Richardson, 2012; Wheatley & Reynolds, 1999; Wright, Stanger, Stafford, & Martland, 2006). Teachers cannot create this construction for our students and we cannot merely "show" them how our number system works. Students must construct understanding for themselves in their own meaningful ways, because "students without the knowledge do not tend to acquire it as a result of an explanation or demonstration. That is, the transition requires a building up of the understanding through students' activity and reflection and usually comes about over multiple experiences" (Simon, 2006, p. 362). The teacher's role, then, is to anticipate students' need to struggle with the concept of place value and provide a variety of ongoing challenges so they have the opportunity and support needed to make this conceptual leap.

A child reaches an important mathematical milestone when they are able to think of 10 both as one thing or 10 things simultaneously, a composite unit. When students have constructed 10 as a composite unit, they are well positioned to develop powerful methods for adding and subtracting large numbers. Unitizing 10 plays a major role in number development, forming the foundation for conceptual development of and procedural fluency with addition and subtraction, as well as multiplication, fractions, decimals, percents, and proportions.

Constructing 10 as an abstract composite unit is central to using number meaningfully (Wheatley & Reynolds, 1999). It is important to know what the existing categorizations of conceptual development are regarding two-digit numbers and place value. Wright, Martland, Stafford, and Stanger (2006) outline a framework for students' conceptual place value progression. This learning framework for early number knowledge contains three levels of development of base-10 arithmetical strategies: Level 1–initial concept of 10; Level 2–intermediate concept of 10; and Level 3–facile concept of 10. The descriptors of each level are presented in Table 2.4.

Table 2.4
Levels of Base-Ten Arithmetic Knowledge

Level	Description
Level 1–Initial Concept of Ten	The child does not see 10 as a unit of any kind. The child focuses on the individual items that make up the 10. In addition or subtraction tasks involving 10s, children count forward or backward by ones.
Level 2–Intermediate Concept of Ten	Ten is seen as a unit composed of 10s and 1s. The child is depending on re-presentations (like mental replay or recollection) of units of 10 such as hidden 10-strips or open hands of 10 fingers. The child can perform addition and subtraction tasks involving 10s when these are presented with materials such as covered strips of 10s and 1s. The child cannot solve addition and subtraction tasks involving 10s and 1s presented as written number sentences.
Level 3–Facile Concept of Ten	The child can solve addition and subtraction tasks involving 10s and 1s without using materials or re-presentations of materials. The child can solve written number sentences involving 10s and 1s by adding or subtracting units of 10s and 1s.

Adapted from Wright, Martland, K. Stafford, and Stanger, 2006, p10.

Cognitively Guided Instruction (CGI) also provides an outline of students' development of place value understanding (T. P. Carpenter, Fennema, Franke, Levi, & Empson, 1999). Base-10 development begins at the Counting by Ones stage. At this stage, groups of 10 hold no significance and are unrelated to the number used to label a collection of objects. When presented with a collection of objects grouped by 10s, children at this stage are not able to use the grouping and instead count by 1s, not understanding that they can count groups of 10 directly. A child has entered the Counting by Tens stage when they are able to count the same collection of grouped objects by 10s, then count the 1s left over. For example, a child at this stage might count a collection of

53 objects grouped as five 10s and three 1s as 10, 20, 30, 40, 50, 51, 52, 53. In this stage, a child is able to use basic base-10 number concepts, but this is a cognitively demanding task.

The highest stage of base-10 development is Direct Place Value. This is a more flexible conception of base-10 concepts. When presented with a collection of objects grouped by 10s, a child would not count the groups but rather would immediately recognize the total number of objects in the grouped sets (e.g., five groups of 10 is 50 objects) and add the 1s to this number (e.g., three more make 53). This type of thinking is more advance and flexible than that of a child who counts by 10s and is less cognitively demanding. As the cognitive demand decreases, children are more able to engage with more sophisticated mathematical concepts. So it is important not only to be able to distinguish that a student is able to accurately identify 10s and 1s, or even that they are able to manipulate numbers based on place value, but to understand *how* a student thinks about those manipulations—a difference between procedural and conceptual knowledge.

The importance of number in the elementary mathematics curriculum and the central role of place value as a core topic within number is well documented within mathematics education literature. Fosnot (2008) emphasized, "for students today, a deep understanding of place value and equivalence is critical . . . to be able to assess the reasonableness of an answer found by using a calculator . . . to have good mental arithmetic strategies . . . [and] to know how to calculate efficiently" (p.6). Deep conceptual understanding of place value and arithmetic calculations lays a foundation for algebra, for example. Students who come to understand the properties and relationships of numbers that allow for numerical calculations can apply these same properties and relationships to simplifying algebraic expressions and solving equations. “If students genuinely understand arithmetic at a level at which they can explain and justify the properties they are using as they carry out calculations, they have learned some critical foundations for algebra” (T. Carpenter et al., 2003, p. 2).

Given the importance of place value understanding to later mathematics, it is imperative for teachers to be able to formatively assess and address student needs within this core topic. The conceptual development of students’ place value understanding is not easily observed within the usual classroom routine, and although summative assessments can easily identify whether a student has procedural understanding of place value, it is through the use of formative assessment that students’ conceptual understanding of place value can be accurately determined.

Classroom Assessment and Intervention in Number

Results of research on formative assessment consistently indicate the power of this form of assessment to inform instruction and affect student learning. The use of formative assessment in the classroom is a powerful tool for transitioning from an emphasis on *access to* mathematics to an emphasis on *learning* mathematics in the elementary classroom. The purpose of assessment is to help students learn, and the focus of any mathematical assessment should be how students process information and not whether answers are right or wrong. Assessment should provide opportunities for feedback and revision, and what is assessed must be aligned with established learning goals (National Research Council, 2005). In mathematics, assessments *must* (a) be focused on important mathematical concepts (Where are you going?), (b) provide evidence of students’ conceptual knowledge and strategies rather than procedural facility alone (Where are you now?), and (c) enable teachers to make purposeful instructional decisions about next steps (How are you going to get there?) (Hattie & Timperley, 2007). Results of research on formative assessment consistently indicate the power of this form of assessment to inform instruction and affect student learning.

It is imperative for teachers to uncover when a student does not truly understand a process or that they have given a right answer because they have memorized the "rules." To do this, teachers need to be engaged in a continuous process of gathering evidence, making judgments, and adjusting instruction with all students. The timeliness, flexibility, and ongoing nature of formative assessment techniques are most helpful in informing instruction for teachers and closing achievement gaps for students (Hattie & Timperley, 2007; Sadler, 1989). However, implementing formative assessment in the classroom is not simple for teachers to do and is certainly not a skill set most of them bring to their classrooms. Experts have argued that a lack of "assessment literacy" is at the heart of this difficulty (e.g., Stiggins, 2002).

To use formative assessment correctly, teachers need to increase their knowledge in a particular domain, pedagogical content, assessment knowledge, and knowledge of students' previous learning (Heritage, 2007). When done correctly, though, significant learning gains can take place. Studies have shown that when teachers learn about research on students' mathematical thinking, they are able to use that knowledge in ways that have a positive impact on their students' mathematics learning (T. P. Carpenter et al., 1999; Cobb, Wood, & Yackel, 1991; Fennema et al., 1996; Fennema & Franke, 1992; Steffe & D'Ambrosio, 1995).

Development of formative assessments should not be done haphazardly. They must be coherent, comprehensive, and aligned with curriculum, instruction, and assessment. Most state education agencies, including the North Carolina Department of Public Instruction, have sought ways to establish a more balanced approach to their state accountability systems, including the incorporation of "formative assessments" into those systems. With the call for a balanced-assessments approach rather than a one-time, high-stakes test to determine student achievement, along with the convincing research behind formative assessment practices, the demand for effect formative assessments has increased. School districts and teachers are searching for materials and methods that will help them address the needs of their students while meeting state and federal accountability standards.

AMC Pilot Project – North Carolina Department of Public Instruction

During the 2009–2010 school year, the North Carolina Department of Public Instruction (NC DPI) piloted reading and math diagnostic assessment systems across the state. The Mathematics Assessment Pilot was developed as a Governor's initiative that included an exhaustive search of available assessments that used personal digital assistants (PDAs). At the time, two products were available, one that used the Assessing Math Concepts (AMC) Program developed by Kathy Richardson, and another based on the work of Dr. Herbert Ginsburg. Comparing the assessments with the North Carolina Essential Standards, the new state standards that had been adopted in September 2009, the AMC assessments matched many of the standards, whereas the other assessments matched very few. As a result, the Kathy Richardson assessments were chosen as the foundation on which to base the pilot.

A formative assessment process based on student interviews and mediated by technology that guides teachers' use of the assessment and collects data in real time can provide vital information to inform teachers' practice in mathematics. This was recognized in the state in that the Mathematics Assessment Pilot was initiated as a way of getting formative assessment data K–2.

Assessing Math Concepts

Richardson (2002) developed the Assessing Math Concepts (AMC) series of nine assessments based on her identification of core concepts. Each core topic encompasses a number of essential understandings, what she calls Critical Learning Phases, which serve to structure an understanding of a student's development within each core topic in kindergarten through third grade. These essential understandings represent milestones or hurdles in students' developing understanding of the core topics on which each of the assessments is focused.

AMC assessments are administered in a one-on-one interview format, usually taking between 5 and 10 minutes to administer, depending on the assessment. Teachers determine which assessment to use with a student based on their particular areas of need or the concepts being taught, and data are used to make instructional decisions. The results help document student progress, identify gaps in knowledge and understanding, and determine next steps to improve student learning (Perie, Marion, Gong, & Wurtzel, 2007). Historically, data from interviews were collected using a recording sheet that teachers could then use to aggregate and analyze classroom data. During the Mathematics Assessment Pilot, PDAs were used to guide teachers through the assessment protocol and to collect data, which were available once the PDA was synched and the data downloaded. Currently, AMC can be administered using an online interface. This online portal permits data to be collected and viewed immediately, allowing teachers to use data to make instructional decisions quickly.

AMC assessments are based in essential understandings; therefore using these assessments allows a teacher to locate a child along a learning trajectory. The results assist teachers in understanding both *what* their students know about number and *how* they know it. Once the teacher has identified where a student is, however, they must plan instruction that will move this child along in their number knowledge.

Assessment of Place Value. The transition from second grade to third grade represents an important mathematical transition related to knowledge of number. It is at this juncture that students are expected to demonstrate "mastery" of the concept of place value and its use, particularly in solving multidigit addition or subtraction problems with and without regrouping. The Common Core State Standards for Mathematics (2010) indicate the need for fluency with basic number combinations for addition and subtraction by the end of second grade, with multidigit whole-number operations for addition and subtraction by third or fourth grade and with multiplication and division by fourth or fifth grade. According to the CCSSM, students should develop a solid understanding of place value by the end of second grade. In third grade, this focus shifts to students' *use of* place value knowledge to make sense of other topics such as multidigit operations. Given the role of place value understanding in students' ability to access other ideas in grade 3 and the ease with which students often appear to "know" place value without true understanding, it is important for teachers to be able to uncover and address the essential understandings underlying the core topic of place value.

In AMC, teachers use the Grouping Tens assessment to uncover students' place value understanding. The essential understandings associated with the Grouping Tens assessment are presented in Table 2.5.

Table 2.5
AMC Grouping Tens Assessment, Core Topic, and Essential Understandings[2]

AMC Assessment	Core Topic	Essential Understandings
Grouping Tens	Place Value: Numbers as 10s and ones	• Counts groups of 10 • Knows total instantly when the number of 10s and 1s is known • Knows the number of 10s that can be made from any group of 1s and the number of 1s left over • Knows the number of 10s in any two-digit number • Knows 10 more for any two-digit number • Knows 10 less for any two-digit number

The Grouping Tens assessment is based on the core topic of Place Value: Numbers as 10s and 1s. Students are assessed at three levels of place value understanding: 10s and 1s to 20, 10s and 1s to 100, and adds/subtracts groups of 10s (see Table 2.6). Each of these levels are composed of several stages through which students progress in the process of developing place value understanding (see Appendix A). Each stage requires varying levels of support from teachers as students develop a conceptual understanding of place value.

[2] Adapted from Richardson, K. (2012). *How children learn number concepts: A guide to the critical learning phases*. Bellingham, WA: Math Perspectives.

Table 2.6
Grouping Tens Assessment

Level	Description
Level 1—Tens and Ones to 20	This section of the assessment determines whether students can decompose numbers from 11 to 19 into one 10 and some leftover 1s, and whether they understand that the one in the 10s place represents 10 objects.
Level 2—Tens and Ones to 100	This section of the assessment determines whether the students can tell how many altogether when they know how many 10s and 1s there are and if they can add 10 and subtract 10 without counting.
Level 3—Adds/Subtracts Groups of Ten	This section of the assessment determines whether the students can add and subtract groups of 10s without counting. If they are able to think of 10s as units, they will be able to add three 10s as easily as three 1s and take away four 10s as easily as they take four 1s away. If children are not "Ready to Apply" adding or subtracting groups of 10s, they need to continue working with the activities described for Tens and Ones to 100 with some variations.

Using the Grouping Tens assessment, teachers can identify student needs that range from counting by 1s to figure out how many in a group of 10 to fluency with adding and subtracting multiples of 10 to two-digit numbers. Students who have accomplished Level 3 can subtract two-digit numbers by using the underlying structure of 10s and 1s. This, in turn, lays a foundation for understanding two-digit addition and subtraction with the ability to judge the reasonableness of their answers and to make connections between problems (Richardson, 2012).

Intervention. One of the benefits of AMC is its correlation with an instructional intervention process through the Developing Number Concepts (DNC) books. Kathy Richardson developed the instructional series *Developing Number Concepts* (K.

Richardson, 1999a, 1999b, 1999c, 1999d) that links to the *Assessing Math Concepts* assessment tasks (K. Richardson, 2002). One of the elements that was particularly enticing about AMC was the inclusion of an intervention program, Developing Number Concepts, which is correlated with the assessments. At the time AMC was selected for the NC DPI pilot, none of the other programs discussed here had an intervention component associated with it. Once areas of focus have been identified, teachers can look to the DNC manuals for activities that will aid the student in further developing those concepts.

Materials should enable teachers to (a) develop a detailed understanding of their students' current reasoning about specific mathematical topics, and (b) choose learning goals and instructional activities to help their students build on their current ways of reasoning (Battista, 2012).

> "An intervention programme should identify the child's mathematical difficulties through a detailed initial assessment and subsequent ongoing diagnostic observations. This information should in turn inform some of the differentiated teaching which takes place in class, so pupils use part of the daily mathematics lesson to practise the necessary skills." (Haseler, 2008, p. 231)

The AMC materials can help teachers move beyond the "deficit" model of traditional assessment and intervention. Rather than wait until students fail before attempting to identify and address student needs, AMC offers a more powerful, ongoing model for supporting students' mathematics development. By using appropriate intervention activities indicated by data gathered through sound assessments, students can acquire the core knowledge needed to be successful in mathematics.

Situating AMC in the Research

The depth of research on mathematical development gives a clear picture about how children build conceptual understanding by reaching developmental milestones along the way. Making use of this research, teachers can use formative assessment to determine students' understanding of core topics and use this information to further guide instruction.

Effective classroom assessment must be focused on important mathematics and well articulated across the grades (CCSSM, 2010; NCTM, 2000). It must also be grounded in the core topics of mathematics central to K-3 mathematics. The study of number and operations is a major emphasis in the elementary grades. Although it is just one of several strands, number is an essential and, for primary grades in particular, a dominant component of mathematics. Researchers identify the following core topics for number 1–100: (a) counting, (b) number relationships, (c) number composition and decomposition to 20, (d) place value: number composition and decomposition of numbers to 100, (e) place value: number composition, and decomposition of numbers to 1,000 (Baroody & Dowker, 2003; Ginsburg & Baroody, 2003; K. Richardson, 2012; Wright, Stanger, et al., 2006).

One of several resources concerning this early number knowledge, Baroody's *Developmental Bases for Early Childhood Number and Operations Standards* lays out a specific developmental framework based on the pre-K to grade 2 number and operations standard of the *PSSM* and the research about how each of six basic competencies develop during those grades. In Table 2.7, a comparison between Baroody's six key areas of early number and the Core topics on which the AMC assessments are based shows a significant correlation between the two frameworks.

Table 2.7
Comparison of Six Key Areas and Core Topics

Key Areas of Early Number and Arithmetic Development (Baroody, 2004)	**Core topics (Richardson, 2012)**
Using numbers to quantify collections	Counting Objects
Using numbers to compare collections	Number Relationships
Adding and subtracting single-digit numbers	Number Composition and Decomposition to 20
Understanding part–whole relations	Place Value: Numbers as 10s and 1s
Equal partitioning or Grouping	Numbers as 100s, 10s, and 1s
Grouping and Place Value	Equal Groups

Based on this framework, Baroody lays out a set of standards for early childhood number that range from generalized to highly specific (Baroody, 2004). Comparison between the more highly specific goals of Baroody's framework and AMC's essential understandings again reveals significant agreement, suggesting that each is grounded in a common research base.

A number of studies have been conducted and assessment protocols developed with the intent to assist teachers in identifying and addressing student needs in mathematics. The most commonly used in research settings are the Children's Math Assessment (CMA; Starkey, Klein, & Wakeley, 2004), the Research-Based Early Mathematics Assessment Measure (REMA; D. Clements, Sarama, & Liu, 2008), the Test of Early Mathematics Abilities – 3rd Edition (TEMA-3; Ginsburg & Baroody, 2003), and the Early Numeracy Test (ENT; van de Rijt, van Luit, & Pennings, 1999). Four early numeracy skills that are most commonly assessed across these and other assessment measures are (a) verbal counting, (b) structured counting, (c) cardinality, and (d) number combinations. In Appendix B, a comparison of four research-based protocols and AMC across these early numeracy skills reveals considerable agreement across instruments. Although AMC has not had the reliability and validity studies some other assessments have had, the materials have gone through extensive field testing with both students and teachers, and the Assessing Math Concepts approach is consistent with major research-based assessment instruments currently in use.

Although different protocols may use slightly different ways of framing questions that could play a part in how students respond, AMC appears to give the needed support for formative assessment to help teachers make instructional decisions that help move students forward. Whatever the assessment, if we consider it as a tool for characterizing number knowledge, it needs to be tied to learning theory and be grounded in research. The assessments mentioned above all provide evidence of being grounded in learning frameworks and show substantial agreement with the framework on which AMC assessments are based.

To maximize their effectiveness, a teacher should be able to complete formative assessments quickly and efficiently and access actionable results soon afterward. Assessments must be closely linked to mathematics knowledge students need to make other ideas accessible, and teachers must have appropriate resources immediately available to provide targeted instructional interventions for students. However, the research-based instrument discussed above takes more than 30 minutes to complete, as opposed to the 5 to 10 minutes necessary to complete most AMC assessments. When conducting assessments with young children, it is necessary to use measures that are both valid and as brief as possible. Young children may become bored and give haphazard responses, or they may simply refuse to continue testing, negatively impacting the results and rendering them unreliable. Because of the limited attention spans of young children, efforts should be made to simplify assessment procedures and decrease total assessment time.

Current testing practices in use in the majority of classrooms related to assessing K–2 mathematics learning are not necessarily well grounded in knowledge of research about mathematics development in children. Consequently, current tests are limited in what and how they can be used to assess students' number knowledge. Particularly at the K–2 levels, it is not appropriate to administer written tests in the more standard testing format because of issues in reading and writing with young students.

AMC materials offer teachers a powerful type of *formative assessment* that can be completed in a reasonable amount of time and monitors students' learning in ways that enable teaching to be adapted to meet students learning needs. "For assessment to function formatively, the results have to be used to adjust teaching and learning" (Black & Wiliam, 1998b, p. 142). AMC materials provide the kind of coherent, detailed, and well-organized research-based knowledge about students' mathematical thinking that research has indicated is important for teaching (Fennema & Franke, 1992).

Theoretical Framework

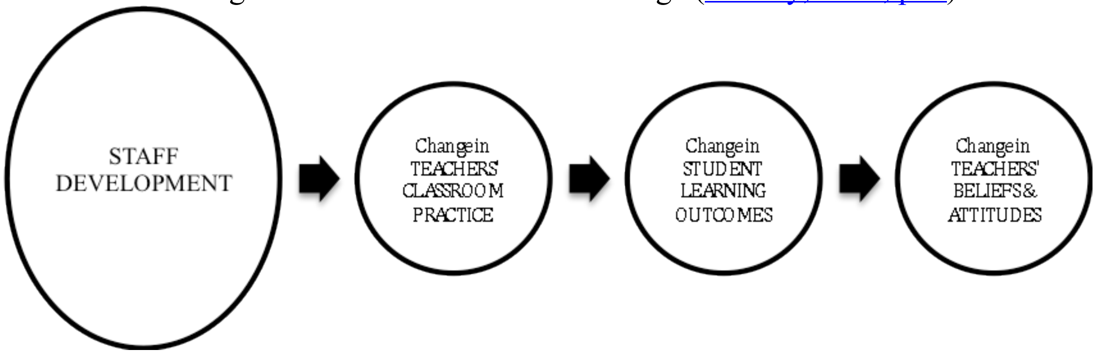
In the summer of 2011, Piedmont School District[3] (PSD) sought to address both

[3] Names of school and location have been changed and pseudonyms have been used.

the persistent achievement gap and lack of student growth as evidenced by state and local mathematics assessment results over several years. My work with PSD was a co-constructed response centered on the implementation of a formative assessment and intervention process in second and third grades. The focus of this partnership was on ways to influence teachers' instructional practice and students' opportunity to learn in a manner that would be lasting and independently sustainable by the district.

With that in mind, Guskey's Model of Teacher Change (2002) was used as a theoretical framework to guide our work (see Figure 2.3). Although professional development programs seek to "alter the professional practices, beliefs, and understanding of school persons toward an articulated end" (G. A. Griffin, 1983, p. 2), this model suggests that it is not until evidence of positive change in student learning outcomes is demonstrated that enduring change in teachers' beliefs and attitudes takes place. Providing evidence regarding change in student learning outcomes can serve to deepen the commitment of teachers to the practices proposed by professional development. An initial change in attitudes occurs before a change in teachers' classroom practice, but it is the change in student outcomes that provides the evidence needed for teachers to solidify those practices.

Figure 2.3: Model of Teacher Change (Guskey, 1986, p. 7)



In considering the application of this framework, it was important to recognize that lasting change does not happen quickly; rather, it is a gradual and difficult process for teachers. The process of implementing new teaching practices requires time and effort and results in a certain level of anxiety that implementation may negatively impact student results. In part because of the gradual nature of the change process, feedback plays an important role as a means of providing evidence of success and supporting teacher change. Therefore, regular feedback focused on the impact of this implementation on student learning was an important component of supporting teachers in changing their instructional practice (Guskey, 1985, 1986, 1989).

The framework indicates that while tentative change in classroom practice may follow the initial professional development, lasting change in teaching practice occurs only as teachers see evidence of positive impact in student learning outcomes. Therefore, ongoing support in a variety of forms is needed to address occasional setbacks, provide individualized and small-group feedback, and encourage teachers to maintain these new practices as they anticipate the student outcomes (Guskey, 2002, 2003; Loucks-Horsley et al., 1998). Enduring change in teacher practices requires time and consistent attention.

Within Guskey's Model of Teacher Change, Cizek's challenges facing formative assessment in the classroom (Donovan & Bransford, 2005) was used as a guide to think about and analyze the third-grade formative assessment and intervention implementation in PSD. This framework consists of seven formative assessment challenges at the classroom level: purpose, resources, preparation, validity, accommodations, compliance, and time. Based on this framework, these challenges must be addressed to realize the full potential of formative assessment in the classroom. About these challenges and their influence on the implementation of formative assessment, he states, "In the end, however, addressing the challenges and embracing the potential power of formative assessment offers substantial promise for stimulating greater gains in students' achievement and responsibility for their learning" (Cizek, 2010, p. 15).

In spite of these challenges, teachers are successfully using formative assessment to understand how and what their students are thinking about important mathematics in order to make instructional decisions. Understanding how these teachers have been successful, what factors support or inhibit that success, and the impact on student learning is an important step toward facilitating successful implementation of formative assessment in other schools.

Purpose of this Study

Black and Wiliam (2003) state that "Although we do not yet know everything about 'what works' in teaching, we believe that there is a substantial consensus on the kinds of classrooms that promote the best learning. What we know much less about is how to get this to happen (pp. 632–633)." It is important, then, to understand how to support and guide teachers as they come to know and enact formative assessment processes in their classrooms, and "given what we know about the benefits of formative assessment to students learning and the importance of learning progressions to the practice of formative assessment, we need to act now" (Heritage, 2008, p. 16).

The purpose of this study was to investigate the ways in which third-grade teachers come to know and implement a formative assessment and intervention process focused on the core topic of place value and the impact of that implementation on student learning. In the process, it is intended that this research will add to the existing literature, providing additional insight into "how to get this to happen."

CHAPTER 3

METHODOLOGY

This study was designed within the context of engaged scholarship. Engaged scholarship is defined as a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems. By involving others and leveraging their different kinds of knowledge, engaged scholarship can produce knowledge that is more penetrating and insightful than when scholars or practitioners work on the problems alone (Van de Ven, 2007). The role of the engaged scholar is one in which the researcher is alternately part of and apart from the research, with the potential to influence the cases being studied, simultaneously "being identified as a researcher but also filling a real-life role in the scene being studied" (Yin, 2012, p. 10).

The purpose of this study was twofold. First, this study investigated how a group of third-grade teachers, both individually and collectively, engaged in a district-wide mathematics initiative with a focus on how they (a) implemented a formative assessment process, (b) made sense of and used data, and (c) used those data in making instructional decisions. Second, this study examined the impact of this process on students' developing understanding of place value in classrooms where this implementation occurred. Specifically, the research questions were

1. How does a group of third-grade teachers, individually and collectively, implement a formative assessment process?

2. What sense does a group of third-grade teachers implementing a formative assessment process make of the assessment data individually and collectively?
3. How does a group of third-grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?
4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?

Research Design

Overview and Justification of Research Design

An embedded, multiple-case study design (Yin, 2011) using a qualitative research approach was used to better understand the implementation and impact of a formative assessment process by third-grade teachers in Piedmont School District[4] (PSD), a rural district located in North Carolina. Using interviews, data were collected on five teacher participants and three administrators at the school level, in addition to three teacher leaders and one administrator at the district level. Professional development documents and student data were collected to contextualize and gauge the impact of the implementation process. Descriptive case studies were developed with the school as the unit of analysis, a bounded case. Simultaneously, attention was paid to individual teachers within the school as embedded subunits, (Stake, 2010; Yin, 2011). These subunits, embedded in each case, were included to "add significant opportunities for extensive analysis, enhancing the insights into the single case" (Yin, 2009, pp. 52-53). Cross-case analyses were completed to expose

[4] Names of district, school, teacher, and location have been changed and pseudonyms have been used.

patterns across cases and increase the potential for generalizing beyond the particular case. The embedded multiple-case study structure used for this study is presented in Table 3.1.

Table 3.1
Embedded Multiple-Case Study Structure

<table>
<tr><th colspan="12">District Perspective</th></tr>
<tr><td colspan="12">Director of Elementary Education
Melinda Wehling</td></tr>
<tr><td colspan="4">Teacher Leader 1
Marcia Eury</td><td colspan="4">Teacher Leader 2
Theresa Fortino</td><td colspan="4">Teacher Leader 3
Myra Brendel</td></tr>
<tr><td colspan="12">District Leadership - One interview each</td></tr>
<tr><th colspan="12">School Perspective</th></tr>
<tr><td colspan="6">J. C. Fletcher Elementary
Case 1</td><td colspan="6">Meadow Lake Elementary
Case 2</td></tr>
<tr><td colspan="6">Principal
Sandra Loder</td><td colspan="3">Principal
Nathan Parkin</td><td colspan="3">Assistant Principal
Craig Tesar</td></tr>
<tr><td colspan="3">Teacher
Elaine Crumbley
Embedded Case 1</td><td colspan="3">Teacher
Laurie Athey
Embedded Case 2</td><td colspan="6">Teacher
Nina Arrigo
Embedded Case 4</td></tr>
<tr><td colspan="6">Interventionist
Audrey Mitcham
Embedded Case 3</td><td colspan="6">Interventionist
Debra Bardsley
Embedded Case 5</td></tr>
<tr><td colspan="12">Case Study Schools – Four interviews each</td></tr>
</table>

Qualitative research methodology was determined appropriate for this study because it is especially suited to research that aims to delve into complexities and processes (Marshall & Rossman, 2011). Particular to this study, the implementation and impact of a district-wide mathematics formative assessment and intervention process is decidedly complex and not well understood (Heritage, 2007). The qualitative method facilitates data collection and analysis that is responsive to themes and patterns that emerge throughout the research process. It also allows a holistic consideration of multiple variables, with attention given to the nature of those variables in context. The capacity for this methodology to handle variables in situ was an important consideration, given the interconnected nature of teachers' experience coming to know and implement a formative assessment and intervention process and the impact on student achievement.

The use of a case study is suitable when variables are intertwined with their context (Yin, 2011) and when a study aims to understand the features or the patterns of a phenomenon within an integrated, bounded system (Stake, 1995). Particularly, case studies are the preferred strategy when "how" or "why" questions are being posed and when the focus is on a contemporary phenomenon within some real-life context (Yin, 2011).

This study was both instrumental and descriptive in nature (Scholz & Tietje, 2002; Stake, 1995; Yin, 2011). Instrumental case studies seek to examine typical cases to increase understanding about a particular issue or phenomenon or to refine theory (Stake, 1995); the particular case itself is of secondary interest. In instrumental case studies, cases are selected to advance understanding of the phenomenon of interest. As an instrumental case study, the multiple cases were investigated to afford insight into the district-wide implementation of an assessment and intervention process at third grade and how that process supported students' understanding of place value rather than on the specific cases themselves.

Descriptive case studies offer insight into the particular case, taking into account the social context and interactions within the case, and documenting and describing the topic of interest (Marshall & Rossman, 2011; Yin, 2012). This study was also descriptive, designed to examine and describe the process by which teachers within a district, both individually and collectively, implemented an assessment and intervention process and the ways this implementation supported students' understanding of place value. In this capacity, findings from this study provide a basis for further research (Yin, 2012).

Researcher Role

Throughout this implementation process, and during the year of this study, I served as a consultant and co-constructor of the implementation of the formative assessment and intervention process in the district. This collaborative approach included planning and debriefing meetings with district administrators and teacher leaders, professional development with the pool of all schools from which the case study schools were drawn, and school visits with teachers and teams to address context-specific issues associated with the implementation. In designing this research, the intent was to capitalize on the unique opportunities afforded me by my role as an engaged scholar while minimizing the challenges associated with this technique.

Benefits associated with engaged scholarship include the opportunity to gain access to case study participants in unique ways and the opportunity to intentionally and purposefully influence aspects of the case (Van de Ven, 2007; Yin, 2011). In this study, my role as a mathematics consultant afforded me the opportunity to collaborate and build effective relationships with case study teachers and administrators and to become personally familiar with their professional contexts. Through this role, I was also able to influence the scope and nature of the mathematics professional development.

Challenges associated with engaged scholarship include (a) reconciling divergent viewpoints generated by engagement and triangulation; (b) negotiating the research relationship by establishing and building relationships with stakeholders; (c) being reflexive about the role of the researcher in the study; and (d) spending time in field research sites

(Van de Ven, 2007; Yin, 2011). During the period of data collection, I attempted to address these challenges by engaging in genuine relationship building and being explicit about the nature of my role in a given situation. I aimed to reduce the influence of researcher bias by employing trustworthy research practices and making the scope of my dual role as researcher and collaborator transparent to all.

In spite of careful attention to trustworthiness and limiting researcher bias, the combined role of researcher and collaborator influenced the analysis of data and certainly the responses to the research questions. Some qualitative researchers argue that a second researcher, with the same theoretical perspective as the first, using the same rules for data collection and analysis, and assessing a similar set of conditions, should come up with a similar theoretical explanation (Strauss & Corbin, 1998). No such claim is made here. In fact, because of the situated nature of this research, the embeddedness of my role as researcher, and the complexity of the data corpus, it is presumed that other researchers would come up with different theoretical explanations. Further, it is presumed that narratives resulting from interactions with the data *will* change from telling to retelling because they are heavily context dependent and sensitive to place, time, and even participation in the telling (Reissman, 2002). Rather than attempting to define the methods such that they could be applied and result in the same outcomes for another researcher, I aspire to faithfully render some truth from the perspective of one of the socially situated actors within the context of this study.

Establishing Trustworthiness

Throughout the research process, steps were taken to strengthen the trustworthiness of the research findings (Guba & Lincoln, 1989). A number of procedures, including redundancy of data gathering and procedural challenges to explanations, can be used to increase the probability that credible findings have been produced by qualitative research (Denzin & Lincoln, 2008; Marshall & Rossman, 2011). The same procedures can be used to maximize the validity and credibility of a qualitative case study (Yin, 2011) and confer rigor on the process of qualitative analysis (Barbour, 2001). Several technical “fixes” have been identified to help establish credibility of qualitative research (Barbour, 2001). Of these techniques, this study used triangulation, prolonged engagement, member checks, and multiple coding to establish and maintain the credibility of the findings. Each of these procedures and their use within this study are presented in the following sections.

Triangulation. Triangulation is generally considered a process of using multiple sources to clarify meaning, thus verifying the repeatability of an observation or interpretation (Stake, 2010). Two different modes of triangulation were used in this study (Denzin & Lincoln, 2008): (a) the use of multiple and different sources, and (b) the use of multiple informants. First, this study employed different sources to obtain information about (a) how teachers implemented a formative assessment process, (b) how they made sense of and used data, (c) how they used those data in making instructional decisions, and (d) the impact of this process on students’ developing understanding of place value in classrooms where this implementation occurred. For example, professional development documents, field notes, and audio-taped interviews with participants were used to increase the likelihood that credible findings were produced. Second, this study employed multiple informants to verify the findings or clarify interpretations. For example, data for this study were collected from teachers, school administrators, district teacher leaders, and district administration.

Individual viewpoints and experiences were verified against those of others, providing a rich picture of the implementation process based on data gathered from a diversity of participants.

Prolonged Engagement. This study was designed to allow for prolonged engagement in the research setting, increasing the credibility of interpretations (S.B. Merriam, 2002). The duration of the study allowed for persistent observation to identify emerging themes and explore those themes in depth during subsequent data collection or analysis. Prolonged engagement enabled careful consideration of multiple interpretations of data and allowed for reflexive monitoring of my own developing constructions in order to reduce the influence of my own inherent assumptions.

Member Checks. Collaborative planning sessions and informal conversations with teachers throughout the period of this study allowed for member checks with the research participants. The continuous engagement with the collaborative team provided opportunity to share and receive feedback about initial interpretations and findings, which permitted further refinement. During conversations and interviews, participants were asked to elaborate, share more examples, and explore the meaning of their ideas and experiences for themselves, their team, and their instructional practice.

Multiple Coding. Within qualitative research, multiple coding is used instead of the inter-rater reliability approaches employed in quantitative research. This procedure addresses the issue of subjectivity often associated with the process of qualitative data analysis. Multiple coding involves the cross-checking of themes and interpretations of data by independent researchers. Although analysis of the entire data corpus by another is not necessary, its use on some portion of the data can be a valuable strategy for refining themes and interpretations. In the current study, ongoing sessions in which the emerging themes were reviewed and discussed with advisors and colleagues allowed an opportunity to "have another person cast an eye over segments of data" (Barbour, 2001). Such conversations allowed for the consideration of alternative interpretations and an opportunity to clarify explanations.

Through the use of these techniques, triangulation, prolonged engagement, member checks, and multiple coding, I sought to establish findings that are credible, dependable, and confirmable. The findings provide thick, rich description such that others can judge the application of these findings and conclusions to their own contexts and situations.

Establishing Transparency of Researcher Position

During the 2011–2012 school year, given the positive outcomes of implementing a formative assessment process in one school, district administration decided to implement that process district-wide, beginning with grade 3 and, as finances allowed, grade 2. Throughout the school year, third-grade teachers from all elementary schools in PSD were engaged in ongoing, district-wide professional development, working toward implementation of an assessment and intervention process in mathematics. My involvement in the implementation process was at the request of senior administration in the school system. My assistance involved facilitating and investigating the implementation of the assessment and intervention process in grade 3.

During the year of this study, in the spirit of engaged scholarship, I served as a consultant, teacher educator, and co-constructor of the formative assessment and intervention process in PSD. I worked collaboratively with a team of four other educators, the Director of Elementary Education and three teacher leaders, to plan for, enact, reflect on, and adjust the implementation of the formative assessment and intervention process at grades 2 and 3 within the district. This collaborative approach included planning and debriefing meetings with district administrators and teacher leaders beginning in June 2011, 3 months prior to our first professional development session with teachers. Starting in mid-September, ongoing professional development began with the pool of all schools from which the case study schools were drawn. These sessions continued throughout the school year and included sessions on topics such as formative assessment theory, data collection and analysis, intervention planning, and discussions of current research. Between professional development sessions, numerous school visits were made with individual teachers, grade-level teams, and school administrators to address context-specific issues associated with the implementation. The overarching goal of our collaborative work was to support teachers in implementing a formative assessment and intervention process within their classrooms and move toward engaging in a continuous cycle of formative assessment (Black & Wiliam, 1998b; Heritage, 2007; Popham, 2008) focused on student learning of important mathematics (Baroody, 2004; Fosnot & Dolk, 2001; K. Richardson, 2012).

In my role as mathematics teacher educator, I spent some time providing classroom- and grade level-based support to case study teachers, including modeling assessment protocols, co-planning instruction for intervention, and providing extra assistance for particular teachers. These experiences allowed me to become familiar with teachers within the study and allowed the teachers to become comfortable with my presence in their schools and professional development sessions. Furthermore, working directly with the teachers provided opportunity for first-hand insight into the challenges of the unique teaching context in each school.

During the year of this study, I spent at least part of a day on an average of one day per week at the district to engage in research or implementation project activities. This level of presence facilitated regular informal interaction with participants throughout the district, including case study schools and district leaders. It was not unusual for collaborators and participants to discuss both personal and professional topics that were unrelated to mathematics instruction. Through ongoing formal and informal interactions with all engaged in this study, I was able to build mutually respectful and trusting relationships. As the year progressed, candid discussions with teachers, collaborators, and administrators regarding hopes, struggles, and concerns related to this implementation and other topics became increasingly common.

Setting and Participants

Setting

In the winter of 2010, one elementary school in PSD initiated a formative assessment and intervention approach to address the mathematics learning needs of their students in grades K–5. The multitiered program involved a number of general classroom interventions combined with small-group and individual interventions aligned with what is currently called *Response to Intervention* (RTI) in the literature (e.g., Lembke, McMaster, & Stecker, 2010)and in national education policy. Consistent with current understandings of the RTI programs, the approach in PSD is a three-tier model that includes quality instruction to all students in the general classroom setting (Tier I); specialized small-group interventions for students who require additional supports (Tier II); and individualized instruction for those who require even more intensive supports (Tier III). The Tier II program in PSD is the Assessing Math Concepts formative assessment program based on the work of Kathy

Richardson (2012). This Tier II program was the focus of the work I conducted with PSD and is the assessment and intervention process employed throughout the research period

The need to implement and investigate an assessment and intervention process in PSD was driven by multiple factors. From the perspective of PSD, the importance of conducting the research was to confirm that resources invested in this program were leading to improved student outcomes as intended. Furthermore, investigation of the formative assessment and intervention approach provided PSD with valuable information regarding the logistics and resources necessary for implementation throughout the district. The program in PSD provided a unique opportunity to examine the process and the impact on student learning in mathematics. In response to this need to, I proposed a research protocol as described herein. The proposal was approved by the Human Subjects Review Board at the University of North Carolina at Chapel Hill and by the research committee at PSD.

From this pool of all elementary schools in the district, two elementary schools were recruited for inclusion in this study. Third-grade teachers in each of these case study schools were invited to participate in the study; therefore, the study comprised two elementary schools and their respective teachers. Cases were considered based within the purpose of this study, which sought to investigate how a group of third-grade teachers, both individually and collectively, engaged in a district-wide mathematics initiative with a focus on (a) how they implemented a formative assessment process, (b) how they made sense of and used data, (c) how they used those data in making instructional decisions, and (d) the impact of this process on students' developing understanding of place value in classrooms where this implementation occurred.

Case Selection

This study was conducted in two elementary schools in PSD, a rural school district in North Carolina, with a focus on third-grade teachers and particular focus on teacher in two elementary schools. Considering cases from a single grade level allowed for in-depth focus on participants using common curricular goals and incorporating many of the same curricular materials into their instructional practice. These commonalities further enabled explication of those elements that bound these cases together as well as what set them apart from one another (S. B. Merriam, 1998; Stake, 1995). In this case, the fact that the cases were from a single grade level minimized some differences across cases. Being within the same school district, these teachers used the same curricular materials and were guided by the same district documents and expectations. Although from the same grade level, characteristics of the teachers also set these teachers apart. Traits such as years of teaching experience, comfort at this particular grade level, and familiarity with teaching and assessing mathematics served to maximize differences across cases and made a focus on the individual as well as the collective experience of teachers useful to study.

Recruitment and Sampling

Purposive sampling using both convenience and maximum variation sampling was used to select two schools as cases for this study (Creswell, 2007; Marshall & Rossman, 2011). With the help of district administrators in PSD, schools were identified for possible inclusion in the study, and e-mails were sent to administrators in those schools to extend an invitation to participate as cases. Purposive sampling was used to select two schools based on the potential to "reflect differences or different perspectives" (Creswell, 2007, p. 126) related to the questions under consideration for this study. In particular, the first case study school, J. C. Fletcher Elementary, had piloted the formative assessment and intervention process for 3 years prior to this study. This case represented the most experienced perspective, serving as the vanguard for the district implementation process.

The second case study school, Meadow Lake Elementary, was in their first year of implementation and had no exposure to the materials or process prior to the training that was the focus of this study. This second case represented the least experienced perspective, exemplifying the more typical experience of schools within the PSD.

Once case study schools had been selected, each principal arranged for an information session during which information about the study was presented and teachers were invited to participate (see Appendix C). Two third-grade teachers and one interventionist from each participating school were selected for interviews. Purposive sampling was used to select the two teachers based on their potential to provide diverse and varying perspectives while identifying important common patterns in relation to the questions under consideration for this study (Marshall & Rossman, 2011). As interviewing began, one selected teacher did not respond to attempts to set up an interview and, by default, was no longer included in the study. No other teacher was available at the time; therefore, only one teacher and one interventionist represented one of the schools.

School leaders were also selected to provide insight into the broader context in which these cases occurred. At the school level, the principals of each case study school were interviewed for their knowledge of the different cultures, histories, and school-level contexts in which the assessment and intervention implementation was situated. At one of the schools, the assistant principal was also interviewed.

Selection of District Leader Participants

Leaders at the school and district levels were selected for their potential to provide insight into the broader context in which the case study schools were implementing the formative assessment process. At the school level, the principals were selected for their knowledge of the culture and history of their schools and the school-level context in which the implementation of the formative assessment process was situated. At the district level the Director of Elementary Instruction was selected to provide a district perspective of the assessment implementation as well as the overall picture of mathematics teaching and learning within the district.

For this project, three district leaders were charged with implementing the formative assessment process. The district Math and Science Coordinator had recently retired, so these three teachers were selected to take on this leadership role in addition to their regular instructional duties. These teacher leaders, assigned to coordinate and conduct the professional development and serve as support for individual schools engaging in the implementation, were selected for their perspectives on the needs and challenges associated with this implementation process. Conducting interviews with the teacher leaders and district leaders who were connected with this implementation provided the background information needed to understand this research within the larger context of the school district.

Measures

Data were collected from a variety of sources to answer the research questions previously stated. These data sources included teacher interviews, school and district leader interviews, records of the ongoing implementation process, and student assessment results. Table 3.2 provides an overview of the relationship between research questions and data sources.

Table 3.2
Relationship Between Research Questions and Data Sources

Research Questions	Data Sources
1. How does a group of third-grade teachers, individually and collectively, implement a formative assessment process?	Teacher interviews Professional development documents Student formative assessment data
2. What sense does a group of third-grade teachers implementing a formative assessment process make of the assessment data individually and collectively?	Teacher interviews School/district leader interviews Professional development documents
3. How does a group of third-grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?	Teacher interviews School/district leader interviews Professional development documents Student formative assessment data
4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?	Student formative assessment data End-of-grade pre- and post-test results Teacher interviews School/district leader interviews Professional development documents

Each of these measures provides a lens through which to better understand the individual and collective experience of teachers as they implemented this formative assessment process. These measures were selected to shed light on this process, thereby helping address the research questions.

Interviews

Using a focused interview (Yin, 2009) approach, interviews were conducted with participating teachers at each of the participating schools, the school principals and assistant principal, the Director of Elementary, and the three teacher leaders in charge of this assessment and intervention implementation process. The data collected through these semistructured interviews were focused on understanding the background of the case study schools, district, and professional development efforts that were part of the implementation of these assessments within this district. In addition, these interviews asked participants to consider reflections about the impact of this implementation process on students' learning and teachers' instructional practice.

Interviews with Teachers. Interviews with participating teachers were conducted to better understand the individual and collective experience of the implementation process, influence(s) on instructional practice, and impact on student understanding. The protocol used to structure the interview with participating teachers is presented in Table 3.3.

Table 3.3
Initial Questions for Interviews with Participating Teachers

Think about the way(s) in which you used assessment prior to this year.

- Describe what that "looked" like in your classroom.
- What role did assessment data play in your teaching?
- What did you learn about your students through those assessments?
- What did "mathematics intervention" look like prior to this year?
    - How were students identified for intervention?
    - How often did it occur?
    - Where did it take place?
    - Who taught the student/group?
    - What resources were used for instruction?
- How have the things you described to me changed this year?
    - How do you explain these changes?
- Is there anything else you would like to add or share that you feel it is important for me to know?

Interviews with School Leaders. Interviews with school leaders at both J. C. Fletcher Elementary and Meadow Lake Elementary were designed to elicit the leaders' perspectives on school history and culture as well as current issues related to mathematics teaching and learning at their respective schools. These interviews were conducted late in the spring semester and took 1–2 hours each. The protocol used to structure the interview with participating principals and assistant principals is presented in Table 3.4.

Table 3.4
Initial Questions for Interviews with Principals and Assistant Principals

School history and culture:

- Who are the students who come to this school?
- What have been the challenges at this school, historically and at present?
- What do you perceive as the current strengths of this school?
- How are decisions made at this school?
- What, if any, "pressures" come from the district and state leadership and how do they influence what goes on at this school?
- In what ways and to what extent do the accountability measures related to the EOG's influence the way things are done at this school?

Mathematics-related school improvement efforts:

- What initiatives are underway to improve mathematics instruction this year? What is the intent of each? From your vantage point, how are teachers and students responding to these initiatives?
- What is your involvement with improving mathematics instruction? How do you see your role?

Is there anything else you would like to add or share that you feel it is important for me to know?

Interviews with District Leaders. Interviews with the Director of Elementary Education and the district-level teacher leaders were designed to gain a district-level perspective on the implementation of the formative assessment process as well as an understanding of the perceived needs and challenges of the schools within the district. Interviews with each of the district leaders were 1–2 hours each. The protocol used to structure the interview with participating district and teacher leaders is presented in Table 3.5.

Table 3.5
Initial Questions for Interviews with District and Teacher Leaders

District history in relation to mathematics teaching and learning: • How would you characterize elementary school student achievement in mathematics in this school district, both currently and over the last 5–10 years? • What is the level of priority of mathematics instruction in your district currently? What has it been historically (last 5–10 years)? • What are the district-level expectations for elementary mathematics instruction? To what extent have these remained constant or changed? • What factors, external to the school, influence the way mathematics is taught? How have the factors influencing mathematic instruction changed over the last 5–10 years? • What current initiatives are underway to improve mathematics instruction?
District implementation of *Assessing Math Concepts*: • Why is this particular assessment process being implemented? • How is this assessment process the same and different from what teachers are used to using? • What do you see as the major challenges elementary teachers face in learning to use this assessment process? • What is the nature of district-level support during this implementation year? What is the district doing to support teachers? Schools? Administrators?
Is there anything else you would like to add or share that you feel it is important for me to know?

All interviews with school and district leaders were audiotaped and videotaped. Simultaneously, field notes were used to capture the contents of the interviews. Immediately following the interviews, field notes were used to guide ongoing data collection and analyses. Audiotapes were reviewed for emerging themes and transcribed for use in additional analyses. Videotapes were reviewed to further contextualize information gathered through the interview process.

Professional Development Documents

Throughout the year of this study, records of the professional development project and collaboration among the district-level leaders and the researcher were collected. Data sources included PowerPoint presentations used for professional development, exit cards as a form of teacher reflection on the professional development, district surveys, leader notes, agendas, and school assessment and intervention plans. These data sources were used to further contextualize the study and provide a look behind the scenes of the formal study.

Student Assessment Results

One way to measure the impact of the intervention studied is to compare student performance on mathematics assessments. At the beginning of the school year, disaggregated data related to students' achievement on the released North Carolina End-of-Grades Grade 3 Pretest in Mathematics Form X was collected. This assessment was administered to all PSD third-grade students in August 2011, and student responses were collected in a district database. At the end of the school year, disaggregated data related to students' achievement on the mathematics section of the North Carolina End-of-Grade (EOG) Grade 3 Test were collected. The EOG is a criterion-referenced achievement test in which students receive scores between 1 and 4, with a score of 3 or higher considered passing. This test was administered to students in mid-May 2012. Permission to collect testing information was granted through district administration and disaggregated data on all district third-grade students were collected from PSD personnel in charge of accountability.

Data Management Procedures

Data collection yielded a number of items in a variety of forms, including paper and electronic documents, and numerous audio and video recordings. To organize the extensive amount of data and assist the process of systematic data analysis, the following data management procedures were employed:

- All audio recordings were transcribed, integrated with field notes, and saved as text documents. I personally transcribed audio recordings in which an understanding of the data was partially reliant on field notes. One other transcriber was enlisted to transcribe all interviews that did not rely on such field notes. Transcripts were reviewed and minor revisions made to transcripts completed by others, with special attention paid to sections of transcripts where the transcriber noted uncertainty with the dialogue.
- Next, observations from the videotapes were integrated into the transcripts of teachers' interviews. For instance, a teacher's "showing" how a student demonstrated understanding of a particular concept during an intervention session was nested within the interview transcript. This process of nesting teachers' actions demonstrating students' work within the transcript of the interview gave easy access to data situating that work in relation to instructional practices being discussed.
- After these data sources were converted into text documents and all identifying information was deleted, they were imported into Dedoose (SCRC, 2012) in preparation for systematic data analysis. This data analysis platform facilitates the iterative process of inductively identifying themes, modifying and expanding those themes, and searching for meaningful patterns across data sources (SCRC, 2012).
- Disaggregated student pretest results were converted to scale scores using the published guide (see Appendix D) and matched with posttest student EOG assessment information. Unmatched data were deleted from the data set. Matched data were de-identified and entered in an Excel spreadsheet in preparation for

importing into Statistical Package for Social Sciences (SPSS) Statistics Version 19.0 (IBM Corp., 2010) for quantitative analysis.

Data Analysis Procedures

The purpose of this study was to investigate the implementation of a formative assessment and intervention process in one district and the impact of that implementation on student learning. Through an embedded multiple-case study approach, several data sources were used to inform analyses as patterns and themes emerged within and across case studies of individual schools and subcases of individual teachers (Merriam, 2008; Yin, 2012). Triangulation among data sources was used to construct and examine emerging themes and patterns throughout a process of iterative data collection and analysis (Mathison, 1988).

The primary unit of analysis was at the school level, J. C. Fletcher Elementary and Meadow Lake Elementary schools. The third-grade teachers at these case study schools implemented a formative assessment and intervention process (Research Question 1), analyzed assessment data (Research Question 2), and used those data to make instructional decisions (Research Question 3). The students in these classrooms engaged in learning opportunities based on those instructional decisions (Research Question 4). However, attention was also given to the subunits of analysis, the classroom teachers (Yin, 2011).

Analysis units at two different levels in a study allowed this researcher to analyze data from different sources, including interviews, assessments, and document reviews, to conduct qualitative analysis through comparisons and syntheses of potential emerging themes (Strauss & Corbin, 1998; Yin, 2011). In addition, it allowed this study to integrate a cross-case analysis method to promote comparisons and integrations of findings across the subunits within the case (Miles & Huberman, 1994; Yin, 2011).

Analysis During Data Collection

Data analysis took place as data were collected. This occurred in the form of reviewing field notes as they were completed and situating those most recent observation notes within the context of the whole of the data to that point, therefore recursively reviewing previous data in light of new information. Consistent, regular cycles of data analysis were the basis for informing themes that had been previously identified and for exposing emerging themes and issues (Patton, 2002). Data analysis during the collection process thus allowed consideration of and response to those themes and issues that emerged during the research study.

Analysis of professional development documents provided an initial understanding of the teachers' struggles and concerns, which served as a lens that shaped subsequent professional development and school-based activities. In particular, the exit cards teachers completed during each professional development session and turned in at the conclusion of the session provided an opportunity to gauge teachers' questions and concerns with the implementation and the formative assessment process itself. This provided an opportunity for the team to address teachers' specific concerns, clarify broadly stated concerns and questions, and collectively represent these with school and district administrators in real time. Additionally, this information led to revisions of plans for subsequent professional development sessions and revealed themes that were intentionally explored throughout the remainder of the study.

Analysis After Data Collection

Qualitative Data Analysis. In addition to informal analysis conducted during data collection, systematic analysis of data also took place after qualitative data were collected, transcribed, and integrated to gain a holistic view of the research. After interviews were fully transcribed, a complete reading was done to reveal themes and variations while points of interest were noted as a first cycle of analysis (Saldana, 2009). Qualitative data analysis software was employed to more efficiently compare and analyze the emerging themes (SCRC, 2012). After first-cycle analysis was complete, themes were reorganized and reconfigured into a smaller list of more meaningful units of analysis. First-cycle themes were reviewed for commonality and patterns were sought, so that passages revealing similar themes would be aggregated and assigned similar descriptors (Miles & Huberman, 1994).

Collectively, the patterns revealed a larger theme of challenges that schools and teachers faced in implementing the formative assessment and intervention process. In reflecting on this pattern of challenges, a connection became apparent between the emerging patterns and Cizek's challenges facing formative assessment in the classroom (Cizek, 2010), which had been used as a guide to think about the implementation process during the study. A careful review of the patterns revealed that Cizek's seven challenges as described in Chapter 2 (see page 58), with the addition of Disposition as an eighth challenge, represented the major themes emerging from the data. Specifically, the following eight facets of challenges related to the implementation process guided the organization of results: purpose, resources, preparation, validity, accommodations, compliance, time, and disposition to change. Table 3.6 provides a definition of each of the eight facets.

Table 3.6
Definitions of the Eight Challenges

Challenge	Definition
1. Purpose	Identification of and adherence to a clear, focused purpose for the assessments.
2. Resources	Commitment of resources to support professional development, time for planning, administration and feedback, and support for additional materials as needed to implement an effective assessment program.
3. Preparation	Preservice and in-service training for educators to provide two different competencies: the concepts necessary to administer and interpret traditional summative assessments, and the skills required for developing and interpreting classroom-based formative assessments.
4. Validity	Assessment provides accurate, actionable information. Techniques to detect and reduce the extent of bias in formative classroom assessments have been developed, disseminated, and incorporated into the preservice training and professional development of educators.
5. Accommodations	In order to enable all test takers, including students with special needs, to demonstrate their true levels of knowledge, skill, and abilities, considerations are made for the role of accommodations, any deviation from standard test administration conditions that does not threaten or alter the characteristic being measured or the accuracy of the intended inference, in the formative assessment context.
6. Compliance	The relevance of laws, policy, and administrative rules to guide and support the implementation of the formative assessment process. • Should formative assessments be considered in constructing IEPs? • Should formative assessment be documented? • Does formative assessment information constitute protected educational records?
7. Time	Reallocation of time and effort to support instructional planning, modified instructional practices, and individualization of instruction on the part of teachers and students. Reconfiguring daily classroom life and reorganizing the instructional day to provide the time necessary for effective formative assessments.
8. Disposition to Change	The emotional reaction, positive, negative, or neutral, experienced as a result of engaging in the process of implementing the formative assessment process.

The eight challenges along with definitions and examples of each can be found in Appendix E.

Typical patterns within cases were identified, data were used to either support or contrast these patterns as they emerged, and case studies were developed. Persistent themes were then explored across cases. This iterative process resulted in a rich, nuanced understanding of the data and is situated not just in the data itself but also in the interaction between the researcher and the data. The use of an inductive analysis cycle supported the process of qualitative interpretation of the data. As such, issues of interrater reliability and objective coding schemes are not applicable and would, in fact, yield a very different type of understanding of the phenomenon being studied.

Development of Case Stories. Using results of data analysis, individual case stories were developed. Stake (2010) states that case stories should be fully developed before cross-case analysis is conducted, to protect the integrity of the individual case stories against becoming overshadowed by themes that may emerge during the process of cross-case analysis. This is meant to preserve the unique aspects of the individual cases.

After separate analyses of the formative assessment and intervention process implementation at each school, case stories were developed to examine the ways in which teachers individually and collectively made sense of and used that process. Broadly, this analysis involved identifying evidence of the challenges faced by teachers at each study school and the ways in which they worked to address those challenges, in terms of implementation, data analysis, and instructional decision making. For a given identified challenge, I first reviewed the interview data from that particular case, then compared it with interview data from the other embedded cases at that case study school. Through this analysis, teacher commentary on individual and collective experiences relating to the implementation process was considered. Next, I examined how data collected over the course of the year might be related to the particular challenge and the ways it was addressed over time. Through this process, I sought to establish patterns of reaction and response to challenges that appeared to be prevalent within the school. In other words, I attempted to discern when a given challenge seemed dominant in determining a particular response pattern. These analyses form the basis for the construction of each case story, offering insight into the ways teachers within each school, both individually and collectively, made sense of and used the formative assessment and intervention process and the impact on students.

Cross-Case Analysis. Throughout the process of data analysis, themes identified in one school were explored in the other school. After the individual case stories were developed for each school, cross-case analysis was conducted to look at commonalities and differences across cases. Specifically, four analyses across cases were performed. These cross-case analyses will be presented in Chapter 5.

First, occurrences of challenges related to the implementation of the formative assessment process were identified across cases. To accomplish this analysis, excerpts from interview transcripts marked with codes used to identify these challenges were collected across cases by code. Through review of these excerpts, challenges facing implementation and the ways in which these were addressed were sorted into two groups: those that were evident in both cases studied and those that were evident in one case but not the other. Consideration was then given to what the sets of challenges had in common, and an explanation was devised suggesting why some practices are more readily used than others.

The second cross-case analysis involved examining the challenges teachers faced in making sense of assessment data. First, teachers' responses concerning their use of data in the previous year and their use during the year of the study were reviewed to determine the extent and nature of change in the ways they engaged in data analysis. Next, data from interviews, professional development meetings, records of informal conversations, and other sources were reviewed for teachers' commentary related to challenges faced in making sense of data and how, both individually and collectively, those challenges had been addressed. Teachers' classroom experiences, as detailed in the case stories, were also taken into account. Through this process, an explanation of teachers' differing levels of change was constructed with particular consideration of how teachers' classroom experiences influenced change in the ways they approached making sense of assessment data.

A third cross-case analysis involved reviewing the case stories to discern patterns in challenges related to using formative assessment data in making instructional decisions during the school year. Through this review, an attempt was made to conceptualize the data across cases by first identifying dimensions of teachers' use of assessment data in making instructional decisions that served to capture the response patterns of the teachers studied. Next, explanations for how challenges influenced teachers' individual and collective actions were examined related to each dimension of teacher response. In particular, effort was made to identify factors that appeared to facilitate or limit teachers' actions related to the particular dimension of data-based instructional decision making. Through this analysis, an explanation was developed to describe how challenges drove particular teaching practices.

The final cross-case analysis aimed to identify how the implementation of this formative assessment and intervention process influenced students' mathematics understanding in schools in which this study was situated. The data corpus was reviewed for instances when teachers and school leaders provided commentary on how this implementation had influenced the students in their particular teaching and school contexts. In particular, attention was given to instances when teachers referenced the needs or nature of students at their school or in their class and how this formative assessment and intervention process met or did not meet those needs within the context of mathematics instruction. Throughout this analysis, consideration was given to how and to what extent particular factors influenced the impact of the implementation on supporting students' learning in mathematics. This analysis resulted in construction of an explanation of the role the implementation of the formative assessment and intervention process played in supporting students' developing understanding of the core topic of place value in third grade.

Quantitative Data Analysis. Quantitative analysis of the impact of the formative assessment and intervention process implementation on students' learning was also conducted. The North Carolina End-of-Grades Grade 3 Pretest in Mathematics Form X and the North Carolina EOG Grade 3 Test served as pre- and post-tests. North Carolina does not use a parallel test as pre- and posttest for students in third grade, but using specific rules published by the state for converting pretest scores (see Appendix D), pretest scores were converted into standard scores that could be compared with end-of-grade scores. Standard scores for 339 students who completed the assessment in the fall and spring of the year were compared using a one-tailed, paired samples *t*-test. Using the common standard score scale, the effect size (Cohen's *d*) of the intervention was also calculated.

Summary

This study was designed within the context of engaged scholarship, which involves the researcher in a reciprocal partnership with the community and integrates roles of teaching, research, and service. Although there is variation in current terminology (public scholarship, scholarship of engagement, community-engaged scholarship), engaged scholarship is defined by the collaboration between academics and members of the larger community for the mutually beneficial exchange of knowledge and resources in a context of partnership and reciprocity. Through this lens, using a qualitative research methodology, an embedded multiple-case study was used to better understand the processes by which third-grade teachers in one school district came to understand and implement a formative assessment and intervention process and the impact of that implementation on student learning.

This chapter provided a detailed description of how data were collected and analyzed during the current investigation. In the following chapter, case studies are presented to report the research findings. In the final chapter, the cross-case analysis, conclusions, and implications of these findings are discussed, and avenues for further research are proposed.

CHAPTER 4

FINDINGS

An embedded, multiple-case study design was employed to examine the implementation of a formative assessment and intervention process by third-grade teachers in one rural school district in North Carolina. This study was guided by the following four research questions:

1. How does a group of third-grade teachers, individually and collectively, implement a formative assessment process?
2. What sense does a group of third-grade teachers implementing a formative assessment process make of the assessment data individually and collectively?
3. How does a group of third-grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?
4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?

This chapter presents research findings beginning with a description of Piedmont School District[5] (PSD), in which the case study schools are located. Next, the background of each case study school and both the background and current teaching context of each embedded case study teacher is introduced. This will be followed by case stories detailing the implementation process of each of the two case study schools. Findings related to

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[5]Names of district, school, teacher, and location have been changed and pseudonyms have been used.

challenges teachers and schools faced in implementing the formative assessment and intervention process are offered, allowing each case story to be considered within a more general understanding of the process of implementing a formative assessment process and the impact on student learning.

The District Context – Piedmont School District

The two schools of focus in this study, J. C. Fletcher Elementary and Meadow Lake Elementary, are part of PSD, a rural district in North Carolina. In this section, a portrait of the district context in which these schools are located will be presented to provide a backdrop for consideration of each individual case. First, attention will be given to the district culture, history, and demographics of PSD. This will be followed by an account of the mathematics-related new initiatives and the formative assessment and intervention implementation that took place in PSD during the year of this study.

District Culture, History, and Demographics

Located in a rural part of North Carolina, PSD consists of 13 schools serving students from prekindergarten to grade 12. Faculty, staff, students, and parents are welcoming and engage in friendly exchanges with each other and visitors. There is a general feeling that this is a district that is focused on students and their learning.

Approximately 500 PSD teachers serve an ethnically diverse student population of nearly 7,300 students. As presented in Table 4.1, the diversity of students in PSD is representative of the state of North Carolina as a whole.

Table 4.1
Ethnicity – Piedmont School District and North Carolina

	White	Black	Hispanic	Other
Piedmont School District	65%	16%	15%	4%
North Carolina	53%	26%	13%	8%

Similarly, as Table 4.2 illustrates, the percentage of PSD students who comprise special populations is also roughly representative of those populations throughout North Carolina. Although PSD was one of the last counties to show signs of economic stress during the recent economic downturn, the number of students across the district who qualify for free and reduced lunch is the highest it has ever been. What had been a rate of 28% of students 6 years ago was 40.2% during the year of this study. Like others across the state, an increasing number of families and students of PSD were struggling economically.

Table 4.2
Special Populations – Piedmont School District and North Carolina

	AIG	EC	LEP	ED
Piedmont School District	14%	14.6%	7.7%	40.2%
North Carolina	12%	12%	7%	53%

AIG = academically and intellectually gifted; EC= exceptional children; LEP = limited English proficiency; ED = economically disadvantaged.

Although the average district percentages appear to be in line with those of the state, the individual school averages vary widely. For instance, the percentage of economically disadvantaged (ED) students in PSD ranged from 15.5% in one school to

59.4% in another during the year of this study. Likewise, the percentage of students who qualify as limited English proficient (LEP) was as low as 1% and as high as 23.6% in various schools. With some individual schools having nearly 60% of their students qualifying for free or reduced lunch and nearly 25% of their students having a first language other than English, issues of poverty and language, among other considerations, impact the decision making process in significant ways. Based on the needs of individual student populations, schools within PSD may be designated as Title I schools or receive a variety of supplementary funding from the federal government while others do not.

PSD fully embraced the site-based management approach widely adopted in North Carolina during the mid-1990s. This site-based focus resulted in no designated district-level leadership in the content areas for nearly two decades. When the district hired a Mathematics and Science Coordinator in 2006, not only were there no common curricular materials for mathematics in use throughout the district, it was not uncommon for several different curricula to be in use within the same school and sometimes even within the same grade level in a school. It was also discovered that different versions of the North Carolina Standard Course of Study were in use. To move the district forward and meaningfully address the needs of all PSD students, the coordinator helped teachers to engage in ongoing conversations focused on mathematics teaching and learning.

Mathematics-Related Initiatives

In the spring of 2006, the Mathematics and Science Coordinator began to conduct afternoon meetings with teachers from particular grade level bands to discuss the current state of mathematics in the district and determine next steps. There was no common ground on which to base these conversations, so these meetings were a disaster from the perspective of the Coordinator and the teachers involved in the meetings. The Coordinator sought the advice of a professor from a local university, which resulted in a partnership that provided rich opportunities for teachers to engage in discussions about mathematics in the elementary and middle grades. Teachers voluntarily attended workshops about Cognitively Guided Instruction (CGI) (Carpenter, et. al, 1999), participated in action research projects focused on student understanding of mathematics, and joined study groups centered around discussing research, selecting and writing problems, and facilitating student learning. This was the beginning of the foundations on which the implementation in the current investigation was based.

As teachers engaged in these new opportunities for professional development, natural leaders began to emerge. In partnership with mathematics leaders from two neighboring districts, the Mathematics and Science Coordinator wrote a state grant (MSP) focused on developing teacher leaders in each district. This coincided with the state adoption cycle for new elementary mathematics standards and curricular materials. With all the opportunities that had been provided to discuss and begin to build a common understanding of important mathematics, the nurturing of teacher leaders through the MSP grant, and the recruitment of teachers who were willing and able to represent their schools on the newly formed Elementary Mathematics Leadership Team (EMLT), the district began the process of planning for districtwide change in mathematics.

Drawing from research such as the *Principles and Standards of School Mathematics* (2000), the National Mathematics Advisory Panel Report (2008), and CGI (1999), as well as from their own experiences, in the fall of 2008 the EMLT began to construct what would come to be known as the Piedmont School District Mathematics

Program Matrix (hereafter referred to as the Matrix). Teachers were brought together to brainstorm, identify, categorize, and define the components of the mathematics program they believed would best serve the students of PSD. The Matrix was edited and revised as teacher groups, principals, parents and district administrators reviewed it, provided feedback, and reached consensus on a final version (see Appendix F). The district vision for mathematics that was articulated through the Matrix stated, "Our mathematics program should have a districtwide K–12 focus that seeks to prepare students at all grade levels with deep mathematical understandings that prepare students for advanced mathematics."

Reflecting on this time, the Director of Elementary Education, Melinda Wehling, said, "people started talking about in the district that we needed to have one program of study throughout the schools so that if kids were moving around they wouldn't be going from one curriculum to another and one program of study to another." The first step in accomplishing that vision was to adopt a common set of curricular materials as a framework for structuring the mathematics program and teachers' work. A preliminary comparison of the Matrix with available materials resulted in teachers limiting the choices to those materials categorized as "reform based.". Selected publishers were sent a copy of the Matrix and asked to demonstrate how they could support the PSD vision for mathematics. One publisher declined the invitation, explaining that they did not believe their materials could address the Matrix criteria.

Using the Matrix as a point of reference resulted in substantive, focused, and objective conversations at the district level as teachers evaluated the materials provided for review. Final selection took place at the school level, with each school submitting their top two choices, each with a rationale. A team of district administrators tallied school decisions and the results, along with a summary of the collective rationale, were presented to elementary principals for dissemination to teachers.

Moving from program planning to program implementation, the EMLT began the task of reviewing the content of the selected materials, correlating them with the state standards, and establishing a suggested pacing for classroom implementation. Orientation sessions conducted throughout the summer of 2009 introduced teachers to the new curricular materials and established them as the core of the mathematics program, reiterating the idea that the materials were *not* the mathematics program in PSD. Based on teachers' feedback from the orientation sessions, curriculum guides were completed and distributed to teachers prior to the beginning of the school year. The curriculum guides were reviewed and revised at each of the quarterly EMLT meetings, with input from teachers communicated through their EMLT contact. The Matrix document anchored the work of the EMLT members and helped everyone remain focused on the program guidelines and requirements they had established as decisions were made. To more specifically address questions and concerns, members of the mathematics department frequently attended grade-level professional learning community (PLC) meetings at schools, made presentations at school parent nights, conducted districtwide parent information meetings, met with principals and district administrators, and gave updates to the PSD school board.

It was clear by the end of the implementation year that the Common Core State Standards for Mathematics (CCSSM) would be the next set of standards PSD teachers would need to address. The Matrix was reviewed by the EMLT, and a plan was generated to begin preparing for these new standards, address teacher needs and concerns, and determine next steps.

Assessment was one area of focus for mathematics during the 2010–2011 school year. In addition to the Matrix guidelines regarding assessment, as shown in Table 4.3, a district focus on Response to Intervention (RTI) and the implementation of a districtwide literacy intervention model placed assessment squarely in the center of attention for all members of PSD. While items outlined in Table 4.3, such as Quarterly Assessments and Student Assessment Records, were specifically being addressed districtwide by the EMLT, a way to meet the need for formative assessments supports was being investigated through a pilot project at J. C. Fletcher Elementary.

Table 4.3
Assessment Supports as Outlined in the PSD Matrix

Aligned assessments	Our mathematics program will incorporate a variety of assessments that are purposefully aligned to the NC Standard Course of Study, district pacing guide and the district reporting tools.
Assessment matrix	Our mathematics program will have a grade level assessment matrix that is focused on specific concepts and skills along with standard assessment strategies
Formative assessments	Our mathematics program will promote common formative assessments that are aligned with the concepts and skills at each grade level of the NC Standard Course of Study
Authentic assessments	Our mathematics program will incorporate authentic assessments where students are asked to demonstrate understanding of key mathematical concepts
Quarterly assessments	Our mathematics program will utilize teacher created districtwide quarterly assessments that are aligned with the district grade level pacing guide and reporting tools.
Students assessment records	Our mathematics program will monitor and record each student's understanding of key fundamental concepts that are the building blocks for future student success in mathematics
Self assessment	Our mathematics program will provide students with the opportunities and strategies to self assess and become more reflective, independent learners

As PSD teachers began their third year of using the common curricular materials, resignations, retirements and budget cuts resulted in the elimination of the mathematics and science departments including the Coordinator at the central office in the district. Two teacher leaders were hired to help lead teams of teachers, much like the EMLT, in unpacking the CCSSM and mapping the expected quarterly learning outcomes. Elementary teachers were doing the same work, simultaneously, in language arts and science, preparing for the wholesale changeover of standards in all subject areas in North Carolina beginning fall 2012.

At the start of the 2011–2012 school year, PSD was in year 4 of Title I District Improvement, having missed targets in mathematics. Within the broad context of a district engaged in many initiatives and activities to increase student achievement, PSD administrators also committed significant resources to put in place a districtwide formative assessment and intervention process to improve mathematics teaching and learning with a focus on grades 2 and 3. This formative assessment and intervention project was the focus of the current investigation.

Districtwide Mathematics Formative Assessment Project

Applying formative assessment approaches systemically across schools and districts can be a challenge. At the time the North Carolina Department of Public Instruction (NC DPI) was looking at assessments on which to base the Mathematics Assessment Pilot, the Assessing Math Concepts (AMC) assessments had two particular advantages: (1) they assessed the counting/number combinations knowledge appropriately and went a bit further and (2) they were the only assessments that were also available electronically.

During the 2009–2010 school year, as NC DPI was implementing their Mathematics Assessment Pilot, J. C. Fletcher Elementary was also implementing a formative assessment pilot using the AMC Anywhere materials. The J. C. Fletcher pilot, however, was implemented much more comprehensively than at the state level and was based on previous experiences using AMC materials, experiences which laid the foundation for the district implementation the subsequent year.

AMC Pilot Project – J. C. Fletcher Elementary. In the fall of 2008, Theresa Fortino began working as the AIG teacher at J. C. Fletcher elementary, having recently served as an AIG at the middle school level. As part of her participation in the state grant, Ms. Fortino was asked to conduct seminars with her colleagues based on one of the topics of focus in the grant. Ms. Fortino chose to focus on high cognitive demand tasks, infusing that topic with identifying and addressing the needs of gifted students. The dilemma, however, was that she was unsure of how to appropriately identify students in need of enrichment in the primary classrooms, where standardized assessments are not used and, therefore, results are not available to aid in that identification process.

What resulted from Ms. Fortino's dilemma was the first iteration of a schoolwide use of AMC assessments to identify the individual needs of students in mathematics. These first assessments used a paper/pencil approach, generating a form with recorded responses and results for every student assessed. Although the original purpose was to identify students in need of enrichment, the assessment process was conducted schoolwide and was equally capable of identifying those students in need of interventions other than enrichment.

Although this first use of AMC assessments was illuminating, the results did not affect change in the classrooms on a broad scale. This was primarily attributed to the fact that one team of educators did a schoolwide sweep of students, conducting the assessments and presenting the completed forms to the classroom teachers. Teachers had neither the time to compile and disaggregate data nor an understanding of the assessments themselves to make the results actionable.

What had worked well in this first iteration, however, was the fact that Ms. Fortino and her colleagues, Myra Brendel and Audrey Mitcham, both interventionists, were able to identify students who needed enrichment or intervention as well as pinpoint their area of greatest need. This success spurred the continued development of the formative assessment and intervention process at J. C. Fletcher Elementary. The progression of that process is presented in Table 4.4. By the time J. C. Fletcher joined with the NC DPI pilot project teachers for training in January 2010, they were able to take that new information to refine and extend the process being established within their school.

Table 4.4
Progression of Formative Assessment and Intervention Process at J. C. Fletcher

Year	Activities
2008–2009	In satisfying requirements of a grant, Ms. Fortino seeks to find a tool that will help to identify students in grades K–2 in need of enrichment in mathematics. • Ms. Fortino leads a group in using paper/pencil AMC assessments • Results given to teachers as individual assessment papers • Results are not actionable for teachers Two researchers use university grants to explore ways to help teachers make sense of the AMC assessments and results
2009–2010	University grant used to further expand and focus the K–3 pilot at J. C. Fletcher through: • Participation in NC DPI Pilot training • Training beginning in January 2010 • Purchase and use of PDAs • Purchase and use of intervention materials Just prior summer break, teachers debriefed their experiences using the formative assessment and intervention process and laid out a plan for full implementation in grades K–3 for the 2010–2011 school year.
2010–2011	Continuation of pilot at J. C. Fletcher • Use of Web-based AMC assessments called AMC Anywhere Background information sessions about AMC Anywhere held with teachers and administrators at Birchwood Elementary and Yongedell Elementary
2011–2012	Districtwide training and implementation at second and third grades

At J. C. Fletcher, teachers not only gathered data through the use of the AMC assessments, they also analyzed those data and established a schoolwide intervention process to address student needs as they were revealed. Time was set aside at each grade level for teachers to do additional intervention work with students who required intervention to develop the essential understandings for their grade level.

In the winter of 2010, J. C. Fletcher initiated their most comprehensive formative assessment and intervention approach to address the mathematics learning needs of their students in grades K–5. It was this comprehensive approach that was the basis for the formative assessment and intervention process that was implemented district wide during the 2011–2012 school year.

As Melinda Wehling explained, the decision to take the formative assessment and intervention process districtwide was based on the successes and lessons learned from both the districtwide expansion of the whole-to-part literacy intervention model and the AMC pilot at J. C. Fletcher:

> In the meantime . . . our literacy model of intervention was going so beautifully, that was now adopted districtwide and we were looking for something in the math arena . . . I was offered the position of Elementary Director for the district. One of my charges was mathematics because we were still in LEA improvement in math. And because I had Title 1 as one of my areas of responsibility, I was able to use Title 1 money through LEA improvement to work with every school in the district in the area of math.

In anticipation of the difficulty teachers might have implementing the formative assessment and intervention process, PSD administrators assembled a district implementation team to support teachers in grades 2 and 3 with the implementation. This team, composed of three district teacher leaders and one mathematics educator[6], worked collaboratively with teachers to implement this formative assessment and intervention process during the 2011–2012 school year. At their initial planning meeting, the district

[6] As was previously noted in the Methods chapter, the author was one member of the collaborative team working with 3rd third-grade teachers during this implementation year.

team discussed grade levels in which to begin the implementation, number and focus of sessions, and windows for completing assessments. Notes from this planning meeting are included in Appendix G. The implementation plan that resulted from this initial meeting identified dates, general topics, assessments of focus for each grade level, and implementation team responsibilities for both grade 2 and grade 3. The AMC Implementation Plan is included in Appendix H and the AMC Districtwide Implementation Activities, listing all activities that occurred during the year of this study, is included in Appendix I.

Materials purchased for all schools included manipulatives and the companion intervention activities associated with the AMC assessments. At a second planning meeting in September 2011, the implementation team finalized details for the first professional development sessions and school-based support days. Later that week the team met to organize the support materials that were purchased to be distributed to the schools during the upcoming training.

Across grades, the general format and intent of the implementation project was the same. Teachers met with mathematics educators along with the other teachers on their grade-level teams for full- or half-day workshops over the course of the year. Sometimes support personnel, such as special education teachers, would join these sessions. Workshops focused on mathematics knowledge for assessing students' through the formative assessment program and pedagogical knowledge associated with teaching selected interventions associated with those assessments. Workshops also intentionally offered opportunities for teachers to discuss issues and ask questions related to assessments and interventions currently underway. In addition to these ongoing sessions, the district team members visited each school on a rotation and as requested.

The third-grade teaching teams from all elementary schools, including the two case study schools, met for workshops four times during the school year. Although all of these workshops focused on number concepts with a specific focus on place value assessment and intervention, the topics for each individual workshop are presented in Table 4.5. Pedagogical issues were continuously discussed alongside a focus on mathematics content, however sessions 3 and 4 included particular attention to pedagogical topics. These included instructional use of targeted mathematics activities and games, engaging students in explanation and justification of mathematical ideas, and the teacher's role in supporting students in their developing understanding of place value within whole-group, small-group, and individual contexts.

Table 4.5
Focus of Third-Grade Workshops

Session	Major Workshop Topics
1	Understand the purpose, rationale and history behind this project Connect the AMC assessment tasks to curricular materials, Common Core, RTI, and PLCs Determine the rationale for this type of assessment Learn to complete the Grouping Tens Assessment using the AMC Anywhere software
2	Debrief experiences administering the Grouping Tens assessment Run reports using the AMC software Compare/Contrast different reports and the information they highlight Link assessment with instruction Focus on Intervention Become familiar with the materials in the intervention kits Determine a timetable for administering assessments
3	Analyze data to identify students' needs Understand various ways to provide intervention for Tiers 1, 2, and 3 for RTI Establish a model of intervention Plan activities for the model of intervention
4	Present and celebrate growth Share strategies that enabled growth Examine strategies for effective differentiation of mathematics Focus on next steps for nonproficient students Plan for vertical articulation between second- and third-grade teachers Plan for vertical articulation between third and fourth grade teachers

Workshops typically began with schools sharing their experiences implementing the assessment and intervention process and airing questions and concerns that had arisen since the last meeting. At times, this portion of the meeting took much more time than was considered by the district leadership team to be ideal, however, in most cases, the teachers described this sharing out to be very beneficial to their own implementation processes. Next, the team led teachers through activities related to the mathematics content and pedagogical foci of the session. Typical activities in this part of the sessions included discussion of videos of student assessment, data analysis, linking student assessment data with intervention activities, and discussions of students' mathematics development. Then, when appropriate, workshops ended with teachers setting goals for their grade level assessment and intervention process and making plans for school-based support activities with the district leadership team member assigned to their school.

As part of the implementation process, the third-grade team at each school was assigned one member of the district implementation team as their contact and support person. Grade levels or individual teachers would typically make arrangements at the end of a session with their contact person to provide support on a particular date. Most often, teachers requested support in the form of modeling a particular assessment, attending PLC meetings to discuss particular issues related to the implementation process, modeling an intervention activity, or clarifying aspects of a particular training session.

Teacher feedback throughout the school year and on end-of-year evaluations indicated that teachers found the districtwide implementation process to have been helpful in supporting their use of formative assessment and intervention in their classrooms. Teachers expressed that the sessions helped them feel more confident with their implementation of AMC assessments, use of the intervention activities, and generally more knowledgeable about elementary school mathematics and how children develop mathematically. In addition, teachers felt that the school-based support helped them to see how the formative assessment and intervention practices discussed in the sessions might work with their own students. Although most of the feedback on the formative assessment and intervention implementation was positive, teachers also expressed concern about being out of their classrooms so frequently for this and other professional development. Teachers expressed that, in the following school year, they would like to continue with mathematics professional development with meetings scheduled after school to minimize time out of their classrooms.

Summary of the District Context

During the year of this study, PSD was intent on improving student learning in mathematics. The district had made many positive strides in recent years, which were attributed to the development and implementation of a districtwide mathematics program, adoption and use of common instructional materials, and formation of a districtwide mathematics leadership team. In turn, the success of these initiatives was attributed to ongoing professional development efforts. With this in mind, PSD administrators hired a team of three district teacher leaders and one mathematics educator to provide professional development in the form of ongoing sessions throughout the 2011–2012 school year when it was decided to expand the formative assessment and intervention process from a pilot program at one school to a districtwide initiative. The goal of these sessions was to support teachers' use of this new process and transition to formative assessment-based instructional practices in mathematics. Other initiatives begun during the same year competed for teachers' time and focus, making it challenging for them to keep up with all that was expected of them. Despite this, teachers began to implement the formative assessment and intervention process in their classrooms with the purpose of impacting the mathematics learning of their students.

The Case Study Schools and Their Teachers

The two case study schools began the year of this study with very different experiences in relation to formative assessment and intervention in mathematics. In particular, the first case study school, J. C. Fletcher, had participated in various professional development and research projects focused on using AMC as the foundation for formative assessment and interventions beginning in 2008. During the 2009–2010 school year, each of the third-grade teachers at J. C. Fletcher had participated in a K–3 pilot study using a technology-based version of AMC and had continued and extended that work throughout 2010–2011. The case of J. C. Fletchers represented the most experienced perspective, serving as the vanguard for the district implementation process.

In contrast, none of the Meadow Lake teachers had previously participated in professional development related to formative assessment and intervention in mathematics. These teachers had no prior experience with the materials utilized throughout the implementation of the formative assessment and intervention process in PSD. This second case represented the least experienced perspective, exemplifying the more typical experience of schools within the PSD. Meadow Lake teachers did, however, report an understanding of the importance of helping students develop conceptual understanding of mathematics and the role of assessment in supporting that development.

The teachers at both case study schools entered the year of this study both excited and apprehensive about the districtwide implementation of the formative assessment and intervention process. Each of these schools also began the year with new principals, presenting a shift for even the more experienced J. C. Fletcher teachers as the districtwide implementation began.

Although the teachers in two schools of focus in this study share some commonalities, they have varied backgrounds and experiences. Furthermore, there was significant variation in the composition of the two case study schools' students. A summary of demographics by school, including a focus on third grade, is provided in Table 4.6.

Table 4.6
Student Demographics of Case Study Schools

		Gender %		Race/Ethnicity %				School Services %			
School	n	M	F	B	H	W	O	ED	AIG	EC	LEP
J.C. Fletcher	456	52	48	27	21	48	4	60	5	13	10
Grade 3	78	55	45	35	15	46	4				
Meadow Lake	605	48	52	9	38	49	4	57	9	13	24
Grade 3	95	43	57	9	37	48	6				

B=black; H=Hispanic; W=white; O=other; ED= economically disadvantaged; AIG = academically and intellectually gifted; EC=exceptional child with disability; LEP = limited English proficiency.

In the sections that follow, aspects of each case study school's background and that of the teachers who comprise the embedded cases will be described.

The School Context: J. C. Fletcher Elementary

For this study, two third-grade teachers and one interventionist comprise the embedded cases within the case of J. C. Fletcher Elementary. In this section, a portrait of the school context in which these teachers work will be presented as a backdrop for consideration of each embedded case. First, attention will be given to the school culture, history, and demographics. Next, aspects of the background and current teaching context for each of the embedded cases at J. C. Fletcher will be described.

School Culture, History, Demographics

J. C. Fletcher Elementary is the most geographically remote school in PSD. The school serves 456 students from kindergarten to grade 5. The school also houses two prekindergarten classes that are not included in the elementary population count. Based on the low socioeconomic status of the student population, J. C. Fletcher is a designated Title I school that receives supplementary funding from the federal government.

The student population at J. C. Fletcher consists of 48% White students, 27% Black students, 21% Hispanic students, and 4% from other racial/ethnic designations. With nearly 60% of those students qualifying for free or reduced lunch, J. C. Fletcher has the highest percentage of students identified as Economically Disadvantaged (ED) in the district. The intervention needs of J. C. Fletcher's student population are significant. A recent analysis completed by a local university professor using a long-standing behavior rating scale revealed that 24% of the J. C. Fletcher student population in need of Tier III prosocial behavior intervention. When students in the Tier II category are added into the total, nearly 200 students reveal a need for varying levels of support. In response, the administration at J. C. Fletcher implemented initiatives focused on addressing students' needs, some of which required teachers to discuss readings from books and articles chosen by administrators or the committee that was charged with, "working on finding articles and some things we can do through PLCs to just get a better understanding . . . so we can change what we can, which is us and how we're addressing things."

Based on their 2010–2011 data, J. C. Fletcher Elementary was in year 1 of Title I School Improvement going into the year of this study. In addition, J. C. Fletcher had not made adequate yearly progress, but had been designated a School of progress (60%–80% of students at grade level) and Expected Growth (a measure of student learning achieved in one year). Although the percentage of students achieving at or above grade level increased on the 2011–2012 EOG assessment and the number of performance targets met had increased to 81%, the school was given a designation of No Recognition. This indicated that although 60% or more of J. C. Fletcher students in grades 3–5 scored at or above grade level, they had not demonstrated at least 1 year of growth from the previous year. Data for J. C. Fletcher Elementary for years 2009–2012 are presented in Table 4.7.

Table 4.7
Data Snapshot – J. C. Fletcher Elementary

		2009	**2010**	**2011**	**2012**
		Percentage of Students At or Above Grade Level			
NC EOG Math Grade 3	JCF	85.7%	71.80%	78.90%	79.49%
	PSD	86.2%	81.30%	84.29%	86.96%
	NC	81.3%	81.90%	82.10%	82.80%
		Status			
ABC Status		–School of Progress –Expected Growth	–School of Progress –Expected Growth	–School of Progress –Expected Growth	No Recognition
		Percentage of Goals Met			
AYP Data	JCF	100%	88.2%	76.5%	81.0%*
	PSD	90.7%	83.3%	70.7%	98.4%*

*AMOs for mathematics and reading were recalculated for the 2011–2012 school year as part of the U.S. Department of Education flexibility waiver granted to North Carolina.

In total, 38 teachers worked at J. C. Fletcher. As a group, teachers' years of experience differed significantly from the district and state statistics, as illustrated in Table 4.8. At the time of this investigation there were five National Board Certified Teachers at J. C. Fletcher and 37% of the faculty had advanced degrees. J. C. Fletcher administrators cited the staff as one of the strengths of the school:

> . . . just an amazing group of people. There's a lot of cohesion and I think an amazing amount of dedication too. So folks are very, very dedicated and interested in improving. So they're reflective. And . . . as a whole . . . I feel like these teachers work well within their teams. . . .

Table 4.8
Years of Teaching Experience – J. C. Fletcher

	0–3 Years	**4–10 Years**	**10+ Years**
J. C. Fletcher	32%	32%	37%
District	19%	29%	52%
State	18%	32%	50%

At 8%, the teacher turnover rate at J. C. Fletcher was below both the district rate of 9% and the state rate of 12%. According to the North Carolina Teacher working conditions survey conducted during the year of this study, 94.7% of teachers at J. C. Fletcher agreed with the statement, "Overall, my school is a good place to work and learn".

At J. C. Fletcher, decision-making took place on multiple levels, from individual teachers within a grade level, to grade level teams, to decisions made by the entire staff. When making decisions based on requirements from the district or state, the administrators sometimes sought the input of the faculty to gather information and support to help make those decisions purposefully. Grade levels made most decisions through their PLCs. The administration at J. C. Fletcher reported that the PLCs were strong and within the PLC meetings teachers engaged in the process of setting goals, analyzing student data, and making decisions rather than simply acting as a typical grade level meeting focusing on logistical and administrative tasks. J. C. Fletcher teachers generally expressed appreciation for the ability to provide input for decisions and the many professional development opportunities at the school. However, teachers also reported being overwhelmed by the time involved in providing that input and the multitude of simultaneous initiatives they were expected to learn about and implement.

J. C. Fletcher Elementary – The Embedded Cases

Elaine Crumbley. During the year of this study, Ms. Crumbley was in her third year of teaching. She had attended a traditional university-based teacher education program and joined the J. C. Fletcher third-grade team immediately after graduating. As part of her teacher education program, Ms. Crumbley completed courses on elementary mathematics content and elementary mathematics methods. Ms. Crumbley graduated with a double major in Special Education and Elementary Education.

The summer prior to this study, Ms. Crumbley began pursuing her master's degree, choosing a program focused on literacy to address and area she considered to be her weakness. Her graduate coursework entailed completing an action research study. She created a site to present the findings of her research in lieu of writing a paper.

Ms. Crumbley was the newest member of the J. C. Fletcher third-grade team. With a background in Special Education, she frequently taught the classroom with a cluster of students with disabilities with extra push-in support from the special education personnel. Being hired at the beginning of the 2009–2010 school year, Ms. Crumbley had been part of the formative assessment and intervention process at J. C. Fletcher for her entire teaching career.

Laurie Athey. Ms. Athey grew up in the vicinity of J. C. Fletcher Elementary, graduated from a nearby school system, and completed an undergraduate degree in communications. After that, she immediately completed a degree in elementary education. Ms. Athey then joined the J. C. Fletcher third-grade team and had taught there for 5 years at the time of this investigation.

Ms. Athey received her master's degree a year prior to this study with a focus on literacy. Her goal in pursuing this advanced degree was to eventually become a reading interventionist or a literacy coach, assisting struggling readers at the elementary school level. Her research focused on students' facility with technology, schools' preparedness for upcoming computer-based standardized tests and how literacy instruction might be modified to incorporate some of general computer knowledge students will need to ensure they will be assessed on what they know about literacy, not on their experience with technology.

Having taught third grade at J. C. Fletcher for the previous 5 years, Ms. Athey was one of the senior members of her team. She and her primary teaching partner, Marcia Eury, were the architects of much of the formative assessment and intervention processes in place in third grade at J. C. Fletcher. Within the context of that process, Ms. Athey typically worked with and addressed the needs of those students with mild to moderate intervention needs.

Audrey Mitcham. Ms. Mitcham was a teaching assistant serving as an interventionist at J. C. Fletcher Elementary. She worked with sales and marketing in the computer industry for 15 years, a job she resigned from to be home with her children. When her children started school, Ms. Mitcham began to volunteer in their classrooms and, eventually, in other classrooms as well. What began as mostly administrative tasks turned into conducting reading and mathematics groups and eventually to administering particular assessments the teacher had taught her to conduct. This volunteer work became a long-term substitute position for a teacher on maternity leave and then a position as a permanent substitute at the school.

When the assistant principal at the school where Ms. Mitcham volunteered was named principal of J. C. Fletcher, he asked Ms. Mitcham if she would come work there as a tutor interventionist, still working part-time. Her primary focus at that time was to work with students in grades 3–5 to get them ready for the state mandated End of Grade tests. Interacting with these students, Ms. Mitcham came to understand that what was most needed was intensive work on foundational skills that would give these children access to grade-level content. Ms. Mitcham attended several staff development sessions focused on elementary mathematics and incorporated what she learned into her work with students.

Three years prior to this study, another principal hired Ms. Mitcham as a full-time teaching assistant, planning and conducting intervention groups with students K–5. Ms. Mitcham was part of the J. C. Fletcher team who lead the implementation of the AMC pilot during the 2009–2010 school year and began to use the assessment and intervention materials within her groups. During the year of this study, Ms. Mitcham was leading intervention groups in both reading and mathematics at various grade levels.

The School Context: Meadow Lake Elementary

Within the case of Meadow Lake Elementary, one third-grade teacher and one interventionist comprise the embedded cases for this study. In the following section, a portrait of the school context in which these teachers work will be presented to provide a backdrop for consideration of each embedded case. The culture, history, and demographics of Meadow Lake will be presented first, followed by a description of the background and current teaching context for each of the teachers that make up the embedded cases for Meadow Lake Elementary.

School Culture, History, Demographics

Meadow Lake Elementary is the southernmost school in PSD. The school serves 605 students from kindergarten to grade 5. Based on the low socioeconomic status of the student population, Meadow Lake is a designated Title I school that receives supplementary funding from the federal government. The student population at Meadow Lake consists of 49% White students, 38% Hispanic students, 9% Black students, and 4% from other racial/ethnic designations. With nearly 58% of those students qualifying for free or reduced lunch, Meadow Lake has the second highest percentage of students identified as Economically Disadvantaged (ED) in the district.

Approximately 40% of the students at Meadow Lake are Hispanic, the highest percentage for all schools in the district and two and a half times the district average. This has been a significant demographic change in the student population of Meadow Lake over a short period of time. The Hispanic population made up 7% of the student body at Meadow Lake 6 years ago, a group comprising two students 2 years prior to that. The administration at Meadow Lake has implemented initiatives focused on involving all families within the school, but a specific focus has been identifying and addressing the needs of both students and families in this part of their school community. Explaining that support, Craig Tesar, Meadow Lake assistant principal, stated:

> We are actively trying to get all of our parents involved. We have a SIT team – School Improvement Team – that encompasses teachers, parents, administration and the goal is to address the student, school improvement goals and meet monthly to update the team where we are with the school . . . Last year we started with a Hispanic SIT team . . . One of our outreach specialists . . . meets with them . . . their concerns are a little bit different. It's not necessarily academic concerns. It's . . . expectations and the needs of their children when they're here . . . How can they support their child?

The language needs of Meadow Lake's student population were significant, with 23.5% identified as Limited English Proficient (LEP) the second highest percentage district wide and more than three times the district average. According to their School Improvement Plan, Meadow Lake's faculty and staff were addressing the needs of these students with positive results. In grades 2–5 there were high numbers of students in the "expanding" and "bridging" proficiency levels in overall score and there was significant progress in the amount of students exiting the Limited English Proficiency program (LEP).

Although the percentage of students achieving at or above grade level in both reading and mathematics decreased from the 2010 to 2011 EOG's, as did the percentage of AYP goals that were met, Meadow Lake Elementary was designated a School of Progress, High Growth. This indicated that at the beginning of the year of this study, according to EOGs, 60%–80% of students in grades 3–5 at Meadow Lake were performing at grade level and had made more than one year of growth during the previous school year. Both the achievement and AYP percentages for Meadow Lake increased from 2011 to 2012, with approximately 85% of students performing at or above grade level in mathematics, 68% in reading, and adequate yearly progress made with 100% of performance targets met. Data for Meadow Lake Elementary, including third-grade mathematics results, for years 2009–2012 are presented in Table 4.9.

Table 4.9
Data Snapshot – Meadow Lake Elementary

		2009	2010	2011	2012
		Percentage of Students At or Above Grade Level			
NC EOG Math Grade 3	ML	83.7%	84.40%	76.50%	86.74%
	PSD	86.2%	81.30%	84.29%	86.96%
	NC	81.3%	81.90%	82.10%	82.80%
		Status			
ABC Status		–School of Progress –High Growth	–School of Progress –High Growth	–School of Progress –High Growth	–School of Progress –High Growth
		Percentage of Goals Met			
AYP Data	ML	100%	100%	69.6%	100.0%*
	PSD	90.7%	83.3%	70.7%	98.4%*

*AMOs for mathematics and reading were recalculated for the 2011–2012 school year as part of the U.S. Department of Education flexibility waiver granted to North Carolina.

Looking deeper into these data, despite evidence of overall growth at Meadow Lake, administrators stated concern that these numbers mask an underlying lack of growth for students identified as academically and intellectually gifted (AIG):

> One of the other challenges was . . . that our AIG cluster, they're not making the growth that they should be making. That's just like our EC group not making the

growth, it's on the other end of the spectrum. . . . Yes, they're mastering, they're passing the test, but are they making the growth?

In total, 48 teachers worked at Meadow Lake. As a group, the faculty's years of teaching experience mirrored the district statistics and closely aligned with those of the state, as illustrated in Table 4.10.

Table 4.10
Years of Teaching Experience – Meadow Lake

	0–3 Years	**4–10 Years**	**10+ Years**
Meadow Lake	19%	29%	52%
District	19%	29%	52%
State	18%	32%	50%

There were 15 National Board Certified Teachers at Meadow Lake and 46% of the faculty held advanced degrees, both of which were higher than the averages at both the district and state levels. Meadow Lake administrators cited the staff as one of the strengths of the school:

> I think it is a supportive staff that truly cares about the kids and the families as people. I think that there is . . . some excellent staff in the building. Just topnotch . . . glad I'm an administrator, because I get to go in and say . . . 'I should have done that when I was teaching.' So that's good! Love that.

At 9%, the teacher turnover rate at Meadow Lake is comparable to that of the district and below the state rate of 12%. According to the North Carolina Teacher working conditions survey conducted during the year of this study, 92.3% of teachers at Meadow Lake agreed with the statement, "Overall, my school is a good place to work and learn".

At Meadow Lake, teachers were active in the decision-making process and were open to making their opinions known. Administrators at Meadow Lake utilized technology to elicit feedback from faculty and staff to efficiently gather information and support to help make those decisions purposefully.

> I think teachers understand that there are certain things that are just mandated and we just. . .you have to do them. There's no resistance when it comes to those types of decisions. But things that they have a direct involvement in, by gum they're gonna speak their mind and they're going to express their concerns. For the most part, I think administration . . . we listen. We listen and . . . we make the final decision based on their opinions. With Google Docs, that has been very, very helpful in my years of teaching. When it's kind of difficult to get to everybody, all we have to do is create a document where they can respond and we hear immediate feedback without having to chase people down and gather people around. That has been very, very instrumental in . . . the things that they have a say in.

Grade levels made most decisions through their PLCs. Meadow Lake administrators reported that the PLCs needed to become stronger so that within the PLC meetings teachers are, "really looking at where are our kids at, how are we going to move them forward, who's going to pick up the pieces, how are we doing, how do we improve it?" rather than determining the next field trip. Nathan Parkin, principal of Meadow Lake, summed up this need for stronger PLCs:

> We have a lot of good teachers here. We have to move to great . . . And the difference is, it's becoming more reflective in what we do. And knowing that no

matter how good I am, when one of my kids fails, that's me – that I didn't do something right.

On the 2011–2012 NC Teacher Satisfaction Survey, over 91% of teachers at Meadow Lake expressed satisfaction with their ability to provide input for decisions and approximately 81% were satisfied with the many professional development opportunities provided at the school. However, teachers also report being overwhelmed by the time involved in the various initiatives they were expected to learn about and implement.

Meadow Lake Elementary – The Embedded Cases

Nina Arrigo. At the time of this study, Ms. Arrigo was in her 11th year of teaching and her fifth year teaching third grade at Meadow Lake Elementary. She received her BA in Interdisciplinary Studies and an MA in Elementary Education. Ms. Arrigo taught for 6 years in fifth and sixth grades in another state, serving as both a gifted education teacher who looped with her class and the school mathematics coach. After arriving in North Carolina, Ms. Arrigo worked as an outdoor educator in a science camp at a state park, something she says she wished she had done right out of college but which did not pay very well. The science camp was a week-long overnight camp during which Ms. Arrigo and the campers lived out in the woods, hiked, and used a lab-type structure to investigate the wetlands.

Ms. Arrigo had been teaching at Meadow Lake for five years. Although she stated, "I can't stand science classes. I sucked at them all through college," Ms. Arrigo has been a science leader in her building and district. With her rich background in informal, experiential science education, she had been instrumental in establishing a summer science camp with a focus on hands-on, problem-based science experiences.

Ms. Arrigo also trained to be a lead teacher for a districtwide grant partnership between PSD and a local science and nature group, although summer scheduling conflicts prevented her from being able to do it.

Ms. Arrigo was also active in mathematics in the district. She was part of the third-grade team at her school when they piloted one of the mathematics programs during the districtwide adoption process and provided feedback to the district and her colleagues throughout the year. Ms. Arrigo was also part of a second- and third-grade study group for 2 years, participating in monthly meetings for several hours after school. These meetings included topics such as Cognitively Guided Instruction (T. P. Carpenter et al., 1999), leading productive mathematics discussions, and implementation of the pilot program materials.

Debra Bardsley. Ms. Bardsley was in her 34th year of teaching during the year of this study. She received her BA degree in Elementary Education and a masters' degree in administration. Ms. Bardsley had taught in several states and a handful of counties within North Carolina. Throughout her career, Ms. Bardsley served as a classroom teacher, assistant director of Title I, interventionist, and math teacher. Her teaching career began in 1st grade and included teaching every grade level from kindergarten to 6th grade throughout her first 14 years. For most of the last 20 years she has taught math, serving as an interventionist in diverse school settings, ranging from affluent to Title I.

At Meadow Lake, Ms. Bardsley works to support 14 teachers in grades 3, 4, and 5. During fifth grade mathematics time, Ms. Bardsley supported both teachers' regular mathematics instruction and enrichment time. At third grade, her work focused on supporting teachers in their implementation of the formative assessment and intervention process, primarily through leading intervention groups. The fourth-grade work was less structured, what Ms. Bardsley described as ‘catch as catch can’. Ms. Bardsley was an active member of grade level PLC meetings and supported teachers’ work at every grade.

As the implementation process began at Meadow Lake, Ms. Bardsley realized that the K–2 teachers at her school needed support in their efforts to prepare students to be ready for third grade. She wrote a grant seeking funding for staff development funding, manipulatives and materials to support her K–2 teachers and was awarded the grant in the spring. Ms. Bardsley ordered materials and planned to sort and prepare them during the summer, with a rollout meeting scheduled to take place at the beginning of the 2012–2013 school year to introduce teachers to these new resources.

It was within the context of these schools and this school district that the implementation of a formative assessment and intervention process occurred. Now that an overview of the two case study schools and their teachers have been shared, attention will turn to presenting the case of each school, starting with Meadow Lake Elementary.

The Case of Meadow Lake Elementary

Meadow Lake Elementary entered the year of this study with no prior knowledge of or experience with the formative assessment and intervention process that was being implemented in PSD. Teachers in grades 2 and 3 had participated in professional development activities focused on mathematics over the last several years, but they reported not having had any formal training in formative assessment.

Meadow Lake teachers did report an understanding of the importance of helping students develop conceptual understanding of mathematics and some experience using formative assessment, as they understood it. The faculty and staff at Meadow Lake

Elementary had worked hard to meet the needs of a rapidly changing student population and had benefitted from a supportive administration. Yet, with a new principal leading the school, numerous district initiatives, and the formative assessment implementation, teachers were presented with many challenges to address throughout the year this study was being conducted.

The case of Meadow Lake Elementary that follows is presented in four sections with detail provided through the experiences reported by Ms. Arrigo and Ms. Bardsley, the teachers who represent the embedded cases. In the first section, evidence of the challenges Meadow Lake teachers faced as they worked to implement the district wide formative assessment and intervention process and the ways in which they worked to address those challenges will be presented. Next, the challenges of and responses to making sense of assessment data will be explored followed by teachers' reactions to challenges faced when making instructional decisions based on those data. Finally, the impact on student achievement will be presented.

Implementation of the Formative Assessment Process – Meadow Lake

Prior to implementing this formative assessment and intervention process, Meadow Lake teachers had already established a grade level routine for writing, administering, and grading what they referred to as 'common formative assessments'. They also worked as a grade level to review results and conduct interventions based on those results. As Ms. Arrigo explains:

> . . . I guess during my first year that we were here we did . . . DuFour training – and we sort of revamped the whole way that the third grade has historically done assessments here and we made up formative assessments per skill, or small clump

> of skills at least, and started administering those . . . whenever it naturally fell into the skill and maybe every other week roughly. We generally still do this . . . And then within like the next week, we'd pull as many adults as possible to be in charge of those groups and hone in on what that weakness was . . . it was often just going back to number sense, because ultimately that was, oftentimes, the root of what was wrong, that they were lost in everything because they didn't have number sense to begin with. And so instead of trying to teach them adding up fractions, it's like "Well let's just talk about the basics in fractions." And then the high group that had all of it, they would be doing some enrichment, and that was generally a large group and a teacher would have 25–26 kids in that group doing enrichment and the other group as small as we could possibly make it with as many teachers.

At the beginning of the implementation process during the year of this study, then, having already established their own assessment process as the norm, the foremost concerns for Meadow Lake teachers included the challenges of purpose, preparation, time, and resources, all of which were infused with emotions that resulted from and were related to change and the implementation process.

Purpose. Having developed a system they felt was working for their students, the teachers at Meadow Lake needed to be convinced that the district had a clear and convincing purpose for the different approach to implementation that was the focus of this investigation. Furthermore, they had to be convinced that they would be provided all the tools and skills necessary to robustly implement the new process, and that they would be allowed time to do this work well. In talking about his teachers, Assistant Principal Craig Tesar said:

> I think there has to be a clear understanding. Teachers have to have an understanding of what is expected of them before they embark on it . . . I mean, for complete, total understanding of what this is going to entail.

At the first training session in September, Ms. Arrigo specifically asked about the rationale for implementing this program. Although many of the teachers questioned how the use of AMC Anywhere assessments and the interventions would fit within the scope of their adopted curricular materials, Ms. Arrigo's question was, "Is this all to fill in gaps/weaknesses that [our curriculum] did not address these past 4 years?" Ms. Arrigo also questioned, "Why did we administer the district beginning of year test?" indicating that the implementation team had not yet made clear to her, and others, the purpose of formative assessments that were the basis of the districtwide process. In contrast, several of the teachers included in their daily reflection that they had learned, "the reason we are learning about these assessments," and "the History of AMC project / Purpose of the assessment," during the session. Although some teachers appeared to understand and accept the stated purpose of the project early on, for others it took more time. Although the district implementation team had addressed the purpose and history of the process as a major part of the first session, Ms. Arrigo and a handful of others needed more convincing that this process was going to be beneficial to their students and their instructional practice to buy in to the rationale for implementing another assessment system in PSD.

What the Meadow Lake teachers began to observe as they began to use AMC with their students was that the approach helped them identify student needs more specifically and address those needs more strategically and efficiently than their previous assessment system. Through direct experience, Meadow Lake teachers came to understand the stated purpose of implementing this assessment and intervention process. Ms. Arrigo shared her experience as student needs began to emerge through using the assessments:

> . . . with the AMC assessments after we assessed everybody, very quickly too, . . . it was able to get them up and see specifically where the hole was. And we liked that a lot 'cause we just never knew how to address it with those low kids and we were just 'Well they need number sense.' . . . and logically, we knew that. We just didn't know how to address it, label it.

As Debra Bardsley explained, the AMC assessments did help the Meadow Lake teachers identify student needs with specificity:

> And so AMC did correlate the fact that you start with this huge mass spectrum and then you get down to a certain spot. And it's like if we can get them to understand this one thing, maybe that will help them go to the next . . .

By the end of the training sessions in January, Meadow Lake teachers began to not only see and understand the purpose of implementing this formative assessment process, but were also beginning to connect this work as a cohesive part of some of the upcoming initiatives they would soon be asked to do, particularly the implementation of the Common Core State Standards for Mathematics in 2012–2013. As one member of the district implementation team who worked with the Meadow Lake teachers said:

> I think teachers as a whole . . . generally understand why we're moving to the performance-based assessment . . . they understand that we are gonna look at [students'] thoughts and it's more important . . . how they got the answer than the right answer. And so they're shifting. I can't say all teachers because I only know for sure just the ones I've worked with on math are shifting. We're not changing our performance assessments just because we're changing the assessments. We're changing it because Common Core is changing the way we're teaching . . . because we want to see what kids can do and what kids can think and how they process. And [one teacher] said, 'Yes, if we're going to teach that way then we need to be able to assess that way, because you need to be assessed in that way in a classroom.'. . . and it's coming up in conversation. So I feel like we're prepared and I think it has to do with a lot of the AMC stuff.

In the end, teachers at Meadow Lake came to understand the purpose of the AMC implementation as a result of using the formative assessment and intervention approach with their own students. Some felt they understood the purpose after the initial professional development session, but for others the fact that they already had a similar process in place made it more difficult for them to fully embrace the shift to this new approach. As soon as they started to use the approach and saw how it improved their ability to understand and address the needs of the students they taught, the purpose became clear to them.

Preparation. Concerns surrounding preparation also presented a challenge to Meadow Lake teachers as they implemented the formative assessment and intervention process. As part of the implementation, teachers were asked to return to their schools after the first professional development session and, over the next day and a half, assess 3–5 of their students using the resources and approaches discussed in that first session. The implementation training during the first session centered on using the Grouping Tens assessment, which focused on students' facility with the essential understandings underlying the core concept of place value. Within this assessment, teachers record both student responses and the strategies that they use. Initially, teachers expressed concern about being prepared to conduct the assessments properly, focusing mostly on the differences between the possible strategies students might use and what those would look like in an assessment situation. The teachers felt unprepared to observe these strategies, yet they did complete the 3–5 assessments with some level of success.

After completing the assessments, teachers returned for the second session asking for further clarification about observing and selecting strategies as well as the use of particular wording in specific questions. For instance, one teacher noted on her exit card, "Do not digress from structure/language", referring to a conversation during the session about maintaining the validity and reliability of the assessments. In general, teachers continued to express concerns about adequate preparation during the second session, but their concerns were much more focused on specific aspects of their preparation.

During the course of the year, this preparation challenge expanded to include what assessment(s) to do next, how to implement interventions to address the identified student needs, and how to purposefully group students to address those needs. For instance, one teacher exit card after the third session noted, "What activities are suggested for [level] N students? What manipulatives do I make for these activities?" and another teacher wrote, "How will we know for sure they are ready to retest? Gut feeling? When should all activities be completed and ready for classroom use? ASAP, right?" When teachers were asked to reflect on the training process after our final session, many of the Meadow Lake teachers responded that the aspects of the training that were most helpful to them were those that allowed them time to practice the assessments, engage in some of the intervention activities, begin to prepare materials, and meet as a PLC to plan for how they might incorporate what they had learned during the session. In contrast, a few teachers believed that the inclusion of preparation time in the sessions was a waste of time noting, "There's no reason that we should have been here cutting out things and discussing plans . . . No! We don't need to be doing that."

The third-grade team at Meadow Lake addressed the challenge of preparation in a variety of ways, both as a group and individually. The overwhelming response during the first session was that teachers did not feel adequately prepared to conduct the AMC assessments, but using the assessments helped them narrow the scope of their questions and concerns over time, and general concerns regarding preparation shifted to issues of preparing to teach and use the information they gathered in their assessment. With time, many of the challenges Meadow Lake teachers faced surrounding the issue of preparation began to intersect with the challenges of time and resources.

Time. Time was a challenge and consideration throughout the year of this study, as Ms. Arrigo and the third-grade team, along with Ms. Bardsley, began to map out possible ways to implement the formative assessment and intervention process within the scope of their current instructional practice. The Meadow Lake teachers left the first session highly skeptical of the feasibility of meeting the requirement in the time they had been given. In fact, 6 of the 8 Meadow Lake teachers commented about concerns with time on their exit cards. Ms. Arrigo, Ms. Bardsley and the other third-grade teachers worked quickly over the day and a half following the first session and were able to assess not just 3–5 students in each of their classrooms but *all* of the third-grade students at Meadow Lake. Like many of her colleagues, Ms. Bardsley had initially reported concern about the time that would be required to conduct the assessments, especially in light of the other assessments they were required to do. Having completed a full round of assessments with their students in a day and a half, however, the issue of time in regard to conducting the assessments was no longer a priority and was not mentioned by any of the Meadow Lake teachers during the remainder of the year, other than to say, “Thanks! Like that it’s quick assessments.”

Addressing the challenge of time for teachers at Meadow Lake shifted from what was needed to prepare for and conduct the assessments to the amount of time involved in leaving their classrooms for training sessions and the time needed to address the student needs that came to light as a result of conducting those assessments. As the year came to a close, these issues of time remained for the Meadow Lake teachers, although they planned to collectively re-examine these at the start of the new school year.

Resources. Having completed several assessments and seen positive preliminary results, the teachers at Meadow Lake came to fully understand, the purpose, feasibility, and potential of the approach they were learning. However, they did not believe they had the resources necessary to fully achieve the potential. They began to address the need for more human resources by integrating their interventionist into the process. The Meadow Lake third-grade team also approached their principal to ask for additional human and material resources they required to fully implement all aspects of the formative assessment and intervention process.

Material Resources. At the beginning of the year, Ms. Bardsley reported concerns relating to the resources available to support the implementation of the formative assessment and intervention process at Meadow Lake. As an interventionist, Ms. Bardsley was aware of the amount and type of materials her classroom teachers had available to them and anticipated the need for additional materials at Meadow Lake. She asked focused questions within the training sessions about the number and type of materials that would be most beneficial to her teachers, where they could be purchased and about how much they would cost. Although the district distributed some materials at the conclusion of the second session (e.g., intervention books and manipulatives for each grade level team), the funding from the district was not adequate to purchase a full set of materials for each teacher. Although the district had anticipated the challenge resources would present, but what was provided did not adequately address the needs of Meadow Lake teachers and students, as Ms. Bardsley understood them.

Following the second session, Ms. Bardsley approached her principal, Mr. Parkin, to ask about funding for additional materials and, when she was told none were available at the school level, she sought out grants to purchase enough materials to set up a mathematics materials library at Meadow Lake. Ms. Bardsley wrote a proposal for purchasing resources to support her teachers' efforts to implement this process and was awarded the funding in the spring of 2012. At the time of our interview, Ms. Bardsley had received the materials and was beginning to organize them so that teachers would be able to easily locate and check out the materials they would need to implement intervention activities in their classrooms. Ms. Bardsley's excitement surrounding the opportunity to provide these resources was evident in our conversation:

> Basically it was for AMC things to close our achievement gap . . . And it was basically to work with . . . kindergarten, first and second grades, so that we could bring them up to grade level, create a generation of problem solvers, and ask for all the materials . . .

The challenge of material resources and human resources often intersect, especially when considering the issues of organizing and maintaining those materials. Not only did someone have to take time to identify a funding source, write a grant, and purposefully spend the funds, it was also necessary for someone to organize and store the materials. As Ms. Bardsley pointed out:

> And I ordered all the materials, everything. I just have to go set it up . . . but I don't have the AMC stuff and the boxes that go in . . . all the supply bags [yet].

In addition, in order for the materials to be useful to the teachers, someone needed to introduce both what was available and how they might be able to use the materials when working to implement the formative assessment and intervention process. Again, Ms. Bardsley made herself available to do that with her teachers:

> Well, what I want to do at the beginning of the year . . . is I want to show them all the things that are available . . . I have cardstock, I have laminating film, things like that they can make. If they'll tell me what they want, I'll make it. We can run it off. And just have everything at their fingertips. I want them to come in and check it out. Not even check it out. Just take it. But bring it back so somebody else can use it, because I've pretty much got enough so if 2 classes are

> doing basically the same skill, there’s enough there for either a center or a teacher to work with a group . . . So I want to expose them to the things that are available to them.

During this first year of intervention, the teachers at Meadow Lake faced what they believed was a shortage of the resources required to fully implement the assessment and intervention approach. However, the team was extremely resourceful in their efforts to secure funding to purchase the additional materials they felt they needed to fully achieve the potential of the approach and begin to organize those materials in a thoughtful way.

Human Resources. Meadow Lake teachers knew they had access to human resources that their colleagues at other schools did not necessarily have available. Ms. Arrigo summed it up when she said, “We had a math [coach] . . .who else had a math coach? We’re so fortunate.” Indeed, the personnel who were there and made themselves available enabled Meadow Lake teachers to implement the formative assessment and intervention process in a manner that differed from those schools that did not have those personnel. Ms. Arrigo recognized that

> . . . she [Ms. Bardsley] could pull groups throughout the week and . . ., “I’m gonna pull these four kids, work on this activity for thirty minutes twice this week. Here’s the activity, so if you have any free time in your class, you can do it too and then after a month I’m gonna give ’em the exact same assessment on AMC” . . . if our math coach was not here, we would have had to continue those little intervention groups . . . and it would have changed [everything].

As an interventionist who had been working with teachers and students for several weeks already at the time of the first session, Ms. Bardsley considered ways she could be available to serve as a resource to support teachers and students within the scope of her overall work throughout the implementation. The third-grade teachers also reported that sometimes teachers had to make choices about when and how to utilize these personnel, "[The] ELL [team] has made themselves available during math time but not a lot of teachers prefer them during math times."

Other personnel were also available at different times. The interventionist that worked primarily with students in grades 1 and 2 also came to work with third-grade students, Ms. Arrigo said, "She made herself free to us . . . since spring . . . not for EOG stuff but for intervention of skills. And so we really benefited from that." And, as the need arose, additional personnel were recruited to work with groups of students.

> We call them math clubs. They generally happen two days a week after the assessment. And that was like pulling in as many interventionists or assistants or tutors or whoever was available – anybody . . . . Or we used [the teacher] who subbed for AIG . . . and if we had the TA, we'd have them help circulate in the low group.

Although they used as many people as were available, the third-grade team also understood that the interventions needed to be implemented purposefully. Anyone who was available might be used to assist, but only those adults specifically trained on the intervention activities and expectations for students were able to lead such groups. Making sure these adults were adequately trained required resources but resulted in a cadre of knowledgeable adults addressing the demonstrated needs of students.

The Meadow Lake teachers recognized their fortunate circumstance and, as they became more immersed in using the formative assessment and intervention process and began to see results for their students, they began to advocate for similar human resources being made available to their colleagues in other schools:

> Another thing is, is that it would be nice to designate someone—either a teacher's assistant or somebody—. . . assigned to working with these kids for AMC... you know, I don't know why you couldn't do that in all the elementary schools.

This idea was echoed in the exit card comments as well, several teachers stating, "All schools need an interventionist/math coach to help the load of needs and assessment & intervention".

The Meadow Lakes teachers also had the good fortune of having an administration that acted as a resource, supporting their ever-evolving understanding of the formative assessment and intervention process throughout the implementation. The team of third-grade teachers would solicit the support of the administrators whether needing to restructure schedules, identify personnel to assist with interventions, or analyze data. When asked about the role of Mr. Parkin during the implementation process, Ms. Arrigo stated:

> He's very approachable. He was very receptive whenever we said, "Look, we have an intervention happening this day. We don't have enough people. Can you find some people for us?" . . . [or] "We need this interventionist right now . . ." He was very supportive in the interventions that were happening.

Throughout the implementation process Meadow Lake teachers came to identify and better utilize the resource available to them, both material and human. With the support of their administration they began to put a system in place that capitalized on and developed those resources to address student needs.

Disposition to Change. The Meadow Lake teachers, along with their colleagues, experienced a wide range of emotions which affected dispositions toward the implementation throughout the year of this project. For the implementation team, it was important to acknowledge and, in some cases, address those emotions both individually and collectively.

At the outset, the emotions expressed were most often negative or cautious. One teacher expressed her concern, writing on her exit card that she was "optimistic, but worried about finding the time and personnel." The frustration and anxiety of one of her colleagues was evident in the comment, "5–10 minutes per student is a lot when I am still trying to finish [other assessments]". After the initial round of assessments was completed, though, many teachers expressed relief that these were, "Easy assessments!"

As the implementation progressed and the process became more familiar, comments indicating ongoing confusion, particularly in terms of grouping students or selecting "the best" interventions, were interspersed with excited celebrations such as, "I am ready to exit some students from groups now!" Comments such as "Seeing how we can go back and help students by re-teaching basic concepts is great! This is a logical step that has been ignored for too long," showed growing support for the implementation. After every training, more than one comment was written that revealed teachers' frustration about the need to attend the training. Even if they understood the need for it, they made it clear that, "It's hard to be away from my class for training, but I understand why."

As teachers began to really put the assessment and intervention process in place and began to see changes in their students, the teachers' dispositions toward the process became more positive. Ms. Bardsley said, “AMC and the way it’s approached . . . I love it . . . I get excited about it. Because I’ve seen those kids get so excited. And there’s so many ways you can do it.” And for Ms. Arrigo , her caution and resistance at the start of the year became a sense of relief and excitement. “I never taught like this before,” she said. “I loved it. Oh my gosh . . . why doesn’t everybody meet with kids in small groups? This is so much more effective.”

Reflecting on the implementation of the formative assessment and intervention process throughout the year, principal Nathan Parkin expressed hope that this was just the beginning, that this would be the start of his teachers becoming even more reflective about their instructional practice and students’ opportunity to learn. He was also hopeful that classroom teachers would see themselves as the major drivers in the process rather than viewing it as something that takes place outside of their classroom or a process by which they would pass on results and allow others to bear the responsibility of addressing student needs.

> [My role is] helping them to see that, 1) it’s an ongoing process; and 2) that the process is an active role that you play in individualized instruction, rather than waiting in the middle. It’s changing how you teach. Because you’re taking the gaps and filling them in, but then you’re really looking at the types of questions that I’m asking kids, it’s not . . . asking higher level questions for the sake of asking a question . . . who am I asking that question to? Why am I asking them that question? And what am I going to do with the information that they give me?

For Mr. Parkin, there was hope that teachers would continue to develop the capacity to know and understand what to do with the data generated by these assessments as well as by observing students at work. For the Meadow Lake teachers, making sense and using data had already been part of their culture, but doing this with data generated through the AMC assessments presented its own challenges.

Making Sense of Data

For third-grade teachers at Meadow Lake, making sense of data had been part of their grade level routine for some time. As Ms. Arrigo explains, for the previous four years, after they administered their common formative assessments they would begin working on the data analysis:

> . . . within like a day, we put [the results] into a large spreadsheet of: the kids that were totally lost . . . the kids that aced the whole thing . . . and then the kids in the middle . . . So we grouped them like that . . . and we put the kids' names in and what their need, weakness was and what the group's weakness is . . . and then we assigned our names afterwards. It took a while for us to get to that. It's taken a lot of tweaking but ultimately that has been working so well for us.

For the Meadow Lake teachers, analyzing data was already an established process that had addressed their needs for understanding what their students knew and were able to do. During the year of this study, already having a system in place that they had developed, the foremost concerns for Meadow Lake teachers centered around the challenges of preparation, accommodations, validity, and time.

Preparation. Learning how to access the data was one of the first questions the Meadow Lake teachers asked after the first session. Several exit cards included questions such as, "How can I look at the data and compare throughout the year and across grade levels?" and, "How do I view the data analysis?". Working through the technology interface and discussing the several types of reports available to them was both exciting and overwhelming. During each subsequent session and PLC meeting, issues of data access and interpretation were part of the conversation.

For Meadow Lake administrators, the preparation they needed to make sense of the data was expressed as a challenge. Mr. Parkin talked specifically about the need for administrators to get training to understand the data and support their teachers in the implementation process:

> I can look at numbers all day, but . . . are we good? What exactly are you looking at? So, teaching us how to analyze what we're doing, one. And then teaching us how to then plan accordingly would be nice to see.

For Meadow Lake teachers, it became important for them to be able to interpret student results and thoroughly explain those results to others, including administrators, to advocate for requested changes and resources as well as identify and explain student growth over the course of the year. A further challenge became apparent as teachers asked for assistance in explaining results and growth to parents and guardians during conferences and to other school personnel during student assistance meetings.

Accommodations. The student population of Meadow Lake Elementary included a group of students designated as LEP who made up 24% of the overall student body. For the third-grade teachers, using other assessments had not yielded actionable data when administered to this particular subgroup of the overall cohort of students. With AMC, when appropriate, the Spanish translation was used to conduct assessments, often by the ELL teacher working in collaboration with the classroom teachers. Ms. Arrigo expressed excitement about the fact that, "She even did kids that came in speaking no

English." In most cases, this allowed the teachers to analyze more valid data for these students and, therefore, reveal a more specific sense of student needs, often uncovering understandings that had not been readily apparent before.

Accommodating the needs of other groups of children was not quite so clear-cut. Teachers expressed concern about best ways to assess those children with limited or no verbal capacity. Similar to their collaboration with the ELL teacher, the third-grade team worked with the EC teachers at the school to assess this group of students, particularly at the beginning of the year. As the year progressed and relationships were built and strengthened, the classroom teachers became more confident assessing children within this subgroup, as both the children's comfort with the teachers increased and the teachers became more certain of their understanding of student responses. However, questions about how best to accommodate all students within the formative assessment and intervention process remained as the school year concluded.

Validity. In some cases, the AMC data did not seem to make sense when paired with what teachers observed in other situations or on other assessments. When discussing some of her students' AMC results, Ms. Arrigo expressed some of this confusion.

> There's the kids that I don't think perform at grade level and they passed. And some kids that always perform or participate at grade level that didn't. And so it loses a bit of the validity and reliability for me in looking at all the scores. I was like "Well, the two kids . . . that didn't pass, they should be able to pass." But then on some other kids, well . . .

When contradictions such as these were discussed in training sessions, we revisited the idea of the 'illusion of learning', the perception that a student appears to know or understand a concept when they are in fact successfully following a procedure on a consistent basis without a real understanding of the underlying concept. Teachers were asked to consider those students whose results contradicted what was expected, reflecting on what the inconsistency might indicate. For many of the Meadow Lake teachers, it was difficult to consider that a child who could successfully 'do' the mathematics they were asked to engaged with every day, with consistently positive results, might lack a conceptual understanding of that mathematics. Equally difficult to reconcile were the results of those children who regularly struggled to meet classroom expectations yet demonstrated conceptual understanding on the AMC assessments. Especially in these cases, the validity of these assessments was in question.

As the Meadow Lake teachers grappled with making sense of seemingly inconsistent results, they also expressed concerns about the subjectivity inherent in an assessment system that asks teachers to discriminate between and categorize student strategies. Teachers were regularly asked during professional development sessions to analyze student results and consider how their own preconceived ideas about what students may or may not know might influence their administration of the assessments, bringing to the forefront the idea of bias. Although the technology interface of the AMC Anywhere system reduced bias, the nature of formative assessments made this an issue that continued to be a challenge throughout the implementation process. Attempts were made to discuss and reduce the threat of bias through a process of routinely revisiting valid testing techniques and clarifying what the assessment was asking for and what the strategies looked like.

Time. As the teachers became more familiar with the AMC system they quickly learned how to access the data, read the reports, and see patterns within and between students' responses. The immediacy of the results was one of the most exciting aspects of the formative assessment system. For Ms. Bardsley, this became a key to her work with the students and teachers:

> I love the AMC assessments, because they were right there in front of you. It was like a living document. It was real time. I mean, as soon as you assessed a child, I went back and looked at the report and the numbers had changed automatically. It was wonderful to not have to wait.

The availability of the results electronically, from any computer, was also key in reducing the time needed to share student information between teachers and begin the intervention process. Ms. Bardsley noted how this helped in making sure classroom teachers had access to the most updated data and in continuously reexamining the structure of the intervention groups:

> And [the teachers] . . . could pull up the data, too, so they had all that information . . . whenever [the students] made [a goal], I'd say, 'Okay, they're all yours now.'

For the Meadow Lake teachers, making sense of the data provided through the formative assessment process was a matter of making a few adjustments to a system they had already established. Teachers reported that the system actually addressed some of the challenges of time that had been present in the previous system while it presented others. Teachers found they spent more time restructuring groups to address the continuously changing data and emerging needs of their students. So, although teachers were excited by the immediate availability of the data, it was also a challenge to find the time to make sense of those data.

Although the process might have been familiar, the data sometimes provided insights that were surprising or unexpected and provided a basis for discussion with not only the third-grade team, but with support personnel, administrators, and other grade levels. As Ms. Bardsley pointed out, “We had interesting discoveries. And we’ve had interesting discussions with the principals.”

In order for the formative assessment process to impact student learning, teachers had to use what was ascertained from the data to make instructional decisions. Determining those next steps presented challenges for the Meadow Lake teachers as well.

Using Data for Instructional Decision Making

As with making sense of data, the third-grade team at Meadow Lake also had an established system of using data to plan for and implement intervention groups, what they referred to as ‘math clubs’. Ms. Arrigo explained how data were used to create groups of students:

> . . . after a skill was assessed, [our spreadsheet] showed which kids had nailed it and just needed enrichment. Those kids often didn’t need small groups . . . and the number sense kids usually were in whole group, a small group next. And then often the interventionist after that or a volunteer or tutor . . . . That gave me great data . . . in terms of what the kid needed to work on in groups.

Those data were also used to help determine which group of students a teacher would work with, making sure to not always pair a particular teacher with any particular group:

> The teacher that was the most comfortable teaching the skill and had the best success rate, our PLC would feel comfortable with. And it was a different teacher for every skill. But those kids, they couldn't ever make a goal of like "Well my goal is to hit Mr. Smith's math club for next time to get the highest group." They never knew that. It was such a mix-up every time of teachers and quite a bit of mix of kids in terms of skills.

During the year of this study, as they began to really use the formative assessment and intervention process, the foremost concerns for Meadow Lake teachers in using data for making instructional decisions were focused on the challenges of time and resources.

Time. For this year, given overwhelming data indicating the need for intense interventions, the third-grade team had to make some adjustments to the time they had available to use assessment results to address the needs of their students. In looking for additional time they enlisted the help of Mr. Parkin. Although the result was not ideal, it did serve to provide additional intervention time:

> We cut recess twice a week, the days that you have PE we took away recess those days. But that also added for each of us an hour . . . [for] enrichment every week and we could do whatever we wanted with it . . . and so we did benefit from that.

For the Meadow Lake third-grade team, issues of time were focused only on the current school year. When asked about changes that might be made to the structure of intervention time in the upcoming years, the teachers indicated that the current structure would probably be in place and they expected it would work sufficiently.

Resources. Meadow Lake teachers not only addressed students' needs within their classrooms and at the grade level, they incorporated the interventionist into their system to be even more strategic about addressing very specific needs, both through working with smaller numbers of children, adjusting the intervention setting, and increasing the frequency with which they engaged in intervention activities. Ms. Arrigo described how this process changed when Ms. Bardsley became part of the intervention process:

> . . . we've been pretty comfortable with eight groups, sometimes nine groups. Which was great, because that means those lower groups had fewer kids and that's ultimately what we wanted to happen. If this group needs this one skill you've only got five kids to work with. You know? And it wasn't a lot of time . . . but four or five kids in a group makes it happen, fix it quick.

In some cases, students would work in a particular group for a very short time of intense focus on a particular skill before exiting the group:

> The kids with the least need are the ones I worked with first, what they called the bubble . . . we knew that it wasn't going to take much to get them to the point where they understood. So they all had [level] A's before I would let them go. I mean, I would just keep working with them.

As the end of the school year approached, the third-grade team at Meadow Lake began to look ahead to year 2 of the implementation and beyond. In thinking about the challenges they had faced in year 1, they began to consider how they could enlist the second-grade teachers to help students to begin the year fully prepared to engage in third-grade mathematics.

> When we knew second grade was finishing their assessments, their AMC assessments this year . . . we talked about it briefly. [We] thought if we knew

> ahead of time, when they come in to class that first day . . . we can take those . . . activities that have already been laid out for us and sort of do them as full group or small group as needed in our own class. Those first couple weeks of school you don't want to be doing [the regular math curriculum]. But I could do some of those small activities . . . the place value and the ones I know with the kids. I don't need to assess all 20 kids who are brand new to me. It was easier for second grade to do it now. I can already know those things.

As the implementation progressed, concerns focused on the intervention aspect of the process. Teachers expressed concern over their ability to properly match student needs identified through the assessment with an appropriate intervention approach and their ability to implement that intervention in a timely manner. The Meadow Lake teachers had many resources as their disposal to use in meeting the identified needs of their students. The challenge, however, was in being able to examine those resources carefully and identify particular activities within those resources that could be used to meet their students' needs. The third-grade team faced the challenge by working together with their interventionist, Ms. Bardsley, to better understand the intervention activities. Ms. Bardsley did a lot of background work to help identify interventions that appeared to pair with certain student needs and then shared that information with the third-grade teachers:

> I spent a lot of time going through those books to find different things for each skill . . . you know, the 10s and ones and all of those . . . I knew that the classroom teachers were not going to have time to do it and I didn't want it to be just one

> more thing they'd have to do. So I would go through . . . and I did a lot of tabs on those books so that I could figure out . . . which activity went with what skill . . .

In fact, Ms. Bardsley became quite excited about learning more about the intervention activities, even taking her books to study on vacation to prepare for the following school year and how she could support her teachers:

> And see, I love that . . . I've been at the beach all week and I took my AMC stuff down there and I was looking at how to set up the stations and everything and . . . I was looking at the perimeter and the area and seeing how they'd set it up . And I thought, I got it. You know, that was really neat, because even though we were trained on it this year, it's hard to put it in practice right now.

Ms. Bardsley not only served as a resource for teachers in identifying and making sense of interventions, she also served as a resource for working with groups of students in intervention groups, using data to identify which students to work with, their area of need, and when they were ready to exit the intervention group:

> Basically, they [the classroom teachers] taught their regular curriculum, which exposed [students] to the 10s and 1s also, and then I would do more. I took them in small groups, and every time an assessment report came out, after I'd tested so many kids, I'd go back and look and see who the next group was that I needed to go with . . . I enjoyed seeing the children. They'd go, 'I get this! I get this!' Lots of light bulbs going off. Yeah! That's what you work for.

And as the need for intervention groups slowly diminished, Ms. Bardsley became a resource for classroom work as well. Ms. Arrigo described this transition:

> She was working in AMC with us and then as that started to get smaller and smaller . . . then she started helping us in the classrooms more during the day on our current skills. She actually used enrichment time at the end of the day for AMC work. She works constantly with the classroom teachers. She has been very, very present.

As teachers continued to identify and address their students' needs, taking the time to work in intervention groups and utilizing the resources at their disposal, they saw more and more changes in the ways students engaged in their regular classroom work as well. As Ms. Bardsley pointed out:

> Well, they could probably tell in their work. When those kids kind of like hit that bubble, it was like Wow! . . . They'd say, 'I can't believe this. They really have this now. I've seen a change.' Or 'Yeah, they do understand this. Wow.'

With the formative assessment process emerging at Meadow Lake, student needs were more efficiently identified and addressed. Teachers were noting changes in their students' mathematics understanding in the classroom. What remained to be seen was how these results would translate to the state end-of-grade assessments.

Impact on Student Understanding of Place Value

Meadow Lake Grade 3 mathematics achievement scores indicate that, although this was the teachers' first use of the formative assessment and intervention process, this approach was beneficial for all their students. Aggregated 2011–2012 EOG data show that 86.74% of Meadow Lake's students performed at or above grade level expectations, up from 76.50% the year before. Despite the numerous demands on teachers' time, the various needs of the student population, and the fact that teachers began the year with no knowledge of the process they were to implement, it appears the students in Meadow Lake's third-grade classrooms benefited immensely from the mathematics learning opportunities afforded through this implementation. Mr. Parkin, the principal, commented on the impact the implementation had on student performance on the state tests and teachers' reactions to those results:

> In third grade, they were running math clubs. Based on those results, they also had Ms. Bardsley pulling out kids to be working with them. And when I talk with teachers about it, they were surprised by some of the kids that they thought would fail the end-of-grade test, but had completed AMC, had gotten what they needed to get. They filled a gap for that kid and got them to the level on that assessment that was more proficient . . . And it's because you filled that gap of the foundation, that they could understand something that I thought they wouldn't be able to get – because they had enough reasoning then to get through it.

Looking beyond achievement scores, teachers reported that students began setting their own learning goals. Based on their own performance and teacher feedback on the area of need that had been identified, students came to know what their focus was. This had not been the case prior to implementing the formative assessment and intervention process because, "the kids didn't have . . . any good way of setting the goal other than their score on their own test. They knew what their focus was, I guess."

Meadow Lake teachers expressed excitement about how they were able to use this process to meet the needs of all their students, including the growing population of LEP students within their school. As Ms. Arrigo said, "But ELL [English Language

Learners], all of them passed. Some of them on the second round, but they all passed. One of whom has only been in the United States for 8 months."

Beginning around the end of the training sessions and more so as the year of this study came to an end, the third-grade teachers began to imagine how the impact they were observing in their students could be multiplied with a vertical articulation of the process beginning in kindergarten. Exit card entries from Meadow Lake teachers such as, "Will this be offered to second graders?" and "Encourage vertical meetings at schools" indicated that this was an important consideration. Another teacher commented, ". . . if the students get these skills filled/mastered earlier, the third grade curriculum will be more accessible/attainable to them without being so far behind." When asked about this topic Ms. Arrigo explained further:

> I don't know about kindergarten, but think about if all those first graders came out having all those things mastered. All my kids have it mastered now, going to fourth grade. Fourth grade math is going to be so much easier for them. If those first graders have it mastered independently, that would be great.

When asked to expand this a little more and explain how she thought a vertical articulation of this formative assessment and intervention process would affect students at her grade level, Ms. Arrigo said:

> I can't teach multidigit multiplication and fractions of big multidigits if the kid can't make 10, can't understand that the 10 fingers represent that place value. It doesn't make sense for me to go back and teach that simultaneously with other math skills. And if it is developmentally attainable at a younger age, it would really help the kid. You know?

Ms. Arrigo also considered the impact of the formative assessment and intervention process for the following year, discussing both fourth and second grades:

> Now we guaranteed going into fourth grade at least kids . . . I won't say retain it, but they did perform it and they did have these skills at one time. You know. The place value, the value of a 10 going up, going down, grouping . . . and so we were even thinking, 'My gosh, it would be so cool. In second grade it would be nice if those kids came to us already having those things taken care of.' It's so difficult to realize months, and months, and months in the reason that the kid's failing all this stuff is that they didn't have that one little root skill to begin with . . . and I mean, that's just a devastating realization halfway through the year.

Ms. Bardsley expanded on this idea even more, reflecting on the experiences that the J. C. Fletcher teachers had shared about the impact this process had had on students and their teaching practice in years two and three:

> . . . I mean, they've got to hit the ground running. And if they have to go back and teach second-grade skill, it's just not fair to the kids. I mean, they [students] should be coming in ready for that. . . . when Theresa Fortino was talking about it, she said, 'That's all a big change from that first year and then the second. Those kids came into third grade knowing that stuff.' . . . next year is going to be different and we can hit the ground running a little bit faster.

Rather than just waiting to see what might happen at the beginning of the following year, the second and third-grade teams began talking about how using this process at both grade levels could help ensure that students were better prepared for third grade. In these conversations, the common language and focus of the formative assessment process emerged:

> We had lunch with them throughout those weeks of, "Oh, this is a new thing. This would be great if the younger kids could do this . . . even coming into second grade." And they were realizing that. They were like "Yeah . . . a large portion of our third graders didn't pass [the Grouping Tens assessment]." And they're saying, "Oh my gosh, we need this [information], to fix it down at our end. We want it to be fixed." So we talked with them about how neat it would be if they were working on it last year. I think they started assessing their kids in the spring.

In considering the broad impact on students of this implementation process, Mr. Parkin also expressed the importance of articulating the formative assessment and intervention approach across grade levels. Although supportive of the process and the impact it was having on instructional practice and student learning, he also expressed some concern about the choice to begin the process in grades 2 and 3:

> I wish we would have started in kindergarten and first grade, instead of second and third, and developed UP and have these kids weave through. Because . . . why are we trying to close a gap in the middle. So, with the K–1, the problem with now doing K–1 is that they're going to need a year of learning. And so now I've got varying development going on in a weird fashion, because you've got a tiered staff development going on . . . Now, it does give a good effect to second and third grade. By doing that, they can say, 'Wow! I thought they knew this stuff.' But I wish it would have started there.

According to Ms. Bardsley, implementing this formative assessment and intervention process has broadly affected some of the expectations about what it means for students to demonstrate understanding, and that has had an impact on more than just the students:

> And I think they're fast learners . . . and have a hard time dealing with [asking them to explain what they're doing]. Because they'll say, 'Oh, I know how to do this.' And if you ask them to explain it to you, they can't explain it. And my thing is, if you can explain it to me I'll know you understand it . . . but if you can't explain to me how you did it, instead of just going, 'Well, you multiply this times this, and this times this,' I don't think you really understand what you're doing. And I think that's the foundation of AMC, which has been really nice. Because it's even helped me learn.

For the third-grade teachers at Meadow Lake, much had changed with the implementation of the formative assessment and intervention process, but much had also stayed the same. Given their strong PLC and the assessment and intervention system they had already put in place, some of the resources used, the ways in which personnel were utilized and the time was structured had changed, but, according to Nina Arrigo:

> We've maintained and continued the same stuff we've done in the past. Not honestly much has changed in terms of how we executed those intervention groups. These are the specific skills that kids are missing; this is how we intervene by grade level. We're gonna break 'em up and do it just like how we know how to do it. You're in charge of that 'Bottom A' group. You're in charge

of . . . the ‘I’, you’re in charge of this making 10s, you’re in charge of the ‘P’ group. And we would have addressed it like that.

The Case of J. C. Fletcher Elementary

The third-grade teachers of J. C. Fletcher Elementary entered the year of this study with extensive knowledge of and experience with the formative assessment and intervention process implemented in PSD. J. C. Fletcher teachers had participated in numerous professional development activities focused on mathematics over the prior several years, the most recent having been in conjunction with a pilot study conducted by the North Carolina Department of Public Instruction (NCDPI) focused on using a palm-based version of the AMC assessments.

The J. C. Fletcher teachers were motivated to participate in these professional development opportunities by their desire to address the diverse needs of their students. In terms of the formative assessment process, their experiences served as a model for the district implementation. The faculty and staff at J. C. Fletcher Elementary had benefitted from a supportive administration for several years, yet, with a new principal leading the school, numerous district initiatives, and the formative assessment implementation, teachers were presented with many challenges to address throughout the year this study was being conducted.

The case of J. C. Fletcher Elementary that follows is presented in four sections with detail provided through the experiences reported by Ms. Crumbley, Ms. Athey and Ms. Mitcham, the teachers who represent the embedded cases. Evidence of the challenges J. C. Fletcher teachers throughout district wide implementation of the formative assessment and intervention process and the ways in which they worked to address those challenges will be presented in the first section. The second section presents an exploration of the challenges of and responses to making sense of assessment data followed by teachers' reactions to challenges faced when making instructional decisions based on those data. Finally, the impact on student achievement will be presented.

Implementation of the Formative Assessment Process – J. C. Fletcher

Prior to implementing this formative assessment and intervention process, the third-grade teachers at J. C. Fletcher had established a grade level routine for administering their "common assessments." They also worked as a grade level to review results and conduct grade level interventions based on those results. Ms. Crumbley explained the process that had been in place prior to using AMC:

> We did a lot of common assessments . . . and from that we took our grade level and . . . we broke it down into skills. Okay, what part are they not understanding? And then we would flex group them throughout the grade level . . . we would make groups with like children, common needs across the classrooms . . . and we would do it all across all four . . . just every like 2 weeks . . . at that point in time, since we didn't have AMC . . . we would have to do more work to break down what part did they need . . . at the beginning of the year . . . or before each skill, we give a pretest that we make . . . and then we went through our unit and taught them the skills, and then we did a post-test . . . and that way we could see who grew or who was still struggling.

Before they began using the AMC assessments, the third-grade team used a variety of assessments, including districtwide quarterly benchmark assessments, grade-level-created common assessments, performance-based assessments, and interim assessments on the computer. At the beginning of the implementation process during the year of this study, J. C. Fletcher teachers had already gained extensive experience administering both their own and AMC assessments. Within the scope of their prior work, the concerns of J. C. Fletcher teachers included the challenges of purpose, time, and resources, all of which were infused with emotions that resulted from, were related to and affected dispositions toward the implementation process.

Purpose. J. C. Fletcher teachers understood the stated purpose for the different approach to implementation that was the focus of this investigation. For these teachers, the challenge of purpose was not only fulfilling that purpose for themselves but also to share this with others in a clear, convincing and consistent way. In talking about the intent of this implementation and the purpose of the assessment and intervention process, Ms. Athey explained:

> I don't really know how to train them. I mean, I know teachers are busy, they don't have time. They want a tool that's gonna work and be immediate and be useful. The fact is, this takes some time and some practice to start to understand how it really is helpful. For those teachers who aren't interested in how their students think, they are not going to embrace this, I don't think. Or not in a way that's really helpful to them. But if you're interested in that and you're willing to let different students solve the same problem different ways and share that thinking, then it's amazing what you find out from them.

And Ms. Mitcham expanded on this a bit more, emphasizing the idea that this was a process and that steady progress was being made toward the stated purpose:

> What I have noticed . . . and particularly in second grade and third grade, is that the teachers are pretty much doing all the assessments themselves. It's not that often that they call us in to help . . . for the most part . . . at this point this year, a lot of the teachers are really starting to use it, I think in the way it's meant to be used, which is not . . . we're not gonna assess everybody this date. We're gonna assess as we see the need and as we need information.

What the J. C. Fletcher teachers had observed as they piloted the use of AMC with their students was that the approach helped them identify specific student needs and provided strategic and efficient ways to address those needs. Through direct experience, J. C. Fletcher teachers had come to understand the stated purpose of implementing this assessment and intervention process long before the district implementation began and the challenge for them now was how to help others come to understand that in some meaningful way.

> And I think the emphasis now is more on how do kids think and how are they processing and how are they understanding and what parts of mathematics are they struggling with, what parts do they need, do we need to help them in terms of the Grouping Tens like the place value, which students don't know their number combinations. So the focus went more from teaching as a whole group to kind of looking more at the students and what their strengths are, what their needs are and how can we meet those needs, and what professional development [is needed].

Although the third-grade team was challenged to clearly articulate the purpose of the implementation in terms of their own classrooms, Theresa Fortino, a teacher at J. C. Fletcher and one of the District Teacher Leaders, explained the purpose of the formative assessment and intervention process being implemented within the broader context of mathematics education with a focus on the student:

> With the shift now, it's more towards knowing as teachers how children reason mathematically . . . but I mean, that is gonna be the school culture for the foreseeable future, is a kind of learning included in the standards and one in that our children need to be able to reason mathematically. They need to be able to use numbers in clear, purposeful ways. They need to be intentional with the mathematics. And so it's not enough to get the right answer. And that's a big shift. They need to be able to communicate their thinking and they need to be able to keep other students thinking. So math needs to become part of their lives, not 'math time'. I think the conversation is starting to happen and I think the third grade particularly sees how this project fits in with those pieces. Our assessment needs to help us find out how kids are reasoning mathematically. It isn't about finding out what's wrong with the kids but to find out what's going right and building from there.

In the end, teachers at J. C. Fletcher came to understand the purpose of the AMC implementation more deeply as a result of using the formative assessment and intervention process with their own students and explaining the purpose of that process to their colleagues as they experienced it in their classrooms. Some were able to explain this easily from the beginning of the districtwide implementation process. For other J. C. Fletcher teachers, it was more difficult to express an idea that had become an intrinsic part of their instructional practice some time ago. The process of explaining the purpose, although a challenge for some, improved their own understanding of that purpose while helping clarify it for others.

Time. Time was a challenge and consideration throughout the year of this study, as Ms. Athey, Ms. Crumbley and the third-grade team worked to improve the formative assessment and intervention process they had put in place while supporting their colleagues throughout the district to establish theirs. The J. C. Fletcher teachers, with a formative assessment and intervention process using AMC established and functioning, were able to turn their attention to time issues that occurred within that process. Ms. Crumbley shared one such challenge related to addressing needs within their process that were beginning to expand from the original focus:

> One thing that we've always struggled with is when the kids come in, we've really had to focus on Grouping Tens. We really have not had the time in our curriculum to focus on the Hiding Assessment. So, for example, I had kids at the end of the year – they might have gotten a 3 or 4 on the math EOG, but they're still adding like this [demonstrates counting by ones on her fingers]. But those kids also needed the Grouping Tens.

Ms. Crumbley acknowledged that the student's strategy was functional, but she also knew that it was not efficient and would not serve this student well as the mathematics content became increasingly more sophisticated. Given the time constraints of their school day and the higher priority of place value in the third-grade intervention process, Ms. Crumbley was faced with the challenge of finding time to also address these other needs her students demonstrated.

Issues of time also threatened to undermine some of the key components of the formative assessment and intervention training. Taking time out of their classrooms to attend training is rarely popular among teachers and comments about the time commitment for such trainings are to be expected. The challenge for the J. C. Fletcher teachers was balancing the time issues, which surfaced on a regular basis, with the need for teachers to gain a deep understanding of the assessment process as well as the mathematics behind it. Put in the position of addressing these concerns with their peers, the J. C. Fletcher teachers were again challenged to articulate the rationale behind the district approach to implementation. Ms. Mitcham expressed this particular time challenge during her interview:

> . . . I think the teachers had a hard time with the training because . . . they didn't want the background; they didn't want all that stuff. They just wanted to know, 'What is it I have to do? Teach me how to do it and don't keep me out of the classroom for three days.' So that's kind of a, 'Well, you know, if you get the background though, it helps you understand why you're doing it.' But they weren't interested in that so they weren't going to pay attention to that . . . I see the reason you want to do it. It makes sense. But I felt like the teachers were just, 'Don't do this to us when we have so many other pressures.'

The J. C. Fletcher teachers had resolved many of the time challenges related to assessing students and setting up interventions within and across their classrooms. They were now focused more on the challenges of being out of the classroom for training, both for themselves and their colleagues, and finding some ways to address student needs that did not easily fit within the scope of their established routine.

Resources. Having an established assessment and intervention process, and regular positive outcomes for students as a result of that process, the teachers at J. C. Fletcher came to fully understand the purpose, feasibility, and potential of the approach they were using and promoting. They felt confident they had the resources, both human and material, necessary to fully achieve that potential. Ms. Mitcham pointed out the choice of material resources at their disposal:

> Myra has a lot of resources that I use, things that she's accumulated over the years. And she used to teach Math Their Way and she's a classroom teacher so she's got a lot of stuff for that. We've adopted that. Then we've got all that stuff that Dr. F bought us. And those kits. So we use a lot of that; the Kathy Richardson tools.

With a well-established system of sharing materials necessary for intervention activities, none of the teachers shared any personal concerns regarding material resources. As an implementation team, their primary challenge related to material resources was to help their colleagues examine their resources available at their schools and how o address and perceived needs. The J. C. Fletcher third-grade team did, however, provide some insight regarding challenges relating to human resources.

Human Resources. J. C. Fletcher teachers had human resources that their colleagues at other schools did not necessarily have available. The personnel who were there and made themselves available provided a skilled cadre of resources from which J. C. Fletcher teachers drew when needed. For example, Ms. Athey talked about the EC teacher who came to work with students in her classroom during mathematics saying, ". . . like this year I had two adults assigned to me for math time . . . they give me more support now because I usually get . . . the lower kids. But they were able to do more small work with the kids."

The J. C. Fletcher teachers recognized the integral role of these additional personnel to the ongoing success of the formative assessment and intervention process. Because of that central role, they advocated for the availability of similar human resources being made available to their colleagues in other schools, to support both the students and their colleagues:

> I think like anything you're going to have to have somebody in that school who is very comfortable with AMC and doing the assessments and running the reports . . . somebody the teachers are comfortable going to and asking for help, and who has the time and ability to go and help them.

Administrative support had played a vital role in helping J. C. Fletcher teachers establish their formative assessment and intervention process. That support had continued when their new principal arrived at the beginning of the school year. The teachers also had access to a team of support personnel that acted as a resource for their colleagues throughout the school. Teachers could solicit the support of this team, whether needing to assess, conduct intervention activities, or analyze data. Ms. Mitcham gave the following example about the support that was available as this formative assessment and intervention process was put into place and how they had managed that support as the process evolved:

> So we went in [the training] knowing AMC but when we were using AMC before that, it was the few of us that knew it that had already been trained in it and knew it, that did all of the assessing. And we remember that first year I was running

> ragged at the end of the year trying to make sure all the assessments in K–3 were done . . . and I know the idea was that the teachers would do their own assessments and they could then do them as they see a child is ready . . . and a lot of the teachers do that now . . . but a lot of times they still need help because they are so loaded down with so many assessments that they have to do so frequently and so there are times of the year when they will ask for help.

The availability and use of skilled human resources can sometimes present an unforeseen challenge that must be addressed in a strategic way. In this case, the ready availability and competence of Ms. Mitcham and the other interventionist may have slowed the process of teachers taking ownership of and fully implementing the formative assessment and intervention process within their classrooms. This perspective seemed to be confirmed by a comment Ms. Mitcham shared later in her interview:

> Well I remember one year before the budget was set, before I had actually been hired on contract for the year, one of the teachers called me and she said, "I know you know how to do it and I have to get my kids assessed. Would you mind coming in and helping just as a volunteer?" And I did. I went in and spent a couple of days.

As a result, the full benefit of the formative assessment process might have been diminished for these students while the full responsibility for the assessment and intervention process was gradually transitioned to the classroom teacher.

Ms. Athey also addressed this idea of how to best support others in learning the formative assessment and intervention process, clarifying aspects for them and helping to make it all more accessible during the learning process. Her comment, however, suggests a different approach:

> And it helps not to just have one person telling you this is how you do it. We can actually say, 'Okay, these are the interventions we've done. This is how we group kids. This is how we've managed to use TA's, student teachers, and all these things.' Kind of getting through the logistics of it and telling teachers, 'Okay, this is like the nuts and bolts of what we need to do.' It is doable. But they need to do it themselves.

Ms. Crumbley shared a similar perspective, expanding on the idea of the teachers working together to make sense of the process and having the time and guidance from more knowledgeable others to do so:

> . . . I think a lot of it is just giving the time just to have a grade level work together and figure out like logistically how to do it. And I think that was good this year . . . that there was that time allowed for the grade levels just to sit down and identify their kids. They came back with the data. Okay, now how are we going to group them? Where in the day are we going to fit this in? So I think giving the teachers that time and kind of valuing that time was important . . . that they were able to get that time to kind of work within a PLC and figure out, 'Hey, these are our kids. Now what do we do with these kids and how are we going to fit it in the day?'

As Ms. Crumbley pointed out, having structured time available for teams to work as a PLC while having access to the experience and expertise of the implementation team and J. C. Fletcher teachers was an important part of the training sessions. This process was very beneficial, yet it also added stress and increased responsibility for the J. C. Fletcher teachers.

Disposition to Change. The J. C. Fletcher teachers experienced a wide range of emotions that affected dispositions toward the implementation throughout the year of this project, although perhaps somewhat differently than their colleagues. As the team that had been the early implementers, their expertise was in high demand. At the same time, the District Teacher Leaders were also part of the J. C. Fletcher faculty, which carried additional responsibility for both those named as leaders and their colleagues, who often took on additional leadership roles at the school while the leaders were away from their classrooms. The principal of J. C. Fletcher expressed this as frustration:

> And it may not have been so bad per grade level, but it was third grade's gone and then particular teachers who were leaders of this were gone. 'Marcia Eury's gone. Marcia Eury's gone again. Oh, she's gone again.' And it's like, oh my gosh. And so I know that was a stress for the teachers.

For the rest of the implementation team, it was important to acknowledge that the dispositions of J. C. Fletcher teachers were often not the same as their peers and therefore needed to be addressed differently. Although this was not the implementation year for J. C. Fletcher teachers, they were still subject to the same initiatives that their peers had to pay attention to. The need to focus on so many demands created a feeling of frustration, which would sometimes surface during conversations with these teachers:

> So when we got to the point where these kids were at a certain point in the Hiding Assessment, we needed them to move on in Grouping Tens. And we had this whole other curriculum that we have to teach, so it was kind of a struggle.

As the J. C. team began to see results similar to those their students had experienced spreading district wide, there seemed to be a sense of satisfaction. Ms. Athey, who would be working in another capacity the following year that would not include teaching mathematics, explained it this way:

> I'm kind of sad because I don't think I'll be a part of the new math next year, but it's just been unbelievably beneficial. There's a lot of programs that come in and out . . . and out and don't really have much of an impact. But . . . we just have such clear data to see how much it's helped our kids . . . So I'm really glad it's going systemwide and that people are buying into it hopefully and actually seeing that it does really . . . And it helps the kids mathematically, and it helps you as a teacher . . . it wasn't like a 5-year program that took forever to see results. I mean it was immediate.

As the third-grade team in the school that had been the vanguard for the formative assessment and intervention process the district had decided to implement, the J. C. Fletcher teachers felt a lot of ownership, pride and responsibility for the implementation process.

Making Sense of Data

For third-grade teachers at J. C. Fletcher, data analysis was an integral part of their grade level routine for teaching mathematics, one they had adapted to include AMC data. Ms. Crumbley explained the system of data use that was in place when she joined the J. C. Fletcher team:

> Yeah, what we did is . . . one through five would be the tougher questions or something . . . we had them broken down by what they were . . . And we usually

> just did that just so we could get more specific where the kids need that help. We . . . yeah, we made up our own spreadsheet. We did it by class. And . . . we would e-mail our kids in groups to a teacher, and they would put them into a document where it was columns, saying these kids need this . . . skill. We would talk about the skills and how the students were doing in our PLCs, which was once a week. . .where we really focused on, ‘Okay, how’s your group doing?’ But we really checked in with each other daily and we talked about, ‘Hey, this child, they’re not doing so well,’ or ‘They’re really shining here.’ And we would share ideas daily, and talk about how kids were growing. . .

The system they had developed and put in place was modified when they began using the AMC assessments and had access to the online reports. As J. C. Fletcher teachers continued to make sense of data the foremost concerns centered around the challenges of preparation, accommodations, validity, and time.

Preparation. Learning how to access the data was one of the first issues addressed with J. C. Fletcher teachers in their training, but the challenge was in helping teachers understand what these data were telling them. During her interview, Ms. Mitcham specifically addressed this point:

> . . .the teachers don’t have a good understanding of what reports are available or how to use the reports. And so if I go in a classroom . . .the first thing I do is pull a report. And I do the classroom instruction report because that one clearly gives me the groups of kids and where they are. And then usually . . .I run the reports for the teachers when we’re done. . . .And I’m happy to do it for the teachers. . . . But if I think they understood it better and how easy it is to do, just as they’ve

> started to do more of the assessments, they'll start looking at reports as a better tool as well. I mean, I think it gets to the point where it's easier for them to do it themselves than to call on somebody to come and do it. And that's where we want them to be, I think.

For J. C. Fletcher teachers, the preparation they needed to make sense of the data was expressed as an ongoing concern. Ms. Mitcham talked specifically about the impact of training on the ability of teachers new to the process to become increasingly comfortable and confident in their ability to make sense of the data:

> . . . in terms of my interaction with them, it changed in that they were much more ready for me in terms of they [the teachers] knew what it was they wanted to work on, they had a sense of what kids they wanted to focus on, and they already had a sense of where those kids were. Which in the past, it was more hit or miss. But now, you know, when they send me a group of kids, they're all pretty much in the same place . . .The teachers are starting to tell me about the kids instead of asking me, "What did you find out?" . . .And so they were starting to tell me more about the kids and their thinking and how they're understanding it.

Validity. As J. C. Fletcher teachers became more familiar and comfortable with administering the assessments, some teachers began to modify certain aspects of their assessment protocol. In doing this, the validity of the resulting data may have become compromised. Although maintaining the integrity of the assessment had been a major focus throughout the training, this appeared to be an area that was in need of some attention in order for the data to be valid and actionable.

> I think there's a lot of differences in how we score them based on the kids' responses. . . .You know, when the eyes go up to that number line I'm like "They're doing the rote sequence. . .And some people say, "Oh, well this child is slow to processing and you need to give them more time" and I'm like "Okay." And maybe that's the case. But to me, if they need more time, then what I've been taught is. . .and they don't have it, it's not automatic. So. . .they need more practice.

During training sessions the issue of offering praise or evaluative feedback during an assessment was specifically discussed. During that discussion issues of validity and reliability were raised and a process of constantly revisiting valid testing techniques and delineating between an instructional opportunity and an assessment opportunity was put in place. As Ms. Mitcham pointed out, this issue continued to be a challenge that needed to be revisited:

> Some people would let them read [the question on the computer] or try to read it. There are some differences in how we do the assessments, and that always worried me a little bit but there was only so much I could do or say. I think as we proceed and move forward with this, I think there needs to be something consistent. . .It's not a teaching tool. . . not to use it as a teaching tool and not to give them really specific feedback about the test.

Time. The J. C. Fletcher teachers had been familiar with the AMC system for some time and knew how to access the data and read the reports, and they continued to work to see patterns within and between students' responses. The immediacy of the results quickly became a key component of the teachers' instructional approach. For Ms. Crumbley, this became a key to her work at the beginning of the school year:

> So this year when they came in August 2011, like you still had those kids that were low but you could see exactly where they were low at also because you can look in the spreadsheet that gives you. . . so you don't have to dig as much. You know this is where they are. And you could see where all our kids were. And then this year we did the same thing, where we went down and did the intervention. But this group is much lower . . . But we knew they were academically lower. . . . but it will still be nice to be able to use the data that we're given to see, 'Okay, where are we?

The availability of the results from any computer, was also key in reducing the time needed to share student information between teachers and beginning the intervention. Ms. Mitcham noted how this helped in making sure she had access to the most updated data when she went into classrooms to work with students and in continuously reexamining the structure of the intervention groups. "And so I just go in, I print out a report and . . .can see who they've already done and what still needs to be done or whatever."

The third-grade team was comfortable with the process of data analysis, using the data as a basis for discussion with their administrators, support personnel and colleagues. Ms. Loder, principal of J. C. Fletcher, reflected on her teachers' comfort with using data, indicating that data use was an integral component of their instructional practice:

> They like to have something tangible that they can hold onto, that they're not just sitting there speculating about kids. But it gives them that solid level of data. . . .

> the processes are in place . . . collecting that data and getting it into that AMC web site so we can sort and do various things, and then really working from that vantage point with small groups of students that have common needs and moving them forward.

The system had addressed some of the challenges of time that had been present in the previous system, although Ms. Athey notes that there were other time challenges that needed to be addressed in order for teachers to understand the data the system provided:

> I guess giving the teachers time to talk about what they're learning from the assessments. "What does this data mean and how can you use it?" 'Cause just having the data is not good. It has to be, "Okay, what can we do with this? How is this going to impact your teaching in a positive way?"

Ms. Athey goes on to explain that using this assessment system has helped them save time by creating a way of talking about the needs of students in a manner everyone understood:

> It's a common language. We all know what it means, and we know right when that kid comes in, okay, what groups they need to be in. If they need to be in intervention, can we put them in the regular classroom, or what do they need? So I think just having that common language and that common way of talking about kids mathematically was helpful.

For Ms. Mitcham, this common language allowed her to more quickly understand the needs of her various intervention groups and to work with them more effectively:

> It allows me to do a better job from the get-go. 'Cause I have a better sense of where the kids are and what they can do and can't do yet . . . Then what that does for me is it tells me where to start with them.

The J. C. Fletcher teachers had developed a system for making sense of data as a grade level, relying on their PLC structure to collaboratively analyze those data and plan for next steps for their students. However, making sense of the data is only the first step. In order for assessments to be considered truly formative, the results must inform teachers' instructional practice. The process of using data to make instructional decisions entailed challenges of its own.

Using Data for Instructional Decision Making

Using data to plan for and implement interventions with students was an established part of the mathematics routine for the third-grade team at J. C. Fletcher. Ms. Athey explained how data were used to create groups of students:

> [We noticed]. . . usually the kids trended the same way. Some or most of the kids that didn't understand it, a lot of the skills they just didn't. And the ones that needed the extension were kind of more extension kids all across the board. But every once in a while you'd see a child that was really weak in one area, but was really strong in another area. . . .So they would flex between two extension groups. . . .it was kind of unique to see and you got to pull out their specific skills and see why they were scoring low on certain assessments.

Those data were also used to help determine which group of students a teacher would work with, making sure to pair teacher and group in a way that best addressed the needs of the student:

> So I . . . usually end up with the lower kids. And then Eury usually ends up with the higher AIG, like doing an extension kind of kids because she's really good at that. And then we split Athey and the other teacher with the middle kids. Or sometimes we just take on whose strong in an area, based on the results from the class or who feels really confident. . .who has a really good way at teaching this skill. And so about 2 weeks, kids would be kind of transitioned in and out of these groups.

During the year of this study the J. C. Fletcher teachers began to refine their use of the formative assessment and intervention process to make instructional decisions. For the third-grade team, the foremost concerns were focused on the challenges of time and resources.

Time. For the J. C. Fletcher teachers, much of the challenge during the year of this study was the time needed to determine the groups of students and set up the routines for students to follow for the process to work efficiently. As Ms. Crumbley pointed out:

> It's. . .there's a lot of work that goes into it. It takes some time to set it up. But I think once you have it set up, and if you model it those first few weeks of the year what those activities. . .how it's going to look as the kids go from activity to activity, kids are very good at it and they can take their little contracts and they can monitor themselves and they can go do the activities. The teacher then can monitor the students and see how they're doing and you can go and ask them specific questions and do a little assessment and find out how they're really doing, if it's a meaningful center.

Although the J. C. Fletcher teachers have addressed issues of structuring time, this is something they realized needed to be revisited every year, as the needs of the students who came to them changed. As a result, the structure for mathematics at third grade has taken different forms. Ms. Crumbley described these various structures:

> Some years we do math time is with our regular class, and then we do math IE time, the extension time, with flex grouping. But this year . . . we did more of just switching for the whole entire math class, which I think seemed to work a lot better. Because you're not wasting the whole hour trying to teach to everyone the same exact way . . . you teach the mini lesson of the same skill and then broke up into small groups. And . . .this year I've noticed that with the flex groups, they got more. . . . This year we might do it a little different, where we will do like reading 2 days and math 3 days. . . because we're not going to have all the time in our schedule to do reading IE and math IE. . . .This year our schedules are changing a whole lot, so. . .

For the third-grade team, issues of time extended beyond the current school year. Given data from the second grade the previous year that indicated the need for intense interventions, the third-grade team made themselves available to their second grade colleagues to conduct interventions while their student teachers were teaching full time in their own classrooms.

> I think, first of all, AMC has made life so much easier this year at the beginning of the year, because last year what we did is we had student teachers and so we were able to start intervention groups in second grade. . . .Eury and I would take small groups . . .and we would all have a kid during their math IE, like a little

> group. And so, when they came to us this year, there was – I want to say – at least 75% of those kids proficient with place value. And to when we started up this year, it made it so much easier because you had so many more kids that knew place value versus the year before. So this year when they came in August 2011, like you still had those kids that were low but you could see exactly where they were low at also because you can look in the spreadsheet. . .

Besides considerations regarding how to structure class time, J. C. Fletcher teachers addressed the challenge of how to structure their year. With the information from their work with second grade students, the third-grade team decided to delay when they would begin their curriculum. Balancing the need to provide students time to get some foundational concepts firmly in place with the pressure to begin their curriculum, Ms. Crumbley explained how they structured the beginning of their year:

> We spend a lot more time at the beginning of the year with place value for those kids that are not there. When we get the reports in August, we do place value first thing. That's what we do for math class for the first 2 weeks. We didn't even start the curriculum sometimes. Sometimes we just rolled into place value remediation just to get those kids up there, because without it it's just going to make everything else difficult.

Even when the time needed is adequate, it is a challenge to structure that time each year in a manner that best meets the needs of the students. For the J. C. Fletcher teachers, time represents an ongoing challenge.

Resources.

Material Resources. In some cases, once the groups had been established, students would work within their specific groups using a common resource with differentiated assignments. Ms. Crumbley explains how she adapted the T-Shirt Factory unit at the beginning of the year to allow her group of students access to the content and the final project:

> . . . we decided to make t-shirts and tie-dyed t-shirts part of our T-Shirt Factory. So what I did is, because I was like, 'I don't want just those kids doing [tie-dying],' so I took the T-Shirt Factory and made a simplified version of it for my kids. So we were still doing T-Shirt Factory, but we were doing our T-Shirt Factory so that they could still participate in the tie-dying and understanding why we're tie-dying t-shirts.

Human Resources. J. C. Fletcher teachers not only addressed students' needs within their classrooms and at their grade level, they also served as resources for their second grade colleagues at the end of the year. Ms. Athey described how they began this process by enlisting the help of their principal and approaching the second grade with the data:

> I really think it was one of those things that second grade saw it as a need . . .they were like, 'yes, we're doing it. Absolutely we need this help. We need these kids to be more prepared for third grade.' And they've always been very receptive to just any kind of comments or even constructive criticism that we've had as far as what second graders know and don't know coming into third grade and what they absolutely have to know. So, I mean it was just a matter of us talking to them, and they were like, 'yep, sign us up.'

This cross-grade-level work also challenged teachers to be aware of and address students' needs in grade levels other than their own. The third-grade teachers came to understand the second grade context in which their students had developed mathematically, and the second grade teachers better understood the work for which their students needed to be prepared at the beginning of third grade. Ms. Crumbley explained this idea:

> So I think it just holds more people accountable and it makes [us] vertically more willing to go to the next grade level and say, "Look, I don't want to send you this kid [not ready]. What can I do to make sure they're proficient in the next level for you?"

As the end of the school year approached, the third-grade team at J. C. Fletcher began to look ahead to year 2 of the implementation and beyond. In thinking about the challenges they had faced in year 1 concerning time, they began to consider what would need to happen in order for students to begin the year fully prepared to engage in third-grade mathematics and the impact of including the second-grade teachers in this first year of districtwide implementation.

> It makes it easier for me too, because I'm starting with a group and I pretty much know where they are, instead of having to figure it out. It allows me to do a better job from the get-go. 'Cause I have a better sense of where the kids are and what they can do and can't do. . . .I think the teachers are communicating across grade levels better. They're communicating within their own PLCs better about it . . . they have a common point to communicate on. I think we're all talking the same language a lot better, and that's a huge help.

Impact on Student Understanding of Place Value

J. C. Fletcher Grade 3 mathematics achievement scores indicate that use of the formative assessment and intervention process was beneficial for their students. Aggregated 2011–2012 EOG data show that 79.49% of J. C. Fletcher's third-grade students performed at or above grade level expectations in mathematics, up from 78.0% in 2010–2011, and 71.80% in 2009–2010. It appears the students in J. C. Fletcher's third-grade classrooms benefitted immensely from the mathematics learning opportunities afforded throughout this implementation year in spite of the numerous demands on teachers' time, the various needs of the student population, and the change in school administration.

Ms. Athey commented on the increasing impact on students' place value proficiency over the past couple years as the formative assessment and intervention process at J. C. Fletcher became more deeply established:

> So that [first] year we went through intervention, and I think the kids came in. . . I think they came in and only 20% were proficient. And then it went up to 90-some percent by the end of the year, and that was with us just putting in place the assessments. And we had our math push-in people pulling groups every day with the kids. And then the year after – so that was actually this year – that was with second grade, doing the interventions. They came in. . . I think it was more. . . it was around 60% proficient, which was much higher than the year before. And now I think we're up to like 98% proficient going into fourth grade.

Ms. Crumbley also described the impact of this process on students, the curriculum, and teachers' ability to address specific needs from the very beginning of the school year:

> And that year it was nice, because we started out knowing, okay, where in place value are they weak. . . and so we could target it at the beginning so that it made them stronger throughout the rest of the curriculum with multiplication and division and fractions and everything you need place value for. . . .It took us a while. We got pushed back with our curriculum because we spent so much time focusing on catching them up. But in the end, it was worth it. Because if we didn't do that . . .like we wouldn't have had as good results later on. And then, this year we came in where we had such a small number not understand place value that we only had to do like 2 weeks of intervention versus a whole month. And so we were able to start our curriculum sooner and the kids were understanding. . .and they had the whole language, 10s and 1S, and that ten 10s make, or 10 one's make a 10 stick. And they were able to have that conversation.

Students were also impacted through the developing understanding of their second-grade teachers, who were more aware of what was expected of students entering third grade and had means by which to measure their students' progress toward those expectations. According to Ms. Crumbley:

> . . . for them to understand where they [students] need to be and what we need them to do, it holds them more accountable and they're really willing, they want to push to get their kids proficient in those areas. Because they don't want to send those kids with like I's or N's . . .[not] to third grade.

When considering the districtwide articulation of the formative assessment and intervention process, particularly in terms of students moving between schools, Ms. Crumbley said, ". . .having everyone else in the district understanding it, I think it made it easier because when one of my kids transferred, he already had it done so when he came in I could automatically look at his scores and say, 'Okay, this is where he needs to go,' or 'Oh, he's still not there yet.' We need to put him into an intervention group." The third-grade team not only noticed changes in their students' overall mathematics achievement scores and their growth on the AMC assessments, the grouping and differentiated instruction also had a positive impact on their students' feelings of self-efficacy. Ms. Crumbley explained further, comparing the affect of some of her struggling students from last year to this year:

> And some of my kids that were lower just didn't feel as comfortable and they didn't shine as well. Like they didn't come out of their shell. They were just back there. But this year I've noticed . . . they were willing to participate and speak out and come to the board and do things because they just felt comfortable.

When asked to expand on this a little more and explain how she thought grouping by identified need across the grade level impacted her students, Ms. Crumbley said:

> Yeah, because we do try so hard to get those kids where they need to and we do such a good job, I think, as a PLC matching up the kids with other kids that need the same skill as them and with the [right activity] . . . We actually do it based on the type of skill . . . I just think the kids do so much better with it . . . because a lot of those end up being behavior kids. But it's interesting because you see how they participate more. So, it might be a little crazy and chaotic because you have more of the like the kids that shout out and the ones that move around the room all the time. But their behaviors academically, like they're more involved and

engaged into the lessons or the activities because they feel confident and comfortable with kids [around] them.

For the third-grade teachers at J. C. Fletcher the districtwide implementation of the formative assessment and intervention process they had been using for some time presented both challenges and opportunities. Their strong PLC structure and available resources allowed them to expand their efforts beyond their own classrooms while deepening their understanding of how best to utilize the process to the benefit of their own students. Reflecting on the overall impact of implementing the formative assessment and intervention process, Laurie Athey said:

> I think just having the materials and having the training and understanding how to use the computer program really had a huge impact. And we saw it mathematically as far as what the kids could do, not just with place value but just throughout the third-grade curriculum. When we got to rounding and estimating, that was obviously a huge challenge for kids that didn't understand that concept of 10s and 1s and stuff. So I think once we started it, and again, we knew the kids had the gaps and we knew that we had to intervene on place value, but I think once we started it in second grade that's what made the huge difference. Because they came in and we were able to still do interventions based on place value, but then we didn't have to stop everything. We didn't have to stop and it wasn't so many of the kids that we had to address it as a whole grade level.

Theresa Fortino reflected on the overall impact on the students and teachers of J. C. Fletcher Elementary:

. . . I mean, the school I teach at is technically a failing school so EOGs are a big part of it [the culture]. But this year, I think this year showed that good mathematics instruction is important to making that happen. So the group . . . that just finished third grade this year were the kindergartners when we started this project and so they've grown up with us trying to figure this out. And this is the first year we've made math in third grade. . . .I know they had *huge* amounts of growth in third grade. . . and they had major, and I mean major, major behavior issues. So. . .you couldn't say "it was a class of brilliant children and they'll never have a class like that again". There are some very brilliant children, but they're a class of kids, who will be very similar to another class of kids anywhere else . . . But in spite of that, the focus on mathematics instruction—and especially last year with the coordination between second and third grade— . . . it made a big difference.

District Impact on Student Learning

Teachers were able to see their own class data, and administrators at schools were able to look at data across classrooms and grade levels within their school, but districtwide data had not yet been shared with the third-grade teachers when we met on January 26, 2012. At that meeting we began the session sharing the districtwide Grouping Tens data presented in Table 4.11. These data compared the percentage of students proficient on the Grouping Tens assessment by school at two data points, September 29, 2011 and January 21, 2012.

Table 4.11
Percent Proficient by School – Grouping Tens September to January

School	9/29/2011	1/21/2012	Increase
1	33%	63%	*+30%*
2	13%	58%	*+45%*
3	56%	91%	*+35%*
4	19%	51%	*+32%*
5	45%	65%	*+20%*
6	19%	76%	*+57%*
7	16%	64%	*+48%*

These data indicate that every school in PSD, including J. C. Fletcher (school 3 in Table 4.11), showed a minimum of 20% growth in proficiency among their students in conceptual understanding of place value in slightly less than 4 months. One of the third-grade teachers wrote on their exit cards that day, “Growth of all schools – yay!” and another, from Meadow Lake, wrote, “We made tremendous growth!”.

For the third-grade teachers, this was growth to be celebrated while looking ahead to what still needed to be done. Although significant gains had been made, there were two schools who still had less than 60% of their students proficient with place value concepts halfway through the school year and only one school with over 90%. So, although “All schools are showing good amount of growth” was an accurate analysis, the teachers at that session used their planning time that day to discuss how to address the needs of the remaining percentage of nonproficient students by the end of the school year.

One way to measure the impact of the intervention under consideration in the current study is to compare student performance on mandated state mathematics assessments. Unfortunately, the state does not use a parallel test at pretest and post-test for students in third grade, but the state did publish specific rules for converting pretest scores into standard scores that could be compared to end-of-grade scores (see Appendix E). As such, scores for 339 students who completed the assessment in the fall and spring of the year were converted to standard scores. A one-tailed, paired samples *t*-test demonstrated significant differences in scores for the 339 students from pretest (mean = 331.26, standard deviation = 11.58) to posttest (mean = 348.33, standard deviation = 10.04), $t(338) = 38.535$, $p < .001$. Statistical measures are represented in Tables 4.12, 4.13, and 4.14.

Table 4.12
Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	331.2566	339	11.57567	.62870
	Post-test	348.3333	339	10.04330	.54548

Table 4.13
Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test & Post-test	339	.724	.000

Table 4.14
Paired Samples Test

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Post	–17.07670	8.15929	.44315	–17.94838	–16.20501	–38.535	338	.000

Further analysis of the effect size revealed a large effect on student performance on the state-required end-of-grade assessment in mathematics ($d = 1.58$).

Summary

In 2006 PSD was a district immersed in site-based decision making, resulting in a lack of common vision for elementary mathematics. Within 5 years, the district had evolved from a place where multiple standards and numerous curricular materials were in use to one which had clearly articulated what a mathematics program should be and based ongoing decisions on that vision. Through professional development experiences, grant and leadership opportunities, professional conversations, and pilot projects, PSD had established a foundation on which to build their mathematics program.

Several factors, including the state adoption of the CCSSM and continued identification as a district in LEA Improvement in mathematics, spurred the district to seek ways to better identify and address the needs of students in mathematics. A multiyear pilot project using AMC Anywhere in conjunction with ongoing professional development on formative assessment and intervention had produced promising results in one elementary school. Based on those results, the new director of elementary education initiated the districtwide implementation of a formative assessment and intervention process at grade 3.

The third-grade teachers in PSD engaged in the first year implementation of the districtwide formative assessment and intervention process during the year of this study. They encountered and addressed several challenges, both individually and collectively, as they worked to implement the formative assessment and intervention process, make sense of the data, and use those data to make instructional decisions.

Particular challenges emerged as more dominant than others during the course of the implementation year, although the challenges faced by the J. C. Fletcher teachers were not necessarily the same faced by the teachers at Meadow Lake. In spite of the challenges teachers faced, their efforts to understand how and what their students were thinking about important mathematics and base instructional decisions on those understandings yielded significant positive results.

This chapter presented two case studies with description offered through the embedded cases of each to provide a detailed report of the research findings. Understanding the factors that supported or inhibited the implementation of a formative assessment and intervention process in PSD is important in considering implementation of such a process in other grade levels as well as other settings. In the final chapter, the cross-case analysis as well as conclusions and implications of these findings are discussed and avenues for further research are proposed.

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the ways in which third grade teachers in one school district implemented a formative assessment and intervention process focused on the core topic of place value and the impact of this implementation process on student learning of that core topic. The following broad questions guided this research:

1. How does a group of third grade teachers, individually and collectively, implement a formative assessment process?
2. What sense does a group of third grade teachers implementing a formative assessment process make of the assessment data individually and collectively?
3. How does a group of third grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?
4. How does the implementation of this formative assessment process support students' developing understanding of the core topic of place value in third grade?

This final chapter begins with a review of the background and methodology of the study followed by a discussion of findings across cases. Through this discussion, research findings will be synthesized and the four research questions used to guide this study will be answered. Next, implications of this research will be discussed including recommendations for advocates of mathematics formative assessment. Then study limitations will be identified along with suggestions for future research. Finally, summary conclusions will be offered.

Study Background

This descriptive study, done through an engaged scholarship lens, considers one district's efforts to implement a formative assessment and intervention process. Specifically, this study looked at the third grade teachers' implementation within this district and the impact it had on student learning.

Beginning in 2007, a series of professional development efforts in the Piedmont School District (PSD) over several years resulted in a pilot study at one school using the AMC assessment and intervention materials. Through a series of grants, the initial use of paper/pencil assessments and process of aggregating data by hand evolved into the use of a web-based interface and almost instantaneous access to data. In the summer of 2011, based on consistently positive results at the pilot school, the director of elementary instruction for the district decided to expand the process district-wide beginning with third grade. An implementation team was established in order to plan and facilitate that process.

It took careful planning and consistent effort to help teachers understand the purpose and process of formative assessment and how it differs from the summative assessment process they were familiar with. Premised on the use of the three questions, 'where are you going', 'where are you now' and 'how are you going to get there', the formative assessment process used in this implementation required that teachers have a measure of understanding of mathematics content. This implementation process focused on third grade, and, knowing what third grade students were expected to know and do by the end of the year, professional development was concentrated on the core topic of place value. Further, place value is a concept children often appear to have a deep conceptual understanding of when, in fact, they are simply able to follow procedures devoid of any real foundational place value understanding. So, if we know what we want children to know, then we must have an organized plan to find out *if* they know it and *how* they know it. It is the purpose of formative assessment to do just that.

This study was descriptive and instrumental, primarily focused on capturing what the five teachers within the two case study schools were experiencing, both individually and collectively. The study considered the district perspective, the school perspective and the teacher perspective in order to situate the study within the reality of teachers' context. Data collected through interviews provides a thick description of the context within which the study took place. Students' pre- and post-assessment results were analyzed in order to look at the impact of the implementation on student learning. And finally, professional development documents were collected to add further detail and context.

Data analysis was completed both during and after the data collection process to develop case stories and cross-case analyses. Interview data was inductively themed and those themes sorted then combined into overarching themes. What emerged from this inductive analysis of the data were Cizek's seven challenges to implementing formative assessment in the classroom with the addition of one other relating to the affective aspect of teachers' experience throughout the implementation process, what was called 'disposition'. Those themed data were then grouped in answer to the research questions and patterns of response to the challenges teachers encountered throughout the implementation process were identified. Findings related to individual cases were presented in Chapter 4. The following section discusses the findings of the cross-case analysis.

Discussion of Findings Across Cases

The discussion of findings across cases will be presented in four parts. First, attention will be given to the challenges related to the implementation of the formative assessment process in PSD and patterns of response that emerged in light of those challenges will be presented. Then consideration will be given to what study findings suggest about the challenges teachers faced in making sense of assessment data. Three broad categories that capture the ways teachers approached making sense of assessment data will be presented. Next, patterns in challenges related to using formative assessment data in making instructional decisions will be discussed as well as the types of responses observed. Finally, consideration will be given to the impact of the formative assessment and intervention implementation on students' mathematics understanding. Through this cross-case analysis, the research questions that guided this study will be answered.

Implementation of the Formative Assessment Process

The first research question considered in this study was, "How does a group of third grade teachers, individually and collectively, implement a formative assessment process?" Engaging the PSD third grade teachers in this implementation process created a state of disequilibrium as they were asked to consider their current teaching practice in light of new information and new mandates. The very nature of an implementation process implies change and both the teachers and the implementation team had to address several challenges within the scope of that process.

When considering the evidence related to the implementation of a formative assessment process, the most prevalent challenges for the teachers at J. C. Fletcher and Meadow Lake were time and resources, with the most significant challenge being time. Teachers initially reported having no time available to implement the formative assessment process in their classrooms. Later reports indicated that teachers were addressing the issue of time as best they could, but they were still struggling to incorporate time for interventions into their classroom routine. The persistent response to each aspect of the implementation process was, "How am I going to find the time to do that?" though this initial reaction was tempered as teachers addressed issues of time within their classrooms. The implementation team frequently addressed teachers' concerns about their struggles with time throughout the implementation year, though there were some qualitative differences to throughout the study. At first, teachers' expression of their attempts to address this challenge were distressed while later on they were articulated more thoughtfully and with careful consideration of possible solutions, often looking forward to what might be possible the following year.

J. C. Fletcher teachers were those who had piloted this process, therefore they had been addressing the challenge of time for a full year. They had their process set, they knew when their intervention was going to be and they knew how they were going to run it in their classrooms. However, their issue with time was how they could carve out a little bit more time in order to focus on secondary interventions with those children who were really in need of some intensive intervention or enrichment. The challenge the J. C. Fletcher teachers faced was delivering these secondary interventions within the scope of their established classroom routine, not as an add-on to that routine.

The challenges faced by the Meadow Lake teachers were different than those faced by the J. C. Fletcher teachers. At Meadow Lake, the third grade team wondered where they were going to get the time required to do all they had to do already *plus* implement this formative assessment process along with the interventions. As a team, the Meadow Lake teachers were skeptical about finding time to conduct the assessments. Teachers were given time during the first professional development session to go back to their classrooms and begin assessing their students while the substitutes were still there and working with the children. This arrangement worked well for the Meadow Lake teachers and throughout the school year, as teachers needed time to assess, an interventionist, teaching assistant, tutor or administrator would engage the students in classwork to provide the time needed for the teachers to complete their assessments.

The other common challenge faced by teachers in the case study schools was that of resources, both human and material. As with time, the teachers from the two case study schools had different experiences addressing this challenge. The J. C. Fletcher teachers had their human resources identified and organized, and they had an established plan for how to use them. The challenge for the J. C. Fletcher team, both individually and collectively, was considering how to reallocate those resources in order to address the needs of students who required secondary interventions. The teachers wanted to do this without negatively impacting the resources available for the already-established intervention process.

In contrast, the Meadow Lake teachers were concerned with where they would get the human resources they needed to implement the intervention process to begin with. The third grade team enlisted the help of their principal and their interventionist to address the challenge of human resources. Interestingly, as human resources were enlisted to assist the third grade team, they actually became a hindrance to the implementation process. The interventionists and others who came on board began to take over the intervention piece of the process. As a result, the implementation within the classroom was not quite as deep as the district leaders had intended. This situation presented a challenge at the school and district level, namely helping teachers and schools find that balance between in- and out-of-classroom resources in order to support the change in teacher instructional practice that was the intent of the implementation.

Materials resources also presented a challenge for both case schools. J. C. Fletcher had their materials, had them organized, and they acted as a resource for answering questions about what materials were really necessary and useful to have in order to implement the formative assessment and intervention process. Their challenge was to refine their organization and to share what they had done, how they had done it, and why they had made the decisions they had, striving to make sense of what had become second nature to them. Meadow Lake teachers again struggled to find appropriate material resources to use in the first place. They first approached their principal to determine if funds were available to purchase the needed resources. When they were told there were no funds, these teachers wrote a grant to get the materials they felt would be necessary to fully implement the process. Their intent was to create a mathematics library for the school so that all teachers who would be implementing this process in the future could have access to the material resources they needed, therefore eliminating this particular issue as a challenge others would have to address. However, because this was a grant, the materials arrived late in the year and were not going to be organized until the summer following the implementation year for use the following fall.

Finally, both the Meadow Lake and J. C. Fletcher teachers addressed the challenge of purpose. Purpose was a fleeting issue for the majority of teachers at the beginning of the implementation process, though again it was two-pronged for these two schools. For J. C. Fletcher teachers, the challenge was how to explain the purpose to other people, how to take what they inherently understood and explain it to someone else in a manner that would help them understand as well. For the Meadow Lake teachers, the challenge was that they needed to be convinced that the implementation of this formative assessment and intervention process was going to serve the needs of their students better than the process they had already put in place that they felt was working well. For the Meadow Lake teachers, this challenge was resolved very quickly, as the third grade team was able to assess and identify areas of need for their students with an efficiency they had not experienced before.

Throughout the year of this study, the most enduring challenges teachers addressed across cases were those of time and resources, both material resources and human resources. Though both Meadow Lake Teachers and J. C. Fletcher teachers initially reported challenges related to purpose, in both cases these issues were quickly resolved, though they could, perhaps, emerge in another form in the future.

While the evidence indicates that teachers at J. C. Fletcher and Meadow Lake acknowledged and addressed the challenges they faced in the process of implementing the district-wide formative assessment and intervention process in their classrooms, variation among teachers' response to the disequilibrium created by those challenges was also evident. The patterns of teachers' response to those challenges could be categorized into three groups. These three categories are presented in Table 5.1.

Table 5.1
Responses to Implementation-Based Disequilibrium

	Type of Response	Description
3	Adoption of a New Instructional Paradigm	This type of response can be described as "Change To". In this response type, teachers worked to use the new practices instead of their current instructional practice. In this case, the disequilibrium teachers experienced as a result of the implementation process increased in the initial stages of changing to the new instructional paradigm. This process required support outside of their own efforts to sustain. The disequilibrium was resolved over time as the teacher managed the change and began to see benefits from the effort. In their search for equilibrium, teachers in the Adoption category typically either reverted to their former instructional paradigm or developed a new paradigm that proves more effective.
2	Modification of Current Instructional Paradigm	This type of response can be described as "Incorporate In To". In this response type, teachers worked to use the new practices, making substitutions for elements of their current instructional practice. In this case, the disequilibrium teachers experienced as a result of the implementation process was resolved over time as the teacher fine-tuned the interaction between the new instructional practices and those elements that had been retained. In their search for equilibrium, teachers in the Modification category typically adjusted their former instructional paradigm to incorporate elements of the new process. Adoption of the new practices was dependent on teachers' ability to merge the new and former practices into a cohesive whole.
1	Maintenance of Current Instructional Paradigm	This type of response can be described as "Add On To". In this response type, teachers worked to use the new practices *in addition to* their current practices. In this case, the disequilibrium teachers experienced as a result of the implementation process was not resolved. In their search for equilibrium, teachers in the Maintenance category typically reverted to their former instructional paradigm.

Collectively, the PSD teachers reacted to the implementation process with a Maintenance response, something along the lines of, "Do I have to?" Initially, what they were asked to consider was thought of as something to do in addition to what they already had to do, Two of the case study teachers, both near retirement, held on to the Maintenance response for the duration of the implementation process. Though they fulfilled the minimum district requirements, these teachers did not fully incorporate the process into their instructional practice. In the hope of regaining equilibrium, these teachers held fast to their current practices and reverted to their former practices as soon as possible.

For the majority of teachers, however, there was a relatively quick shift to a Modification response that was sustained by the positive feedback they received from their students. Two Meadow Lake teachers were identified at this level of Response to Implementation-Based Disequilibrium. They eliminated certain aspects of their previous instructional practice and replaced them with some of the formative assessment and intervention practices that were part of the implementation process. Aligned with the Model of Teacher Change discussed in Chapter 2 (Guskey, 1986), it is likely that teachers in this phase adopted the new practice temporarily, but the evidence of positive changes in student learning outcomes served to strengthen the use of those new practices.

Throughout the implementation, ongoing support in a variety of forms was needed to address occasional setbacks, provide individualized and small-group feedback, and encourage teachers to continue with the new practices as they awaited the student outcomes (Guskey, 2002, 2003; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). For the two case study schools, additional support personnel also reinforced the sustained attention to the new practices. In addition, both schools took advantage of and were supported by the district implementation team member assigned to them. Finally, both Meadow Lake and J. C. Fletcher teachers were part of strong PLC's. Throughout the implementation, the PLCs functioned to support teachers as they espoused the formative assessment and intervention practices. Given enough time, support and, eventually, evidence of positive student impact, teachers in the Modification response category found a new equilibrium that included the new instructional practice.

The final type of response to the implementation process was Adoption of a New Instructional Paradigm. This type of response can be described as “Change To”, in which teachers worked to use the new practices instead of their current instructional practice. This change initially resulted in an increased sense of disequilibrium as the teachers worked to make a wholesale change to the new instructional paradigm. It was here that almost all the J. C. Fletcher teachers were operating. They had done this formative assessment and intervention process long enough that they had changed to a new model and a new way of thinking about how to work with their students. As a result of achieving this level of response to the implementation process, the issue with time and secondary interventions was occurring. The amount of time available during the school day was defined, but their understanding of the process and the ways in which the process had become part of the fabric of their instructional practice created a challenge between a desire to address student needs personally and the limited time they had available. While these teachers initiated and supported the process, they required outside support in order to sustain it. The disequilibrium was resolved over time as the teachers managed the paradigm shift and began to see benefits from that effort. In the search for equilibrium, teachers in the Adoption category developed a new paradigm that proved more effective, though they were frequently on the verge of reverting to their former instructional paradigm during the transition.

Guskey's Model of Teacher Change provides a framework for considering teachers’ experience with the implementation process and the space between the Change in Teacher's

Classroom Practice and Impact on Student Learning. During this study, it became apparent that the unidirectionality represented by the arrow within this aspect of Guskey's framework was, in practice, bidirectional. Throughout this study, student learning outcomes influenced and were influenced by Change in Teacher's Classroom Practice, thus creating a bidirectional rather than a linear relationship.

The results of the study also bring into question the Stages of Concern in the Concerns Based Adoption Model (CBAM) discussed in Chapter 2 (Hall & Hord, 2001). This model was considered as a way to describe the teachers' response patterns, however, the Stages of Concern didn't quite fit what emerged from the data. Interestingly, the patterns of response from this study do correlate with those that have been studied and explained extensively by the CBAM model. Though the sample of teachers in this study is small, the patterns that emerged are consistent with those described in CBAM literature (Anderson, 1997; Hall & Hord, 2001; Loucks-Horsley, 1996; Newhouse, 2001; Willis, 1992). Furthermore, the Patterns of Response to Implementation-Based Disequilibrium described above correlate closely with the CBAM Stages of Concern. This overlap and the extensive CBAM literature suggest that it is likely that many teachers engaged in a similar implementation process would respond in ways that mirror the responses of teachers in the current study..

Making Sense of Assessment Data

This study examined the ways third grade teachers made sense of assessment data. The second research question was, "What sense does a group of 3rd grade teachers implementing a formative assessment process make of the assessment data individually and collectively?" Similar to the challenges teachers faced with implementation, time was the most pervasive concern teachers addressed throughout the year of this study. According to Cizek, "…the nature of formative assessment includes nonevaluative feedback, tailored to the specific strengths and weaknesses of individual students..." (2010, p. 12).

In making sense of the assessment data, time was again the major challenge faced by teachers at both J. C. Fletcher and Meadow Lake. They needed time to work with their PLCs to understand the way data were presented in the report, time to analyze the data to figure out what they were showing them about their students' mathematical understanding, and then they needed time to interpret the data and apply their understandings. As with the implementation findings, the challenge of time was experienced differently in the two cases. For the Meadow Lake teachers, the challenge of time was becoming accustomed to analyzing and making sense of data in this new format with their PLC. For the J.C. Fletcher teachers, the challenge was finding the time to dig deeper into the data and look for patterns over time in order to see trends for their students.

The research data for the five teachers within this study indicated three types of data use: instrumental, symbolic and conceptual. Teachers' approaches to making sense of student data varied according to whether they adopted an instrumental, symbolic, or conceptual approach (Sharkey & Murnane, 2006). These approaches along with a brief description of each are presented in Table 5.2.

Table 5.2
Making Sense of Assessment Data

	Approach	Description
3	Conceptual	Assessment data is used to identify patterns in student results, to provide evidence for possible explanations underlying those patterns, and as identifying patterns in student assessment results is only a first step. A second is brainstorming about possible explanations. A third is developing and implementing a strategy for identifying the most compelling explanation
2	Symbolic	Assessment data is used to justify a predetermined viewpoint or decision that has already been made
1	Instrumental	Assessment data is used to make instructional and other decisions for students based on a score without consideration for the underlying causes

Teachers who adopted the instrumental approach to make sense of data used the results to make decisions in a manner consistent with our traditional understanding of the use of test scores. The implementation team received numerous questions about how to represent the assessment results on report cards and how to equate the assessment levels to a percentage in order relate the AMC indicators to the percentage-based grading system used within the schools and the district. Teachers who used the instrumental approach focused on the assessment results themselves with no consideration for factors that may have contributed to those results.

The symbolic approach to making sense of data was used by teachers to justify or support a predetermined decision or perspective (Feldman & March, 1981; Huberman, 1987; Patton, 1997). Teachers who took this symbolic approach were often quite surprised when students who typically did poorly in class performed very well on the AMC assessments or when a student who 'did well' in class had surprisingly low results on an assessment. In both cases, the data didn't fit their idea of what this child should be able to do. Teachers who adopted the symbolic approach often viewed the AMC assessment data as an anomaly within the overwhelming evidence that contradicted those results. Often at the same time, teachers at the symbolic level used assessment results as a source of validation, providing further evidence of their current perception of a child's level of mathematical understanding and providing justification for the status quo in the classroom.

The conceptual approach to making sense of assessment data was the most difficult approach for teachers to use. Teachers who used the conceptual approach to making sense of data viewed the results of an assessment as the starting point for a deeper understanding of what students knew and were able to do and, by association, how effective their instruction had been. As more data became available, a more nuanced understanding of the students, their strengths and needs was created. The teachers who used the conceptual approach to make sense of data were looking for patterns of student response, causes for those patterns, and evidence for what to do next. One teacher at J. C. Fletcher used the conceptual approach to data use on a rather consistent basis. This teacher compiled and referred frequently to students' data records, using trends in those data to describe her students' areas of strength and need. Those data trends also served as the basis for decisions she made regarding intervention settings and activities. While the conceptual approach to making sense of assessment data holds the greatest promise for improving teaching and learning, it is the most difficult approach for teachers to use.

Using Data for Instructional Decision Making

This study explored the ways third grade teachers used data to inform their instructional decision-making, considering the question, "How does a group of 3rd grade teachers implementing a formative assessment process apply their understanding of the data in making instructional decisions individually and collectively?" For teachers at both J. C. Fletcher and Meadow Lake, evidence pointed to time and resources as the primary challenges teachers had to address. Once teachers began seeing the changes in their students' mathematical understanding as they utilized the formative assessment and intervention process, they wanted more time. They wanted more resources. They wanted to learn more about how to do the interventions, what interventions to use, and the challenge was trying to carve out time to make those changes. Again, though both case schools experienced the challenges with time and resources, the nature of those challenges was qualitatively different between the schools.

For Meadow Lake teachers, the challenge was finding the time to get that initial system in place. One of the ways in which the Meadow Lake teachers addressed this challenge was to substitute intervention time for recess twice a week, on the days each class was scheduled to have PE. Because the students had PE on those days, the state mandate for daily physical exercise was met and that time could be reallocated, providing teachers with thirty minutes of intervention time twice a week. While not an ideal solution, the Meadow Lake teachers expressed appreciation for Mr. Parkin's willingness to listen to their needs and offer solutions. Through enlisting their interventionist for both material and human resources, the third grade team began a process of identifying and addressing their students' needs.

Teachers at J. C. Fletcher had an established time structure, as a result, the challenge was trying to modify that structure in order to address the full range of their students' needs within the classroom context as much as possible. The J. C. Fletcher teachers preferred to address students needs within their classrooms as opposed to sending them out for intervention services. As an additional time challenge, the teachers' depth of both practical and theoretical knowledge of the formative assessment and intervention process made the J. C. Fletcher team a knowledgeable and desirable resource for their colleagues across the district. This, in itself, presented challenges for these teachers as they worked to balance these new demands on their time with the needs of their students and colleagues at J. C. Fletcher.

In terms of resource challenges, the J. C. Fletcher teachers had concerns regarding their ability to maintain the human and resource materials they had in place. Their system was working, they were seeing results, but there was some concern about being able to sustain it over time. One of the teachers mentioned the district and state focus on reading as a threat to the resources they had carved out and established for the intervention process, threatening to pull the available support personnel in another direction. This teacher was resigned to the fact that, in the coming school year, the Intervention and Enrichment IE time they had designated during the last 30 minutes of every school day would be cut back to 3 days for mathematics and 2 days for reading.

Looking across cases in PSD, three types of instructional decision-making responses emerged: resource, intervention and differentiation. These are presented in Table 5.3 along with a brief description of each of each type of response.

Table 5.3
Types of Instructional Responses

Type of Response		Description
3	Differentiation	Based on data, students are grouped and paired with another adult outside the classroom for intervention, usually in addition to core instruction
2	Intervention	Data is used to group students according to demonstrated need and tailored instruction is provided to address that need. Typically, this takes place within the regular classroom, either the students' own or another on the grade level and is usually in addition to core instruction, what is sometimes referred to as IE time.
1	Resource	Student data is used to make ongoing adjustments in real time in the core classroom to address demonstrated needs. This is the least restrictive response and most closely aligns with the 'pure' definition of formative assessment

Teachers who employed the resource response to using data for instructional decision-making used the human resources at their disposal to have students with the greatest needs engage in their intervention work outside of the classroom. The resource response was an intensive focus in a separate setting, usually with a specialist and typically in addition to the regular classroom instruction. This was the most restrictive approach to meeting student needs based on their assessment data.

The intervention response to using data for instructional decision-making was employed by teachers using existing human resources (i.e., teaching assistants, other classroom teachers, tutors) to regroup students within the classroom or across classrooms. Using this approach, teachers limited the range of student needs within a group so they were able to address more students with similar needs. Teachers who used this approach also paired teacher strengths with student needs.

The differentiation response was the least restrictive and most closely aligned with what is typically understood to be associated with short-cycle formative assessment. In this process, teachers assessed and responded to student needs in real time, immediately adjusting instruction and assessing student responses. This type of response was often used selectively by teachers within the other response approaches and was typically the most difficult for teachers to use.

In analyzing the responses of both Meadow Lake and J. C. Fletcher teachers, evidence indicated the use of all three types of instructional responses. Given the available resources (materials and knowledgeable interventionists), these teachers were able to better address their students' demonstrated needs and began to see results. As Ms. Bardsley said, "I can't make a difference with 2 days a week. It's not enough. And so when I started getting them 4 days a week, I started making some progress."

Impact on Students' Understanding of Place Value

The study of number and operations is a major emphasis in the elementary grades. While it is one of many strands, number is an essential component of mathematics and, for elementary grades, the dominant focus of their instructional practice. Number and operations are the tools for work in several other strands of mathematics, including measurement, data analysis, and algebra. Knowledge of number also permits students to represent and act on many real life situations and abstract notions through symbols.

Analysis of student EOG results indicated significant differences in pre- and post- test scores, $p<.001$. Further analysis revealed an effect size of 1.58, nearly double the .8 that is generally considered a large effect size. An effect size of 1.0 indicates that a particular approach to teaching or technique advanced the learning of the students in the study by one standards deviation above the mean. For students' growth from one year to the next, an average effect size across all students is 0.40 (Hattie, 2009). In this study, the effect size was nearly 4 times what would have been expected had the students not been part of the district-wide formative assessment and intervention process. As one of the teachers wrote, taking the long view of this implementation process, “we are making progress, and I can't wait to see what the kids will be like 3-4 years from now”.

Not only did teachers observe a quantitative change in students' mathematics ability, they witnessed a qualitative change as well. Across both case study schools affective changes were observed, students expressing deep disappointed if their intervention time was shortened or they were not able to attend for a day. As Melinda Wehling, PSD director of elementary education, shared:

> In classrooms that are using AMC, you’ve got kids running in from the playground for math intervention, disappointed if it is cancelled. …How exciting is that! So now an intervention isn’t a, ‘Oh, you’re going to beat me over the head with the same question over and over again.’ It’s like, ‘Ohhhhh, we get to do some really cool things!’

Teachers from both J. C. Fletcher and Meadow Lake talked about children who were making connections and starting to understand the mathematics they were being asked to do and expecting to make sense of it. Beyond the quantifiable effect of increased test scores, students’ attitude toward mathematics also showed improvement.

Key Lessons

Among the various findings that emerged from this research, three in particular are most significant in planning for and successfully implementing a large-scale formative assessment and intervention process. These key findings are:

1. Anticipate, identify, and address the challenges teachers face as quickly and efficiently as possible.
2. Include and support principals and district administrators throughout the process so they can, in turn, support the teachers.
3. Focus on improving teachers' data literacy, including increasing teachers' mathematics content knowledge.

The first key finding is that the importance of anticipating, identifying and addressing the challenges teachers will face throughout the course of the implementation cannot be overstated. Those challenges should be identified and addressed as far in advance as possible and as consistently and efficiently as possible. Much like the formative assessment process that we are asking teachers to adopt and incorporate into their instructional practice, it is important for leaders of professional development to adopt a similar practice in order to identify where the teachers are, where they need to go, and plan for how to support them in getting there. The big question to ask at this point is *what is the one thing that is stopping this teacher from moving one step closer to fully embracing these formative assessment and intervention practices as part of their regular instructional practice?* In answering this question, staff development becomes more individualized and more effective in supporting teachers as they make changes to their instructional practice and adopt a new instructional paradigm in their classrooms.

If we know that formative assessment holds the greatest potential for ensuring students learn mathematics with greater understanding and facility, then it is our professional responsibility to invest the necessary resources to support teachers' transition to this type of teaching. This means that the challenges to implementing this type of assessment and intervention must be considered, addressed, and supported throughout the process of teachers change. This will be a prolonged effort, not a quick fix, though the student assessment results show an almost immediate impact. However, as Gusky's model of teacher change indicates, this is an ongoing process, not a one-time event and it is not until teachers are convinced of the benefit to their students that real change will happen. Support will need to be ongoing, timely, and personalized in order to address teachers' unique needs and provide personalized reinforcement.

A second key finding is that principals and administrators must be included in all aspects of the implementation process. In actively participating in this process they can better understand the experiences of their teachers, develop their own frame of reference for understanding the implementation process, and support their teachers both as they engage in staff development and endeavor to put new instructional approaches into practice. With greater understanding of the implementation and teachers' experience of that process, administrators can limit or at least contextualize any conflicting information or mandates that teachers will no doubt receive from a variety of sources. In addition, with increased participation in the implementation process and a better understanding of the purpose and power of formative assessment, administrators are more likely to see continuing evidence of positive change in student outcomes and serve as advocates for their teachers and the process as a whole.

Finally, a focus on improving teachers' data literacy is imperative. Data literacy is the ability to accurately observe, analyze, and respond to a variety of data for the purpose of continuously improving teaching and learning in the classroom. Within the current school context, data use is a primary focus of research aimed at understanding how teachers engage in data-based decision making. Teachers are currently overwhelmed by data, but they are struggling to make sense of those data. Most teachers are able to adequately analyze and interpret data, but they are not as clear about what next steps are indicated by those data. Teachers' desire for further training and support in regard to data literacy was clearly evident when, looking at the district exit cards following the final workshop session, every teacher mentioned in some way that they needed to find out more about interventions, wanted to better understand how to pair students needs demonstrated through the data with interventions, or simply stated, "I still don't know that I know what to do next."

Data literacy is highly dependent on teachers' mathematics content knowledge. In the primary grades in particular, few teachers are content specialists in mathematics. Data literacy incorporates knowledge of learning progressions, mathematics content, and children's development of mathematical ideas with data analysis; what is widely known as mathematical knowledge for teaching (MKT) (Ball & Bass, 2000). Lack of data literacy often results in teachers viewing student data as distinct points in development rather than looking for the connection between those points and the underlying explanation for those data. The majority of teachers still look at data very much in a summative way, as an event that has already passed and which they can do nothing about. We must build their data literacy so that they view data as a source of more detail which, in conjunction with other data, paints a more accurate picture of the child's current level of understanding and reveals more about what is needed next to increase that understanding. In general, teachers are quite fluent in deconstructing data through the process of data analysis; however, in order to be truly data literate, they must also be able to reconstruct those data in a way that provides information that is actionable. They must be able to combine what the data says about the child with their understanding of learning progressions and child development in mathematics. All of this informs the efficacy of teachers' data-based decision making and the impact of those decisions on student learning.

Study Implications

Implementing a district-wide formative assessment and intervention process is challenging, particularly in that such a process cannot be solely based on a product, technology, or system. As a result, such a process is not easy. The process of change creates a sense of disequilibrium for teachers and resources must be focused at the district and school levels in order to assist teachers, staff, and administrators with making such change in a manner that is purposeful, effective and provides the greatest opportunity for success for all students. This section will discuss implications of this research for teachers, school and district administrators, and teacher educators.

A systemic approach is needed to train, empower, and support teachers as they engage in the implementation of a formative assessment and intervention process. Implementation teams need to work with teachers, principals and district administrators to ensure this happens. While teachers are the primary players, school and district administrators must have functional knowledge of that process and provide ongoing support for their teachers throughout the implementation. Districts and schools must each commit to sustained professional development for their teachers and the assignment of adequate resources in order to support the implementation. This study has several implications for each of these groups of educators as well as for teacher educators.

The overriding implication of this research for teachers is a need to focus on assessment literacy, including a particular focus on data literacy. Teachers generally lack the skills necessary to make formative judgments about students and use data to draw inferences in order to plan next instructional steps. With respect to data literacy, the greatest emphasis needs to be the focus of such work is helping teachers become more proficient in knowing how to use data to guide instructional decisions. That is the most difficult part of data literacy for teachers. Mathematical knowledge for teaching is also a needed area of focus, primarily because a lot of the instructional decisions teachers are being asked to make are dependent on their level of mathematics content knowledge and knowledge of how students learn mathematics.

For principals and other school administrators, this research indicates a focus on assessment literacy is also important in order to help guide teachers in their work and to make sense of the data. Principals also need to think about and anticipate what impact implementing a formative assessment and intervention process might have on teachers and the school and be understanding of those effects. Such effects might include changes to classroom rules and expectations and a need to reenergize teachers as they struggle to balance the changes they are being asked to make in mathematics with the demands placed on them in other content areas. In particular, principals need to think about how they might need to reallocate resources, including materials, personnel and even time, in order to support the use of a formative assessment and intervention process. Teachers need concentrated time and support to focus on assessment literacy within their PLCs so they can make purposeful decisions about next instructional steps for their students. As teachers work to implement a formative assessment and intervention process, principals have to be knowledgeable about what the process is. Without that knowledge, including what is expected of their teachers and the challenges which teachers are likely to encounter, they will not be able to effectively support that process and may, in fact, have expectations of those teachers that would be in opposition to those of the process being implemented.

The findings of this study also have implications for district administrators. Again, assessment literacy is an area in need of attention. Very few district administrators received adequate training in assessment through our teacher education or administrative certification programs. Therefore, assessment literacy, with a specific concentration on data literacy, must be a focus at all levels within a district implementing a formative assessment and intervention process like the one that is the focus of the current study. District administrators should have a clear idea of what formative assessment is, what it looks like in practice, how to communicate both those understandings to others, and how to implement and sustain a formative assessment process. In addition, district administrators need to identify and clearly address with teachers and school administrators those policies at the district level which conflict with the formative assessment and intervention process being implemented. Such policies might include grading, the format of report cards and the manner in which teachers are expected to complete them, the ways teachers are expected to use district documents, such as pacing guides and benchmark assessments, and the manner in which student assessment results are discussed with and in reference to teachers.

From the district level, professional development must be viewed as a purposeful and sustained practice, understanding and providing for the fact that teacher change takes place over time, taking sometimes 2 to 4 years before teachers are able to confidently and skillfully use the innovation as intended (Mitchell, 1988). District administrators must assure those most closely involved with the implementation process that the effort will be an ongoing one with continued district support throughout that process. This commitment to sustained professional development on the part of districts and schools is essential for teachers to fully implement a formative assessment approach. In addition, structuring time for teachers to develop and reflect on these emerging practices is critical. Supporting teachers in the process of developing formative assessment and intervention practices will lead to significant changes in instructional practices and policies, and staff buy-in and engagement in considering next steps is important.

The findings of this study also have implications for teacher educators. Assessment literacy for preservice teachers, inclusive of data literacy, is something that is not done very well in teacher preparation programs, if at all. Preservice teachers may learn how to conduct an interview and engage in a minimal analysis of the results, but engaging in deep discussions about how to analyze those results and then determine and implement next steps is something that is rarely done. Engaging in such discussions would be extremely difficult given the current mathematics content requirements for most preservice teachers. In the vast majority of elementary preparation programs the methods course is the only mathematics-oriented class required in addition to the minimum university requirements. Methods courses are necessarily limited in the scope of mathematics content that can be addressed. As a result, the depth of content knowledge needed to make informed instructional decisions based on formative assessment data is lacking as these preservice teachers enter classrooms.

The implementation of a formative assessment and intervention process has implications within and beyond the classroom. While professional development to sustain and support such an implementation are essential for teachers to adopt, develop, and refine the formative assessment practices, this development cannot be sustained without the knowledge, endorsement and ongoing support of both school and district administrators throughout the process. It is only through deep understanding of the implementation process that administrators can adequately support their teachers within the context of all that happens in a classroom, a school, and a district.

The implications of this study extend beyond the district as well. As districts increasingly embrace formative assessment practices, teacher preparation programs must adjust their practices in order to adequately prepare preservice teachers for the realities of the school environment. This includes an increased focus on mathematics content and assessment literacy.

Study Limitations and Directions for Future Research

The research findings presented in this study provide insight into the ways 3rd grade teachers in one school district implemented a formative assessment and intervention process focused on the core topic of place value and the impact of that implementation process on student learning. Finding revealed a significant positive impact on students' performance on EOG tests as compared with their pre-test results. However, several limitations must be addressed for the current study.

First, this study is limited in its scope. This investigation focused on five teachers in two schools in a particular school district with a focus on the core concept of place value in grade 3. While the contexts and student demographics of these two schools varied significantly, future research should explore if the experiences and impact are consistent across different instructional contexts, within other grade levels, and focused on other core concepts.

A second limitation of is the limited perspective from which data was gathered. This study focused on exploring teachers' experiences implementing a formative assessment and intervention process as observed in professional development contexts and gathered through teachers' reports in professional development documents and interviews. While this allowed for detailed analysis of how teachers experienced this implementation process, a more complete understanding of the implementation process from the students' perspective and through direct observation of the formative assessment practices in use in the classroom would be beneficial. This study looked at descriptive data and student outcomes, focusing on change in students' achievement as evidenced through EOG scores and teachers' self-reported change in practice. Future research should explore the impact of the implementation process on the teachers themselves, with a particular focus on changes in teachers' beliefs, content knowledge, and classroom practices.

Of particular interest would be an investigation of the ways in which teachers' use of the Developing Number Concepts materials, which serve as the intervention portion of the formative assessment and intervention process, impact those beliefs, knowledge and practices. The Developing Number Concepts materials are unique in that they provide opportunities for teachers to choose from a number of interventions that address students needs based on the data that emerges from the AMC assessments. The Developing Number Concepts materials help teachers know where to go next by connecting assessment outcome levels to appropriate intervention workstations. However, while the intervention is constructed in a way that it could address the demonstrated student need, it is up to the teacher to implement it in a manner that truly addresses those needs. It is the relationship between the teacher and student, mediated by the interventions, where the instructional decisions that have the potential to truly impact a child are made. This again comes back to teachers' data literacy, understanding where a child is now, knowing what the next appropriate step is and how that fits into the bigger picture of the development of mathematical understanding.

Third, this study makes claims about the positive impact of the formative assessment and intervention process on student learning in mathematics. However, this study may address elements of other initiatives that occurred during the same or similar period of time. In considering the possibility of other districts using this research as a basis for implementing a similar process, it is important to point out that experiences PSD teachers have had using RTI as a structure for determining levels of intervention delivery as well as the Whole-to-Part (WTP) literacy intervention process may have impacted teachers' experience with the current implementation, though we have no way of knowing if that is the case. However, the possibility of that interaction should not be discounted as a possibility for explaining some of the findings.

WTP is informative, though that assessment would be classified more as interim and therefore potentially provided a nice bridge for teachers between summative assessments and the current formative assessment and implementation process. However, only the J. C. Fletcher classroom teachers were directly involved in the WTP work. The WTP was a pull-out intervention model which was run by all the specialists within the school. Even given this dichotomous use of the WTP assessment and intervention process, the third grade teachers across the district were very aware of the program and its impact on students.

The setup of the WTP as a pullout program at Meadow Lake also may explain some of the differences in the types of instructional responses used by teachers at the two schools. At Meadow Lake, the structure of the WTP may have set up an expectation that someone else would address identified areas of student need. While the same WTP structure was in place at J. C. Fletcher, the classroom teachers learned about the interventions so that they could use them to differentiate instruction across the day.

The impact of this formative assessment and intervention process resulted in a large effect size. Future research might consider the ways in which concurrent initiatives and pedagogical expectations in other content areas inhibit or augment the process and impact of implementing a formative assessment and intervention process. In addition, the impact on students considers all students as a single cohort. Research states that effect sizes are greatest among low-achieving students and students with special needs (Black & Wiliam, 1998b). Future research should consider that impact in terms of different subgroups of the student population studied.

A final limitation of this study concerns the use of Cizek’s challenges to implementation of formative assessment in the classroom as a means of analyzing the data. The analytic framework for this study was based on patterns of challenge and response that emerged from the data. This inductive approach to analysis was helpful in giving voice to the data. Because inductive analysis was used to identify themes, and Cizek's challenges to implementing formative assessment in the classroom were those that emerged, future research to develop those challenges as a more formal analytic framework and to determine applications for such a framework in other research may be of benefit.

Research emerging from this study will continue to explore the implementation of formative assessment and intervention processes. There is a need to understand the factors that influence primary teachers’ use of formative assessment data to plan for mathematics instruction, with a particular focus on teachers’ data literacy. The current study focused on the portion of Guskey's Model of Teacher Change that is concerned with the change in student learning outcomes as a result of changes in teachers' classroom practice. The final piece of that model, Change in Teachers' Beliefs and Attitudes, should be the focus of future research. Enduring change in teachers' practice occurs when their beliefs and attitudes are changed. Examining the impact of such an implementation process on the beliefs and attitudes of teachers over time may make it possible to predict the likelihood that an implementation will succeed or fail. Exploring this relationship could provide a more robust understanding of the application of Guskey's Model of Teacher Change as a theoretical framework in examining the implementation of a formative assessment and intervention process.

Conclusion

This study was designed to illuminate how third grade teachers implemented a district-initiated mathematics formative assessment and intervention process and its impact on student learning. Teacher and administrator interviews, student assessment results, and professional development documents were analyzed to better understand the individual and collective experience of teachers throughout the implementation process, influences on instructional practice, and impact on student understanding. Eight implementation challenges were identified and study findings suggest that these must be addressed in order for teachers to successfully embrace the type of formative assessment for learning that is increasingly being called for in research, policy, and practice.

In spite of the challenges faced, there are many teachers like those in this study who are successfully using formative assessment to understand how and what their students are thinking about important mathematics in order to better address their needs through purposeful instructional decision-making. Understanding how these teachers have been successful, what factors support or inhibit that success, and the impact on student learning is an important step toward facilitating successful implementation of formative assessment in other schools and, in doing so, addressing the needs of many of our students that have long been left unidentified or ignored.

Quite a bit has been written about the benefits of formative assessment and some of the factors that determine its effectiveness. What this research has not pointed out, however, is the lived experience of teachers working individually and collectively to implement a formative assessment and intervention process. With that in mind, this research has sought to understand the experiences of these teachers and the impact of their efforts to implement such a process district-wide, taking into account the eight challenges that have been identified and the ways in which they impact the efficacy of implementation at the classroom level.

Research has consistently found, and this research has corroborated those previous finding, that if teachers seek out or open themselves to student feedback regarding, "...what students know, what they understand, where they make errors, when they have misconceptions, when they are not engaged - then teaching and learning can be synchronized and powerful. Feedback to teachers helps make learning visible," (Hattie, 2009). If teachers are open to such a process then significant changes can occur for students in their understanding of mathematics as evidenced through this study. If the power of the formative assessment and intervention process is in the synchronization of teaching and learning, then teachers must be given the time, resources and training necessary to make such synchronization happen as an integral part of their instructional practice.

With significant evidence supporting it, implementing research-based formative assessment practices in a meaningful way holds the greatest potential to identify and address students' needs, narrowing achievement gaps while improving the quality of instruction for all students. That is not to say that implementing formative assessment is easy; far from it. But as Shepard (2000) so eloquently puts it:

> This vision should be pursued because it holds the most promise for using assessment to improve teaching and learning. To do otherwise means that day-to-day instructional practices will continue to reinforce and reproduce the status quo. Our goal should be to find ways to fend off the negative effects of externally imposed tests and to develop instead classroom assessment practices that can be trusted to help students take the next steps in learning.

With a focus on the students we serve, Nathan Parkin, principal of Meadow Lake Elementary, states this in his own words as a challenge for each of us to meet:

> It cannot be a, 'Bless their Heart'. It cannot be, 'That's because of this [issue]'. It's got to be, 'This is where my kids are at. This is where I'm going to take them, regardless of where they start'. And these kids are going to learn *because* of us and not *in spite* of us. And if we don't take the time and effort to do something different, then we are nothing better than the status quo.

APPENDICES

Levels - Grouping Tens Assessment

Level	Description
Level 1—Tens and Ones to 20	This section of the assessment determines whether students can decompose numbers from 11 to 19 into 1 ten and some leftover ones, and whether they understand that the 1 in the tens places represents ten objects.
	Needs Prerequisite (N) – Children at this level are unable to answer any of the assessment questions correctly. Focus on teacher-directed experiences asking them to combine one ten with various leftovers. This will help them begin to recognize the pattern that emerges when ten is added to a single-digit number.
	Needs Instruction (I) – Children who need instruction do not fully understand that teen numbers are made up of one ten and some ones and do not understand what is represented by the symbols. Focus on decomposing numbers from 11 to 19 into 1 ten and the ones that are left over and building quantities to represent the symbols.
	Needs Practice (P) – Children are at this stage if they have some understanding of the structure of teen numbers but need more experiences to clarify and strengthen this concept. Focus on predicting the answers before actually building the numbers with the counters. Sometimes use connecting cubes instead of ten frames.
	Ready to Apply (A) – Children who are "Ready to Apply" understand the number of tens and ones in the "teen" numbers and should move on to work with the structure of numbers as tens and ones to 100.
Level 2—Tens and Ones to 100	This section of the assessment determines whether the students can tell how many altogether when they know how many tens and ones there are and if they can add ten and subtract ten without counting.
	Needs Prerequisite (N) – Children at this level if they do not use the concept of tens and ones to find out how many but instead count all of the counters.
	Needs Instruction (I) – Children who need instruction have some awareness of tens, as they are able to count by tens to get to the total number of counters. However, they are not thinking of ten as a unit since they count on to add and take away 10 from 34. Give them experiences learning to count groups and look for patterns. Also give

them a variety of experiences organizing tens and ones in many different situations until they see the relationship between the particular number of tens and ones and the total number of objects.

Needs Practice (P-, P, P+) – Children are at this level when they can combine tens and ones and add and take away without counting. However, they do not fully understand that ten is a unit since they need to count to add or take away one ten.

Ready to Apply (A) – Children who are "Ready to Apply" understand the structure of numbers as tens and ones and should move on to work adding and subtracting groups of tens as described in the following section.

Level 3— Adds/Subtracts Groups of Ten

This section of the assessment determines whether the students can add and subtract groups of tens without counting. If they are able to think of tens as units, they will be able to add 3 tans as easily as 3 ones and take away 4 tens as easily as they take 4 ones away. If children are not "Ready to Apply" adding or subtracting groups of tens, they need to continue working with the activities described for Tens and Ones to 100 with some variations.

Needs Prerequisite (N) – At this stage, the children are not able to add groups of tens. Have the children continue to work with Numbers to 20 or Numbers to 100 at the appropriate level according to the assessment.

Needs Instruction (I) – At this stage, the child who "Needs Instruction (I)" counts by 10s to add and subtract. These children have not yet fully recognized that adding 10s is like adding 1s if you consider the tens a unit.

Needs Practice (P) – The child who "Needs Practice (P)" counts by tens to either add or to subtract. They do not yet fully recognize that adding 10s is like adding 1s if you consider the tens a unit or they need practice to develop facility.

Ready to Apply (A) – These children are ready to begin adding and comparing groups as an extension of what they have been working on before. You can provide a challenge for these children by having them work at Levels 2 and 3, which ask them to compare.

APPENDIX B
COMPARISON OF AMC AND RESEARCH-BASE ASSESSMENT INSTRUMENTS

Comparison of AMC and Research-based Assessment Instruments Across Early Numeracy Skills

Task	Description	TEMA – 3[7]	CMA[8]	REMA[9]	ENT[10]	AMC[11]
Verbal Counting	Knowledge of the counting sequence	Child is asked to count to a specified number (20, 40, etc). Counting is stopped when the child reaches another specified number.	Child is instructed to start counting at one and count as high as they can. Examiner is allowed to prompt child once. After the second error or extended pause, the examiner discontinues the task and the last correctly counted number is recorded. The task is also discontinued if the child counts beyond 100.	"How high can you count? Start at 1 and tell me." Children earn 1 point for every specified number counted to (e.g. 1 point was given if they correctly counted to five).	Children are asked to count to twenty.	***The structured counting task in conjunction with the number combinations task that focuses on going over the decades are used to determine whether a student can count to 100.

7 Ginsburg, H. P., & Baroody, A.J. (2003). *TEMA3: Test of early mathematics ability* (3rd ed.). Austin, TX: Pro-ed.

8 Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly, 19*, 99-120.

9 Clements, D., Sarama, J., & Lui, Xuifeng (2008). Development of a measure of early mathematics achievement using the Rasch model: The Research-based Early Maths Assessment. *Educational Psychology, 28*(4), 457-482.

10 Early Numeracy Test, 1999, van de Rijt, B. A. M., van Luit, J. E. H., & Pennings, A. H. (1999). The construction of the Utrecht Early Mathematical Competence Scales. *Educational Psychological Measurement, 59*, 289-309.

11 Richardson, Kathy. (2012). *How children learn number concepts: A guide to the critical learning phases*. Bellingham, WA: Math Perspectives.

Structured Counting	The ability to utilize the counting sequence to enumerate a quantity	Children are asked to count a specific number of pictures.	Children are asked to count a set of objects.	Children are shown a set of pictures and asked to count them and tell the examiner how many there are	A number of blocks are placed in front of the child. They are instructed to count the blocks. Pointing, touching, and moving the blocks is allowed.	A number of blocks are placed in front of the child. They are instructed to count the blocks. Pointing, touching, and moving the blocks is allowed.
Cardinality	Recognition that the last number counted means "how many."	***How many*** Child is presented with a number of pictures. The pictures are then hidden and the child is asked, "How many [of the picture] did you count? ***Give me N*** Children are given a set of blocks. They are then instructed to give the		***How many*** Children were asked to count a set of objects and then to specify how many there are. ***Give me N*** Children are instructed to produce a set of a specific number out of a larger set of objects.	***Give me N*** Child is presented with a set of blocks (e.g. 15). They are then asked to produce a smaller set of the blocks (e.g. 11).	***How many*** Children were asked to count an unorganized set of objects and then to specify how many there are. ***Give me N*** Child is presented with a set of blocks (e.g. 32). They are then asked to produce a smaller set of the blocks (e.g. 18).

		examiner a subset of the objects.				
Number Combinations	Ability to solve basic addition and subtraction problems such as 1+1=2, presented verbally and/or visually.	Children are visually shown addition and subtraction problems. The problems are then read to the child and the child is asked to solve the problem.		Children were verbally asked questions such as “How much is 2+7?”		Children are asked how many when one counter at a time is added to/removed from a pile in sequence. Children are asked how many there would be if one more is added to/removed from a series of numbers presented out of sequence. Children are asked how many there would be if one more is added to/removed from a series of numbers which go over the decades.

APPENDIX C
SCRIPT FOR STUDY INTRODUCTION TO TEACHERS

Good morning/afternoon. My name is Catharina Ringer and, as you may know, I am a doctoral candidate in the School of Education at The University of North Carolina at Chapel Hill. Throughout this school year you have participated in the district-wide Assessing Math Concepts assessment and intervention process. Since you are already participating in this process, I'd like to ask you to consider participating in a research study I'm doing to investigate the implementation of the assessment and intervention process at your school. I've brought consent forms today for you to look at and return to me if you are interested in joining this study. Should you consent to participate, you would be giving me 1-2 hours of your time to participate in one-on-one interviews where I'll ask you questions about your experience this year with the implementation. Of course, participation in this study is completely voluntary and you could cease to participate at any time you choose. Here are the consent forms for you to consider. You can return them directly to me today, or I will also leave an envelope in the main office if you'd like more time to consider the commitment

APPENDIX D

North Carolina Test of Mathematics
Grade 3 Pretest Form X RELEASED Fall 2009
Raw to Scale Score Conversion

Raw Score	Scale Score
0	297
1	298
2	299
3	300
4	301
5	303
6	304
7	305
8	307
9	308
10	310
11	312
12	314
13	315
14	317
15	318
16	320
17	321
18	323
19	324
20	325
21	327
22	328
23	330
24	331
25	332
26	334
27	335
28	336
29	338
30	339
31	341
32	343
33	345
34	347
35	349
36	352
37	355
38	359

APPENDIX E
DEFINTIONS AND EXAMPLES OF THE EIGHT CHALLENGES

Definitions and Examples of the Eight Challenges

Challenge	Definition	Example
1. Purpose	Identification of and adherence to a clear, focused purpose for the assessments.	And I think the emphasis now is more on how do kids think and how are they processing and how are they understanding and what parts of mathematics are they struggling with, what parts do they need, do we need to help them in terms of the grouping tens like the place value, which students don't know their number combinations. So the focuses went more from teaching as a whole group to kind of looking more at the students and what their strengths are, what their needs are and how can we meet those needs.
2. Resources	Commitment of resources to support professional development, time for planning, administration and feedback, and support for additional materials as needed to implement an effective assessment program.	We've done the training – the half-day trainings, full-day trainings. That's been really helpful. And I don't think the teachers thought they would love it. I think most of them enjoyed it. It was helpful to have time to work with my PLC to plan activities and analyze data. I also think that hearing J. C. Fletcher's experience has been helpful and encouraging.
3. Preparation	Preservice and in-service training for educators to provide two different competencies: the concepts necessary to administer and interpret traditional summative assessments, and the skills required for developing and interpreting classroom-based formative assessments.	The most helpful part of this year was the time for data analysis, sharing of ideas, and time to practice the assessments prior to administering (plus, watching the video of testing administration).
4. Validity	Assessment provides accurate, actionable information. Techniques to detect and reduce the extent of bias in formative classroom assessments have been developed, disseminated, and incorporated into the preservice training and professional development of educators.	Do not change language/script/wording of the questions. Be a hard assessor. A little intervention won't hurt anyone.
5. Accommodations	In order to enable all test takers, including students with special needs, to demonstrate their true levels of knowledge, skill, and abilities, considerations are made for the role of accommodations, any deviation from standard test administration conditions that does not threaten or alter the characteristic being measured or the accuracy of the intended	She even did kids that came in speaking no English and we did another translator. They did the assessment in Spanish. So…and they all tested out eventually too.

5. Accommodations	In order to enable all test takers, including students with special needs, to demonstrate their true levels of knowledge, skill, and abilities, considerations are made for the role of accommodations, any deviation from standard test administration conditions that does not threaten or alter the characteristic being measured or the accuracy of the intended inference, in the formative assessment context.	She even did kids that came in speaking no English and we did another translator. They did the assessment in Spanish. So…and they all tested out eventually too.
6. Compliance	The relevance of laws, policy, and administrative rules to guide and support the implementation of the formative assessment process. • Should formative assessments be considered in constructing IEP's? • Should formative assessment be documented? • Does formative assessment information constitute protected educational records?	'Cause we have to make sure that we are in compliance before anything else. And if we're not in compliance, we're leaving ourselves out to dry and all types of mess can happen. I think people understand that but again it's the end result.
7. Time	Reallocation of time and effort to support instructional planning, modified instructional practices, and individualization of instruction on the part of teachers and students. Reconfiguring daily classroom life and reorganizing the instructional day to provide the time necessary for effective formative assessments.	All the other 3rd grade teams are struggling w/ the same time constraints. We learned some useful techniques about management of students assessments & reteaching. How to better use Investigations Units & incorporate small groups
8. Disposition to Change	The emotional reaction, either positive, negative, or neutral, experienced as a result of engaging in the formative assessment implementation process.	And I was terrified when I found out I had to take more math workshops.

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APPENDIX F
PIEDMONT SCHOOL DISTRICT MATHEMATICS PROGRAM MATRIX

Piedmont School District
Mathematics Program

Core Curriculum		
• **District-wide alignment with:**		
1	Our shared vision for mathematics instruction.	Our mathematics program should have a district-wide K-12 focus that seeks to prepare students at all grade levels with deep mathematical understandings that prepare students for advanced mathematics.
2	NC Standard Course of Study.	In order to have a well articulated structure our mathematics program will be completely aligned with the NC SCoS.
3	Pacing guide (curriculum maps).	Our mathematics program should be flexibly paced in order to ensure that students reach end of year goals while allowing for individual differences in children.
4	Assessments	Our mathematics program should be structured around common formative assessments that help direct student learning opportunities. These assessments will also be aligned with EOG and EOC assessments as indicators of grade level proficiency.
5	District reporting tools	Our mathematics program will be aligned with report card and other tools used to share student proficiency information with students and parents.
6	Current district initiatives	Our mathematics program will be aligned with and benefit from current district initiatives such as our literacy model, inquiry science, CGI, Professional Learning Communities and High Yield Instructional Strategies and 21st Century Skills.
• **Program structure focused on:**		
7	Important mathematics	Our mathematics program will be scaffolded around fundamental mathematical concepts and skills at each grade level.
8	Measurable goals	Our mathematics program will be focused on meeting grade level expectations for fundamental mathematical concepts and skills
9	Research-proven instruction	Our mathematics program will utilize research proven instructional strategies based on how students learn mathematics.
10	Inquiry	Our mathematics program will provide students the opportunity to build conceptual understanding of mathematical concepts through inquiry.
11	Critical thinking and problem solving skills*	Our mathematics program will engage all students with structured problem solving (CGI) and high cognitive demand tasks that are appropriate in exercising student thinking
12	Student understanding and fluency	Our mathematics program will be properly balanced between developing understanding of mathematics concepts and developing skills fluency such as automaticity of number facts
13	Creative student thinking and innovative processing skills*	Our mathematics program will respect individual student thinking and processing in mathematics by recognizing multiple strategies for solving problems.

14	Models and representations	Our mathematics program will incorporate the purposeful use of multiple models and representations to further student understanding of concepts
15	Connections within the grade-level	Our mathematics program will present concepts and skills, clearly and purposefully connecting these across the grade level.
16	High expectations	Our mathematics program will provide clear and consistently high expectations for all students at every grade level.
17	Common structure and procedures	Our mathematics program will provide a common structure and within grade levels (horizontal alignment) and between grade levels (vertical alignment)
18	Tight articulation	Our mathematics program will be tightly articulated between grade levels (vertical) to be sure that students are moved to the next grade with mastery of grade-level appropriate skills and knowledge.
19	Program integrity	Our mathematics program will be structured in such a way that program goals and benchmarks are reached in a consistent manner across the district at all grade levels
20	Verbal communications skills*	Our mathematics program will help develop student verbal communication skills as they share problem solving strategies and practice classroom leadership
21	Written communications skills*	Our mathematics program will help develop student written communication skills as they write about problem solving strategies and self-reflections
22	Common vocabulary for students and teachers	Our mathematics program will implement a clear and documented progression of terms and vocabulary for students as well as teachers.
23	Flexible student grouping	Our mathematics program will incorporate multiple models of student grouping for purposeful instruction (whole group, small groups, flexible groups)
24	Collaborative skills*	Our mathematics program will provide structured opportunities for students to work collaboratively to develop problem solving and leadership skills
25	Student leadership skills*	Our mathematics program will provide structured opportunities for students to practice leadership roles in the classroom
26	Community building	Our mathematics program will provide opportunities to build classroom relationships as a collective community of learners
27	Contextual learning skills*	Our mathematics program will present students with grade appropriate real world problems based on common interests and experiences both inside and outside the classroom
28	Technology integration*	Our mathematics program will incorporate opportunities to use appropriate technologies to demonstrate and/or model mathematics concepts
29	Professional conversations	Our mathematics program will promote multiple modes of professional conversations linking instruction, common formative assessments and differentiation.
30	Curriculum mapping	Our mathematics program will provide access to teacher developed and maintained curriculum maps to assist with **pacing**, scope and sequence, instructional strategies and appropriate assessments
	* Designates 21st Century Skills (http://www.21stcenturyskills.org/)	

Assessment Support		
31	Aligned assessments	Our mathematics program will incorporate a variety of assessments that are purposefully aligned to the NC SCoS, district pacing guide and the district reporting tools.
32	Assessment matrix	Our mathematics program will have a grade level assessment matrix that is focused on specific concepts and skills along with standard assessment strategies
33	Formative assessments	Our mathematics program will promote common formative assessments that are aligned with the concepts and skills at each grade level of the NC SCoS
34	Authentic assessments	Our mathematics program will incorporate authentic assessments where students are asked to demonstrate understanding of key mathematical concepts
35	Quarterly assessments	Our mathematics program will utilize teacher created district-wide quarterly assessments that are aligned with the district grade level pacing guide and reporting tools.
36	Students assessment records	Our mathematics program will monitor and record each student's understanding of key fundamental concepts that are the building blocks for future student success in mathematics
37	Self assessment	Our mathematics program will provide students with the opportunities and strategies to self assess and become more reflective, independent learners
Student Support		
38	Core curriculum	Our mathematics program will provide a core curriculum that supports student inquiry, problem-solving with multiple strategies, flexible grouping, student interaction,
39	Transparency of expectations	Our mathematics program will present clear and purposeful aligned expectations for students at every grade level so students can set goals with understanding
40	Recognize student individual pacing	Our mathematics program will recognize individual student pacing and will address student needs within the context of the regular instructional program
41	Deliberate ongoing review of skills	Our mathematics program will regularly assess knowledge and skills in order to move students fluidly between enrichment and remediation as needed
42	Differentiated instructional strategies	Our mathematics program will provide differentiated instructional strategies to continually supplement the core mathematics program
43	Enrichment strategies	Our mathematics program will provide additional strategies for deepening student knowledge and skills at the current grade level
44	Remediation strategies	Our mathematics program will provide additional strategies for remediation of student understanding and skills development at the current grade level
45	Focused remediation	Our mathematics program will be focused on specific skills and concepts at all grade levels that students are missing
46	Multiple learning styles	Our mathematics program will incorporate supplemental activities that address the different learning styles of students

47	Engaging and invitational	Our mathematics program will create an engaging learning environment for students where students feel comfortable learning and thinking about their learning
48	Resources for long term absence	Our mathematics program will provide structured activities for students who may be absent for an extended period of time
49	Extended opportunities	Our mathematics program will provide opportunities for students to extend their mathematics knowledge and skills through extra-curricular activities such as math clubs, math buddies and math competitions
50	Creative student thinking and innovative processing skills	Our mathematics program will respect individual student thinking and processing in mathematics by recognizing multiple strategies for solving problems.
51	Models and representations	Our mathematics program will incorporate the purposeful use of multiple models and representations to further student understanding of concepts
Teacher Support		
52	Suitable for PLC conversations	Our mathematics program will promote professional conversations linking instruction, common formative assessments and differentiation.
53	Curriculum maps	Our mathematics program will provide access to teacher developed and maintained curriculum maps to assist with **pacing**, scope and sequence, instructional strategies and appropriate assessments
54	Teacher mathematics knowledge	Our mathematics program will provide mathematics content instruction to all teachers to increase their knowledge and confidence before each instructional unit
55	Multiple strategies	Our mathematics program will provide teachers access to multiple strategies for helping students build understanding and skills
56	Differentiation activities	Our mathematics program will provide teachers with research proven methods for deepening conceptual understanding instead of relying always on grade level acceleration
57	Skills matrix	Our mathematics program will provide a skills matrix organized by grade level and linked with instructional strategies and assessments
58	Skills matrix	Our mathematics program will provide a skills matrix organized by grade level that presents a timeline for understanding math facts and attaining automaticity
59	Concepts matrix	Our mathematics program will provide a concepts matrix organized by grade level and linked with instructional strategies and assessments
60	Resource repository	Our mathematics program will provide access to an online resource that aligns scope and sequence with instructional resources and assessments
61	Staff development	Our mathematics program will employ a model of staff development that trains every teacher not just one or two at each school
62	Staff development	Our mathematics program will provide new teacher training each year just as was done during program implementation
63	Staff development	Our mathematics program will provide access to technology training within the context of the mathematics program

64	Staff development	Our mathematics program will provide differentiated staff development opportunities based on the year of the implementation of the mathematics program
65	Staff development	Our mathematics program will provide all teachers with staff development in the use of questioning and inquiry methods in mathematics
66	Staff development	Our mathematics program will provide staff development in the proper use of student notebook prompts as instructional practice and assessment
67	Staff development	Our mathematics program will provide training in the structured conversations that are important in professional learning teams.
68	Staff development	Our mathematics program will provide teachers with staff development in the proper use of multiple types of assessments that inform instruction as well as students and parents
Parent Support		
69	Communications tools	Our mathematics program will provide access to standardized letters explaining critical components of our program (English/Spanish)
70	Reporting tools	Our mathematics program will provide progress reporting tools for our parents that clearly communicate student progress in mathematics
71	School math nights	Our mathematics program will provide district supplemental materials for school-based parent math nights
72	Parent education	Our mathematics program will support meetings and provide materials to assist parents in understanding mathematics concepts and skills as determined by the NC SCoS
73	Home instructional tools	Our mathematics program will provide parents and students with instructional support tools that focus on specific skills and concepts needed by their child
74	Website resources	Our mathematics program will provide access to online support resources for parents
Resource Support		
75	Administrative support	Our mathematics program will provide staff development for administrative staff in observation and assessment of the program components in the context of the new teacher evaluation instrument
76	AIG Support	Our mathematics program will provide staff development for AIG teachers in the use of instructional strategies and materials to support the core mathematics program
77	EC Support	Our mathematics program will provide staff development for EC teachers in the use of instructional strategies and materials to support the core mathematics program
78	ELL Support	Our mathematics program will provide staff development for ELL teachers in the use of instructional strategies and materials to support the core mathematics program
79	Teacher assistants	Our mathematics program will provide staff development for teacher assistants in the use of instructional strategies and materials to support the core mathematics program
80	Instructional tutors	Our mathematics program will provide staff development for instructional tutors in the use of instructional strategies and materials to support the core mathematics program

81	Technology teachers	Our mathematics program will provide staff development for technology teachers in the use of instructional strategies and programs that support the core mathematics program, including but not limited to just websites
82	Technology resources	Our mathematics program will encourage the purchase and use of technologies that support the mathematics learning environment

APPENDIX G
Kathy Richardson Assessment meeting, July 2011

Myra Brendel, Kay Ringer, Dr. F, Theresa Fortino, Marcia Eury, Melinda Wehling

Dr. F commented that the data Myra compiled is quite similar to the results from another county, particularly in that K and 1 are not leaving ready for K and 1 and that Common Core will require some big changes. Question: are Common Core goals reasonable?

*looked at Myra's data

Dr. Wehling pointed out that ECE made huge growth. said that to understand end-of-grade goals, she needs to backmap from 3rd grade.

Marcia commented that place value, grouping tens. She talked about breaking students into 4 groups based on assessment data and using a combination of the Tshirt factory, centers, and intervention/extensions.

Kay pointed out that perhaps some of the issues went back to Dr. F's point that students don't understand the math. She suggested that, without the data from EOGs and benchmarks, it has been difficult to pinpoint how much K-2 teachers understand mathematics.

Dr. F suggested that, at the beginning of the year, every 1st and 2nd grade student should be assessed using the end-of-previous year assessment to determine where they are.

Dr. Wehling asked to focus on 3rd grade to start and one other grade. Dr. F suggested to add 2nd grade, since there is a base in the district, and doing hiding and counting.

3rd grade: need to have place value and grouping tens. Marcia: If kids were proficient in hiding by January, they picked up math more quickly.

Dr. F: start with 5, kids below 5, check for counting.

Marcia: 2nd grade does grouping tens in January. 3rd grade should be assessed with grouping tens in the beginning. Marcia said that they had assessed everyone w/grouping tens and hiding assessment since hiding assessment is a fluency issue and impacts 3rd grade math.

Generalize Marcia's 3rd grade intervention grouping model

Marcia said that she had hiding assessment and grouping tens intervention materials.

1st grade: counting off the bat.

Kay said that no other schools had done counting. She mentioned that perhaps the counting assessment would work well as part of the kindergarten intake.

Looking at training for 2011-2012
*We will assist Yongedell on the dates that they miss due to calendars
Myra will work with S. and J. on the upload.

3rd grade: how many teachers are there district wide? Split into 2 groups, 1 day training for each group.

Dr. Wehling: I would rather do philosophy/MathX for morning. Then pull in a few students to demonstrate the assessment. Then send people back to their schools to test their students in order to prepare for a follow-up with time to plan for interventions. This would look like 1.5 days

Kay suggested that it be broken into 3 half-day sessions. Day 1 (Tuesday): Theory, intro to the assessment. HW: assess a few kids. 1 who is struggling, 2 who you think are "on", and 1 who seems "above". Day 2 (Thursday): Share early live data. Process changes/challenges/questions. This can provide support for teachers. Dr. F thought she might be able to circulate on the alternate day (e.g., Wednesday) and Myra, Theresa, and Marcia could help provide support to schools afterschool.

Dr. F suggested having an interview or two modeled on the second day. Demo and queries. Talk through the data that was found, process teachers went through.

Marcia pointed out that student teachers can play games with kids while teachers are doing the assessments. It becomes very difficult to do the interviews with kids in the room. She also pointed out that WtP assessments are done in the first part of the year.

Dr. Wehling suggested doing the assessments after the Common Core rollout on September 21. J. C. Fletcher will start at the beginning of the year since they have already been trained. Perhaps start with Birchwood and Yongedell earlier?

Could we start training 3rd grade on 9/13 (Day 1, Theory and Assessment demo), 9/15 (Day 2, Revisiting, Finetuning, Consistency). 9/14 is the sandbox day. Wednesday pm: have people onsite for questions. Interviews need to be finished on 9/29 for the intervention group/planning day. Dr. Wehling will talk with principals to confirm grades.

Dr. F suggested that Kay work with 3rd grade.

Dr. F and Kay suggested Arthur Hyde, "Comprehending Mathematics." Dr. F also mentioned using chapters from the "Number Talks" book as possible homework for 9/29. Kay suggested using "Too Easy for Kindergarten, Too Hard for First Grade." Re-assess everyone by December 16.

2nd grade:

Hiding Assessment information could be done in 2 half days since the interventions are easier. Training days would be 4th (theory and assessment) and 6th (follow up with data and look at interventions) with 5th as the sandbox day. People will go to schools on 5th to answer questions and provide support. We will give teachers the pre-made intervention packet on the 2nd day. Talk to L. about the system they had in place. Assessment deadline: 10/21. Start interventions. Full assessment sweep completed by December 16.

Grouping Tens:
2nd grade: 1 half day for grouping tens. Interventions in 2nd grade are different than 3rd grade because they have 1 semester and 3rd grade has 3 weeks. Kay suggested purposeful work with Math Expressions looking how to pull grouping tens out of their regular classroom work and using CGI as a basis. On January 26 am, teach how to do the assessments. All data due on 2/10. Meet on 2/16 am for data and strategy and groupings. Interventionists will need to come as well. Assess as needed.

First grade:
Counting: Feb 28 and Mar 1. 2/28 is philosophy and assessment. Gather data on 2/29. Return 3/1 for processing the data and looking at planning. Full sweep data is due Thursday, March 15. Intervention strategies on 3/22. If needed, introduce hiding assessment and look at the link between the two.

Dr. Wehling will check to see how many teachers there are and cross-check with number of planned training days and total amount of funding for subs. If there is XXX $$, it will be transferred to XXX $$ (hopeful).

AMC Implementation Plan – Piedmont School District***, 2011- 2012 School Year

Grade 3 *			
September 13, 2011	Introduction to AMC and to the Grouping Tens Assessment	Grouping Tens Assessment	Training
September 14, 2011	"Sandbox" day		PLC and Teacher Support
September 15, 2011	Analyze early data and look at process, challenges and expectations		Training
September 28, 2011	All assessments completed – all student data collected and available on AMC Anywhere		Teacher reporting
September 29, 2011	Data analysis, planning for intervention		Training
September 30 – December 16, 2011	Implementation of intervention and ongoing student assessment. **All** 3rd grade students reassessed on Grouping Tens Assessment by 12/16		** Visit 3rd grade PLC's on alternating weeks for a total of Arrangements will be made for YES.
January 26, 2012	Introduction to the 2-digit Addition & Subtraction Assessment	2-digit Addition & Subtraction	Training
January 27, 2012	"Sandbox" day		PLC Support (in combination with the Grade 2 "Sandbox" day)
February 15, 2012	All assessments completed – all student data collected and available on AMC Anywhere		Teacher reporting
February 16, 2012	Data analysis, planning for intervention		Training
February 16 – June 8, 2012	Ongoing Assessment & Intervention	All Assessments/ Interventions	PLC and Teacher Support

* Teachers will report 3rd grade Pretest Results in a database constructed for the district.
** Group 1 Schools visited the weeks of 10/3, 10/17, 10/31, 11/14, 11/28 and 12/12
Group 2 Schools visited the weeks of 10/10, 10/24, 11/7, 11/21, 12/5 and 12/12
*** All names of district, school, teacher, and location have been changed and pseudonyms have been used.

Grade 2			
October 4, 2011	Introduction to AMC and to the Hiding Assessment	Hiding Assessment	Training
October 5, 2011	“Sandbox” day		PLC and Teacher Support
October 6, 2011	Analyze early data and look at process, challenges and expectations		Training
October 19, 2011	All assessments completed – all student data collected and available on AMC Anywhere		Teacher reporting
October 20, 2011	Data analysis, planning for intervention		Training
October 21 – December 16, 2011	Implementation of intervention and ongoing student assessment. **All** 2nd grade students reassessed on Hiding Assessment by 12/16		Teacher reporting
January 26, 2012	Introduction to the Grouping Tens Assessment	Grouping Tens Assessment	Training
January 27, 2012	“Sandbox” day		PLC Support (in combination with the Grade 2 “Sandbox” day)
February 22, 2012	All assessments completed – all student data collected and available on AMC Anywhere		Teacher reporting
February 23, 2012	Data analysis, planning for intervention		Training
February 23 – June 8, 2012	Ongoing Assessment & Intervention	All Assessments/ Interventions	PLC and Teacher Support

*******Modified from original implementation plan, created August 23, 2011. All names have been changed or removed and pseudonyms used.*

APPENDIX I
AMC DISTRICT-WIDE IMPLEMENTATION ACTIVITIES

AMC District-Wide Implementation Activities[12] [13]

Date	Type	Purpose
July 2011	Initial Planning Meeting	• Notes attached – Appendix G
August 16, 2011	Logistics Meeting w/ Dr. Wehling	• Review and finalize dates • Finalize projected topics • Discuss budget and priorities • Discuss materials order and projected cost
September 2, 2011	Team Meeting	• Notes attached – Appendix J
September 7, 2011	Materials Prep	• Unpack and Repackage ordered materials for distribution during Day 2 PD
September 9, 2011	Principals Meeting	• Provide overview and background of the training for the year – begin with Grade 3, add Grade 2 as finances allow
September 13, 2011	Day 1 Grade 3	• Understand the rationale and history behind this project • Connect the Richardson Assessment tasks to *Math Expressions*, Common Core, RTI and PLCs. • Determine the rationale for diagnostic testing • Learn to complete the Grouping Tens Assessment using the AMC Anywhere software
September 14, 2011	Sand-box Day	• Use Grouping Tens to assess at least 4 students using AMC Anywhere ○ 1 who is struggling, 2 who are 'on', and 1 who seems 'above'
September 15, 2011	Day 2 Grade 3	• To debrief experiences with the Grouping Tens assessment • To run reports using the AMC Anywhere software • To become familiar with the materials in your kits

[12] All dates related to the 2011-2012 implementation in both 2nd and 3rd grades.

[13] All weeks not specifically referred to in this chart involved at least one school visit to classrooms by at least one member of the implementation team.

		• To determine a timetable for administering assessments
September 20, 2011	Team Planning Meeting	• Notes attached – Appendix K
September 22, 2011	School Visit	• Hawthorn 3rd Grade PLC Meeting
September 29, 2011	Day 3 Grade 3	• Analyzing data to understand students' needs • Understanding various ways to provide intervention for Tier 1, 2, and 3 interventions • Establishing a model of intervention and planning activities for the model of intervention
October 5, 2011	Meeting w/ Dr. Wehling	• 3rd Grade Pretest
October 6, 2011	*Team Meeting*	• Planning for Grade 2
October 11, 2011	School Visit	• Yongedell 3rd Grade PLC – missed 9/29 PD due to conflict, review work and set up times to come back
November 14, 2011	School Visit	• Meadow Lake 3rd Grade – check in w/ principal
November 15, 2011	*Day 1 Grade 2*	• Understand the rationale and history behind this project • Connect the Richardson Assessment tasks to *Math Expressions*, Common Core, RTI and PLCs. • Determine the rationale for diagnostic testing • Learn to complete the Hiding Assessment using the AMC Anywhere software
November 16, 2011	*Sandbox Day*	• Use Hiding Assessment to assess at least 4 students using AMC Anywhere ○ 1 who is struggling, 2 who are 'on', and 1 who seems 'above'
November 17, 2011	*Day 2 Grade 2*	• To debrief experiences with the Hiding assessment • To run reports using the AMC Anywhere software

		• To become familiar with the materials in your kits • To determine a timetable for administering assessments
November 18, 2011	Principal's Meeting	• AMC Check In – preliminary report on activities and questions
November 22, 2011	School Visit	• Birchwood – EC
December 8, 2011	*Day 3 Grade 2*	• Analyzing data to understand students' needs • Understanding various ways to provide intervention for Tier 1, 2, and 3 interventions • Establishing a model of intervention and planning activities for the model of intervention
January 18, 2012	Team Meeting	• Planning for Grade 3 final PD
27705January 26, 2012	Day 4 Grade 3	• Celebrate growth • Share successful strategies that enabled growth • Examine strategies for effective differentiation of mathematics • Focus on next steps for non-proficient students • Plan for vertical articulation between second and third grade
January 27, 2012	School Visit	• Hawthorn 3rd Grade
February 3, 2012	School Visit	• Birchwood Grade 3 – Hiding Assessment • Yongedell – Check in
February 21-23, 2012	AMC Training	• Grade 2 – w/ Math Perspectives, Kay attend and ask questions
March 1, 2012	*Day 4 Grade 2 (half day)*	• Celebrate growth • Share successful strategies that enabled growth • Examine strategies for effective differentiation of mathematics • Focus on next steps for non-proficient students

		• Plan for vertical articulation between second and third grade
March 8, 2012	School Visit	• Hiding Assessment – new teacher: model and assist w/ completing
March 21, 2012	NC DPI Visit	• Walkthrough, presentation, Q&A
March 22, 2012	*Day 5 Grade 2 (half day)*	• Learn to complete the Grouping Tens Assessment using the AMC Anywhere software • Run Grouping Tens reports using AMC Anywhere software
May 26, 2012	Meeting w/ Dr. Wehling	• Review year • Plan for Principals Meeting
June 4, 2012	Principals Meeting	• Review year – Q&A, next steps
June 8, 2012	School Visit	• J. C. Fletcher
June 11, 2012	School Visit	• Meadow Lake

APPENDIX J

Team Planning Meeting – Notes

September 2, 2011

Math leadership: Dr. F's pencil-paper assessments give to 5th grade? Our 5th graders were 3rd graders when MathX piloted in the district, so are there things missing because teachers were learning the curriculum?

Names of interventionists who are attending the training to Myra
Meadow Lake: Debra Bardsley
Birchwood Elementary: TBA

Melinda will check with elementary principals to find out who will be attending the training.

Myra will check NCWISE for 3rd grade teachers.

Training will happen at Meadow Lake, potentially. Dr. Wehling will ask Nathan.

Litwa and Crumbley attend to help?

Do small groups of teachers per computer. Need laptop cart, 1 laptop per 3 teachers.

We will do all teachers at one time to avoid the "I heard--but I heard--but I heard" conversation. The ½ day-sandbox- ½ day structure is to help with the data interpretation.

Melinda will contact Nathan about visiting ML 3rd grade PLC to provide a heads-up and set the tone.

Outline for training:
Condense philosophy, share grouping tens, demo videos and test.

Training is 7:30 until 11. Melinda will provide edibles.

No more than 10 minute break.

Share data from ECE. Use Myra's Google Doc graphs.

7:30-7:45	welcome/JCFE data	Dr. Wehling, JCFE 3rd grade
7:45-8:45	Historical Background, Connections to RTI, WTP, Common Core	Eury and Fortino

8:45-9:20	Look at books, introduce Grouping Tens	Eury and Fortino
9:20-9:40	video	Kay
9:40-9:50	break	
9:50-10:00	laptops, site navigation	Myra
10:00-10:20	Practice with a partner	Training Team
10:20-10:50	video practice	Kay
10:50-11:00	wrap up, Exit Cards	Dr. Wehling

We need to go to Birchwood and organize materials Wednesday after school.

9/14 Sandbox land:

Birchwood, Yongedell, and Hawthorn: Kay (will travel throughout the day)
Heatherdale: Myra
White Ash: Fortino
Meadow Lake: Eury

9/15 Half day
Questions about the test
How do I know when to reassess
Myra will need to share how to locate, access, run reports
Interventionists will be able to access from different classrooms
Share maps
Tier I: Classroom modifications, relating to scope of MathX curriculum.

For the "N" kids: what do we do? Find out who all those kids are and then contact your school contact.

We will roll out as money becomes available.

Melinda will find the 3rd grade PLC times out for Kay.

APPENDIX K

Team Planning Meeting – Notes
September 20

This will be the Book Fair for Meadow Lake. Where to move? Could we use Yongedell? Heatherdale? we are moved to Heatherdale; confirmed.

Revisit Fletcher data from Year 1 implementation. Does this look familiar?

Tier 1/Classroom level (Kay). How do we change the classroom instruction? Maybe pull a lesson from and have teachers think about ways to differentiate the lesson/where to focus instruction for kids who are at different levels of proficiency. Share maps.

JCF grouping models
Tens and Ones, then Tens and Ones to 20, then Tens and Ones to 100, then oddballs, then proficient

Need laptops available

Teachers will make groups and know their students

How is the best way to do intervention?
Share models (pullout, centers, push in, math workshop, homework, 1xweek switching, etc.)
Let teachers work in groups to develop a model that will work at their school.

Share materials that have been used in the past.

After lunch, let teachers work in PLCs to plan out their intervention activities. Have tools (e.g., scissors, markers, glue sticks, tape, etc.) available if teachers want to make games.

BI grant

When to reassess: if a child is keeping other kids from getting the intervention because that child is so far ahead from other students, reassess and move the child out.
If they are not moving for 2-3 weeks, try something different

Can we videotape on the 29th for Yongedell?

Choosing kids for intervention: 3rd grade story from last year. Bubble kids first and working back from there.

emphasize communication among interventionists and classroom teachers as part of the equation for successful intervention

8:45-9:00: Fletcher, revisited. Share concerns on chart paper.
9:00-10:15: Tier I

10:15-10:25: break
10:25-11:30: Tier II: sharing models, looking at reports, 20 minutes to start building your intervention model design
12:30-12:45: finish intervention model discussions
12:45-1:00: share out model ideas at this moment.
1:00-3:30: Planning time with PLCs in order to implement model. *remind teachers to bring Math X curriculum materials, boxes o'intervention with them
3:30-3:45: wrap-up, Exit Cards, next steps

materials: agenda, exit cards, chart paper, markers, scissors, glue sticks, folders, envelopes, tape

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