GUIDING CLASSROOM INSTRUCTION THROUGH FORMATIVE MATHEMATICS ASSESSMENT

A Record of Study

by

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ABSTRACT

In North Carolina, Local Education Agencies (LEA) control the curriculum resources used to teach and assess the state mathematics standards. Districts that have funds can purchase costly commercially-made assessments which may or may not align to the standards. When using commercial materials feedback is typically not provided in a timely or useful manner that allows for effective changes in classroom instruction. Districts without the funds use teacher created assessments which again may or may not align to standards and the results may or may not be interpreted in a way that easily informs classroom practices. The quality of the commercial or teacher-made assessments typically are comprised of items that tend to have a low cognitive demand, focused on recall, and in a format, that does not mirror the state-created high-stakes End-of-Grade (EOG) assessments. According to most district leaders, many teachers do not value or understand how to use the results of commercial or district made assessments to formatively guide classroom instruction and improve student learning outcomes in mathematics.

In this study, a mixed methods approach is used to research minimum increases in students' mathematics proficiency levels. The quantitative portion of this study focuses on the extant data of mathematics proficiency level scores. The qualitative portion focuses on data collection through interviews with teachers to better understand how teachers used the quarterly assessments to guide classroom instruction.

To explore a possible solution to the problem of minimum increase in student mathematics proficiency levels, the North Carolina (NC) Department of Public Instruction's accountability division developed state formative quarterly assessments. These assessments are highly aligned to the mathematics standards, have high cognitive demanding items, provide timely feedback and use the same format as the high stakes state EOG assessments.

Teachers from six different schools were interviewed. Interviews were coded and themes evolved. The teachers who demonstrated substantial student proficiency level growth had a solid understanding of the purpose of formative assessments and how to use the data to guide classroom instruction. They felt the use of the formative assessments' feedback changed their classroom instruction significantly and helped them to build a deeper understanding of the standards themselves. The teachers collaboratively planned and used error analysis to focus on interventions and enrichment. They realized students needed to make sense of problems and to explain their thinking and reasoning to build a deeper mathematical understanding. Teachers made changes in their teaching practices by focusing more on application, not just on computation. Teachers also realized they had to change their instruction by providing high cognitive demanding tasks daily. Their willingness to use the state-created formative assessments to make change improved student mathematics proficiency levels.

DEDICATION

To my husband, Jim, who, without his support, this process would have been insurmountable. I could not have done this without your relentless patience and love.

To my son, Kyle, for the inspiration to continue my education so I can try to keep up with you.

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NOMENCLATURE

POC	Proof of Concept Study
EOG	End-of-Grade Assessments
LEA	Local Education Agency
DPI	Department of Public Instruction
PCL	Professional Learning Community

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION AND LEADERSHIP CONTEXT

The Context

There continues to be confusion surrounding the meaning and usefulness of formative assessments thus hindering teachers' effectiveness in implementing these types of assessments in their classroom. Though research underscores that formative assessment can improve student learning, formative assessment has evolved over the years and there continues to be much confusion about exactly what the formative assessment process entails (Frohbieter, Greenwald, Stecher, & Schwartz, 2011). Terms such as classroom evaluation, curriculum-based assessments, feedback, and formative evaluation were used to describe what is typically called formative assessments today (Black & Wiliam, 1998a). A decade after Black and Wiliam's findings, research from Frohbieter et al. (2011) referenced a plethora of formative assessment terms including: benchmark assessment, interim assessment, periodic assessments, formative diagnostic assessments, assessment for learning, and assessment of learning. In fact, "assessment," the name of the practice, might also be a contributing factor to confusion about its meaning. Assessment, for some, means an event, rather than the continuous feedback loop that characterizes worthy formative practice (Black & Wiliam, 1998b; Tomlinson, 2014). Many teachers think of assessments as a one-time or periodic events, rather than a continuous looping feedback (Gewertz, 2015). Therefore, as long as the term assessment is attached to formative practices, confusion remains. Until educators build a deeper understanding of formative assessment terms and practices, their effectiveness will be a lost opportunity to improve student learning.

Formative assessment has been defined differently by various researchers. Unpacking the idea of formative assessment and providing a standard definition is important for educators. Earlier researchers such as Black and Wiliam who studied formative assessment defined it as “encompassing all those activities undertaken by teachers and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged” (1998a, pp. 7-8). Heritage defined formative assessment as “a systemic process to continuously gather evidence about learning. The data are used to identify a student’s current level of learning and to adapt lessons to help the students reach the desired learning goal” (2007, p. 140). Tomlinson defined formative assessment as “an ongoing exchange between a teacher and his or her student designed to help students’ grow as vigorously as possible and help teachers contribute to growth as fully as possible” (2014, p. 10). The meanings of formative assessment contain some common threads. Each definition includes the teacher obtaining information about a student’s understanding in order to adjust the next steps in a student’s learning process. The definitions differ in variations in the vocabulary being used. Even though the meaning of formative assessment may differ for many educators, it typically does not for formative assessment experts.

Formative assessment is an ongoing process which can transform teaching and learning. Teachers can obtain information about the student’s understanding and then adjusts their next steps in classroom instruction to support student’s learning. Teachers can gather information through observation, questioning, listening, and student work samples before making informed instructional decisions. For example, when a student answers a question correctly, a teacher may think the concept is understood by the student. Through additional questioning and student's explanations, revelations about a student's true understanding of the concept becomes clear. A student may demonstrate appropriate procedural or algorithmic knowledge but no conceptual or underlying mathematical understanding (Collins, 2011; Fennell, Kobett, & Wray, 2016). After teachers elicit evidence about how students are understanding a concept, they must utilize the information obtained from these formative assessments to help students deepen their mathematical thinking. (Heritage, 2007; Joyner & Muri, 2011). Teachers can then adjust instruction in real time allowing opportunities for the student to reflect on a concept by engaging in appropriate tasks. The ongoing formative assessments process empowers students in their own learning process.

At times, formative assessment has been viewed synonymously with the term summative evaluation causing formative assessments to be lost as an instructional tool to improve student learning. In some accountability environments, assessments are not viewed as information to be used in guiding instruction but only a tool to summarize learning or to rank students (Heritage, 2007). Assessments in the field of education, are constantly being used as an evaluation tool for schools, teachers, and students. Many teachers think of assessments as external, apart from their everyday teaching practice because they offer little to no assistance in classroom instruction (Halverson, Prichett, &Watson, 2007; Heritage 2007; Joyner & Muri, 2011). Many teachers that view formative assessments as a form of summative assessments believe assessments provide little information and are used too late in the school year to assist in the planning process.

Using grades for students' work in conjunction with formative assessment is contrary to current research. One formative assessment purist (Gewertz, 2015) maintained that students' work used in formative assessments should never be graded. Hattie (2012) found that the use of formative assessments was not to measure students' knowledge precisely at a given moment but rather to provide information to teachers about their impact on student learning. Other researchers (Heritage, 2010; Tomlinson, 2014) have provided educators with information about possible next steps to take with instruction and how they should change and modify instruction to meet student needs. Shepard (2000a) tells us that classroom assessments should not be used to satisfy accountability demands. While Fox (2015) noted that when a grade is placed on an assignment, it tends to end the learning process by sending an unintentional message to the student that it is time to move on. Even though some teachers still use formative assessments as a means to grade students, most researchers disagree with this practice when it comes to what "formative" assessment is.

Significance of the Problem and Relevant History

There has been a continuous problem in North Carolina (NC) with students making only minimal mathematical gains each year on the End-of-Grade (EOG) mathematics assessments. NC school districts have attempted to address incremental student achievement growth in mathematics by applying locally-developed or locally purchased benchmark or interim assessments. These benchmark and/or interim assessments have not been truly formative in nature and their implementation and impact has not improved student achievement in mathematics. Some potential reasons these types of assessments have shown little impact on student learning in mathematics are: 1) lack of assessment alignment to the mathematics standards, 2) low cognitive demanding assessment items, 3) feedback not being perceived as useful or timely and 4) lack of teachers' understanding about formative assessment. These reasons are some of the possible causes for the lack of student mathematical achievement in NC.

In NC, school districts control the curriculum resources used in their district to teach and assess the state standards. The districts that have money tend to purchase costly commercially available assessments. Many of the purchased assessments do not align to state standards and feedback is typically not provided in a timely or useful manner. Many of the other districts are using district- or teacher-created assessments. Again, the alignment of the assessments to state standards is sometimes lacking and results may or may not be interpreted in a way that easily informs classroom practices. The quality of assessment items also tends to be comprised of items. Even if the assessments are purchased or teacher created, only a few of them mirror the format of the state-created high-stakes EOG assessment which consists of multiple choice and gridded response items. According to district leaders, no matter which type of formative instruments teachers use, they do not usually value or understand how to use the results to guide classroom instruction. These factors could be responsible for the minimal increase in mathematics proficiency levels of students across the state of NC.

According to feedback from teachers and district leaders, there appears to be four major factors that could be affecting the minimal increases in NC students' mathematics proficiency levels. The first factor is that many district assessments do not align with the mathematics standards. Numerous teachers have expressed concerns about the effectiveness of the district level quarterly mathematics assessments in assessing the mathematics standards. Teachers believe the assessments do not align with the state's rigorous mathematics standards. The second potential reason that could be affecting the minimal increase in mathematics scores is that most district assessment items are not cognitively demanding. The third factor is that feedback is typically not provided in a timely or useful manner. The last factor, and potentially the most significant, is that many teachers do not value or understand how to use the results to formatively guide classroom instruction. These four factors could possibly be affecting the minimal increase in NC students' mathematics proficiency levels as measures by the EOGs.

In order to improve students' mathematics proficiency levels, teachers must value, understand, and overcome barriers that keep formative assessment from reaching its full potential. The proper use of formative assessment can lead to an increase in student achievement according to Goertz, Oláh, and Riggan (2009). However, some conditions diminish student achievement. For example, negative effects may come from teachers who have not "bought into" or who lack deep understanding of the formative assessment process (Goertz et al., 2009). Heritage (2007) noted many teachers think formative assessment is synonymous with high-stakes standardized tests, when, in reality, these assessments can actually improve student learning if used effectively. In order to improve student mathematics achievement, not only is there a need to develop and provide teachers with high-quality formative assessments, but teachers should be provided with resources to assist their understanding of how to use the results from the assessment formatively to guide classroom instruction. Until teachers fully understand how to use data from assessments formatively, the impact on student's mathematical achievement will be minimal; incremental mathematics achievement will likely continue.

The NC Department of Public Instruction (DPI) has adopted and embraced formative assessments as a possible solution to the problem of minimal increases in students' mathematics proficiency levels. The State Board of Education mandated a POC Study to be completed during the 2015-2016 school year. This study led to the state creation of formative quarterly assessments. The goal was to effectively use state-created formative assessments to improve mathematics instruction, ultimately improving student achievement. Formative assessment in mathematics is widely recognized as a powerful integration of assessments with instruction having the potential to increase student achievement (Wenglinsky, 2002). In order to improve students' mathematical proficiency levels, all districts in NC should have access to quality quarterly assessments that are closely aligned to the mathematics standards, include high cognitive demanding items, provide prompt feedback, and use the same format as the high-stakes state-created EOG assessments.

In order to develop quality formative assessments, various teachers from across the state came together to decide which mathematics standards would be formatively assessed each quarter. A one day face-to-face professional development session was oftered on three different occassions in three different regions across the state to support this formative assessments initiative. There were also follow-up webinars throughout the year to support teachers and leaders. To fully implement formative assessments, teachers have to understand how to effectively use the feedback from these assessments formatively to guide classroom instruction. NC DPI has embraced formative assessments as a possible solution to the problem of minimal increases in students' mathematics proficiency levels however, much support will be needed by districts.

Research Questions

To initiate change and increase students' mathematics proficiency levels in NC, a mixed methods approach study was used focusing on these two guiding questions:

1) Did the use of the feedback from the NCDPI Proof of Concept (POC) Study improve student outcome for schools that increased, decreased, or stayed the same in student proficiency levels? (Quantitative extant data) and
2) How did teachers use state created formative assessments? (Qualitative)

Personal Context

The purpose for conducting my ROS study was assist in improving mathematics student proficiency scores by examining the impact of the NC state-created quarterly formative assessments in mathematics to guide classroom instruction. The information I gathered about the implementation of the formative assessments will be shared broadly. My hope is that the results from this ROS study, will influence leaders to make more effective decisions about how best to support teachers with the use of prompt feedback from the state-created quarterly assessments. The recommendations from my study have the potential to help teachers adjust their teaching strategies to make significant improvements in students' mathematical proficiency levels.

In my role as NC's state elementary mathematics consultant, it was my responsibility to support and identify effective use of formative assessments during and after the state conducted POC Study. I helped determine if the feedback from the formative quarterly assessments provided teachers and students with useful information to inform and improve the delivery of instruction. I assisted the accountability department in creating high-quality quarterly assessments and assisted teachers in their understanding of how to use the results of the state assessments formatively to guide classroom instruction. I provided an optional one day professional development session on the state-created formative quarterly assessments and how it could be used to guide classroom instruction. During my ROS study, data collected from the POC Study were used to select a purposeful sampling of schools to learn how teachers used formative assessment feedback. Additionally, I have documented how these teachers used their assessment data, what strategies they implemented and their thinking behind the changes they might have made in instruction. I ultimately used the collected data evidence to create support documents and professional development sessions for district leaders across the state.

Important Terms

- Formative assessments – a process used when the teacher obtains information about the student's understanding of a concept and uses it to adjust their next steps in teaching to facilitate student's learning.

- High-stakes assessment - assessment administered which is used to rate the school and can be used in a teacher evaluation. Additionally, it can also be used in the placement or promotion decisions for students.

- High cognitive demanding item – an assessment or instructional item which requires a mental act or process using knowledge.

- Prompt feedback – feedback data provided from an assessment which are returned in a timely manner, typically one to two days that facilitates actions to improve teaching and or learning.

Closing Thoughts on Chapter I

The problem context for my ROS study was focused on examining the factors that were linked to the minimal increase in NC students' mathematics proficiency levels. To improve student's mathematics proficiency levels, it is essential teachers understand what formative assessments are and how the formative assessment process functions. Until teachers understand how to use data from these assessments formatively, the impact on student achievement will be minimal.

This problem content which I focused on during the conduction of my ROS study spotlights research highlighting formative assessment as a tool to improve student learning. My selection of high cognitive demanding formative assessments items for the quarterly formative assessments created by the state which closely aligned to NC mathematics standards, the conduction of an optional one day professional development session, and support documents (Next Step) are my contribution toward the artifacts created in developing a solution within this problem context. These products which I selected and created focused on an effort to eliminate confusion among teachers guiding their use of formative assessments and grading practices. In my attempt to clear up some of these confusions among teachers hopefully more NC mathematics teachers are using formative assessments effectively. My hope was to potenially change and improve teacher instruction as a result of using formative assessments effectively and having a positive impact on students' mathematics achievement levels as measured by the NC EOGs.

CHAPTER II

REVIEW OF SUPPORTING SCHOLARSHIP

Introduction

Many districts have struggled to implement formative assessments. Districts have been encouraged to use formative assessments because they have been promoted as a powerful improvement strategy. However, many districts lacked the understanding and direction to implement formative assessment (Black & Wiliam, 1998a). Districts have been faced with choosing from numerous commercially-made formative assessments products which has increased their struggle because many of the commercially-made products do not provide necessary feedback in a timely manner to assist with everyday instruction (Frohbieter et al., 2011). On many occasions, the commercially-made products are not closely aligned to the standards being assessed (Tomlinson, 2014). If districts are to implement formative assessment, educational leaders and teachers must be given clear directions on how to effectively implement formative assessment.

A variety of formative assessments are needed to elicit evidence of student learning. Well-designed formative assessments serve to verify what students know and do not know so teachers can teach to learning gaps (Black & Wiliam, 2003; Joyner & Muri, 2011; Shepard, 2000a). When teachers use a variety of assessments, they can capture each student's depth of understanding of the content standards. By using a variety of assessments such as questioning about an open-ended task, teachers do not have to make assumptions about what a student knows. The teacher can begin to understand the student's thinking, what they understand and misunderstand (Joyner & Muri, 2011). Using a variety of assessments also provides opportunity for students to be better prepared to apply their content knowledge to real-world problems. Open-ended assessment tasks support students with critical reasoning skills to solve complex problems which are part of rigorous mathematics standards (Shepard, 2000b). A variety of formative assessments are needed if teachers want to build a solid understanding of what student understand.

Relevant Historical Background

Political pressure and policymakers have greatly affected the use of assessments and instruction. Policy makers have focused on data-driven decision making (Frohbieter et al., 2011). Some politicians believe educators were not effectively using student assessment data (Frohbieter et al., 2011). According to McNeal (2013), when under political pressure, scores on high-stakes tests rise but there may not be a corresponding improvement in student learning. Policy makers have subscribed to the belief that teaching to a good assessment was better than a low-level basic skills assessment, but research in assessment affirms, this is false (Frohbieter et al., 2011; McNeal, 2013). Using only high stakes summative assessments can have a corrupting influence on the good intensions of teachers. Stephens (1995) and McNeal (2013) both found assessments do not always drive instruction, but when assessments do drive instruction, they do not drive it in a way that results in "good" instruction. Thus, the relationship between assessments and instruction cannot be isolated concepts, according to Stephens

(1995). Policymakers and educators must realize assessment and instruction are inseparable; one cannot happen without the other.

These externally mandated assessments hindered thoughtful classroom instruction affecting student learning.   External accountability can lead to a decline in professionalism and skills of classroom teachers (Shepard, 2000a; Tomlinson, 2014). McNeil (2013) studied the use of these mandated assessments and found that they instill in students the desire to receive externally administered rewards and blunt the love and intrinsic rewards of learning for life. McNeil (2013) found some educators believed assessment mandates were ways to warn teachers to conform or leave the field of education which could definitely affect student learning. These externally mandated assessments influence teaching pedagogies impacting the education system.

Assessments that teachers use need to be more informative, changing the perceived meaning of assessment. A shift in classroom practices and expectations can transform assessments, so that teachers and students focus on assessment as a way to enhance learning instead of a discussion about rewards and punishment (Shepard, 2000a; Tomlinson, 2014). During this transformation of assessments into a more formative approach rather than summative needs to be considered (Heritage, 2010; Shepard, 2000b). The culture of the classroom must shift, so students want to learn instead of learning just to perform well on a test. When assessments are more informative, students take ownership in the learning process, Hattie (2015) tells us, “it is their schooling, their lives, their futures that are at stake” (p. 23). When teachers are interactively discussing expectations with students, students begin working diligently to enhance learning

(Shepard, 2000b). If teachers begin reallocating power and establishing collaborative relationships through formative assessments then they can accomplish this change in culture. This change in the focus on formative assessments allows them to have the potential to be more informative for teachers. Assessments that are informative can change the culture of learning where teachers and students have a shared vision with both groups working collaboratively to find out what makes sense and what does not.

Implementation of formative assessments need to be at the heart of systemic school improvement efforts. Although some efforts to reform assessment have been positive, many of the reforms have had negative consequences (Andrade & Cizek, 2010; Halverson et al., 2007). Without receiving timely and accurate information from formative assessments, teachers can only guess what they need to do or the skills and concepts they need to teach to students in their classrooms (Halverson et al., 2007). Sheppard's (2000b) results indicated that reforming assessments should be used as an effort to improve the quality of education by raising the rigor of the content of state standards. This content within the assessment should align to rigorous content standards if there is to be an improvement in student achievement (Shepard, 2000b). If this rigorous approach in reform is not used, Halverson et al. (2007) contended that teachers will continue to reduce their instruction and assessment practices to the status quo practices, leading to minimal improvements in student achievement. Reform by the implementation of formative assessments has the potential to advance quality education.

Alignment with Action Research Traditions

Understanding action research is important when conducting research. Action research is an organized approach of examining a problem and seeking an effective solution to a desired goal (Brydon-Miller, Greenwood, & Maguire, 2003; Stringer, 2013). A value common among action researchers is the respect of the practitioners' knowledge and understanding of the problem being confronted (Brydon-Miller, Greenwood, & Maguire, 2003). According to Stringer (2013), action research seeks to construct a body of knowledge to improve practices. It provides an adaptable and realistic set of practices. There should not be a mindless application of standardized practices, but instead, the thinking of resourceful practitioners should be used to find a solution. If the practitioners are actively engaged in the daily work, they can provide valuable insights to formulating effective and sustainable solutions to issues that arise in the work environment (Brydon-Miller, Greenwood, & Maguire, 2003; Stringer, 2013). When conducting action research, the assumption is that people who are affected by the problem examined should be included in the systematic inquiry research process. An action research approach has the potential of enriching the practices and lives of the practitioners involved.

My ROS study followed the action research traditions. I, the researcher, collaborated with knowledgeable educational practitioners, teachers, district level leaders, and administrators who were engaged in formative assessment work on a daily basis. A systematic approach was used to explore a possible solution, the creation of the state-created quarterly assessments. Interviews of fifth grade mathematics teachers who were affected by the problem were included in the inquiry process to assist in determining the most effective solution. Through the use of action research traditions in my ROS, there was the potential to reach the desired goal of teachers using formative assessments effectively to increase students' mathematics achievement levels as measured by the EOGs.

Conceptual Framework

Understanding a framework is necessary for a researcher since it guides their research design and implementation. A conceptual framework is a skeletal structure used to clearly identify key variables and concepts of the problem in the study (Eisenhart, 1991; Imenda, 2014). Conceptual frameworks are structures of justifications including various perspectives, both insiders and outsiders, in the research problem which helps to explain the evidence collected during the investigation (Eisenbury, 1991). This framework is based on relevant theoretical literature and empirical findings of prior research. It helps to make sense of things and it is timely and reflects the current state of affairs within the research problem (Imenda, 2014). Some researchers find the conceptual framework well suited for research applied to educational issues because it enables comprehensive, useful, and timely approaches to the research problem (Bringle, Hatcher, & Jones, 2012). A conceptual framework takes the form of what is relevant to the study and supports the researcher in carrying out the study.

The conceptual framework of this ROS study includes ideas and commitments that inform and guide the research. The key variables of the framework are displayed in Figure 1. As noted by the framework, it starts with the potential solution to the problem of minimum increases to students' mathematic proficiency levels. The framework also outlines the differences between the state and district created assessments noted from various perspectives and brings the focus to the quantitative phase of the study noted in the first yellow box. Using the data from the quantitative phase, three factors were considered and used to direct the qualitative phase of the study noted in the second yellow box. This conceptual framework helped to explain key variables and the evidence collected during the investigation.

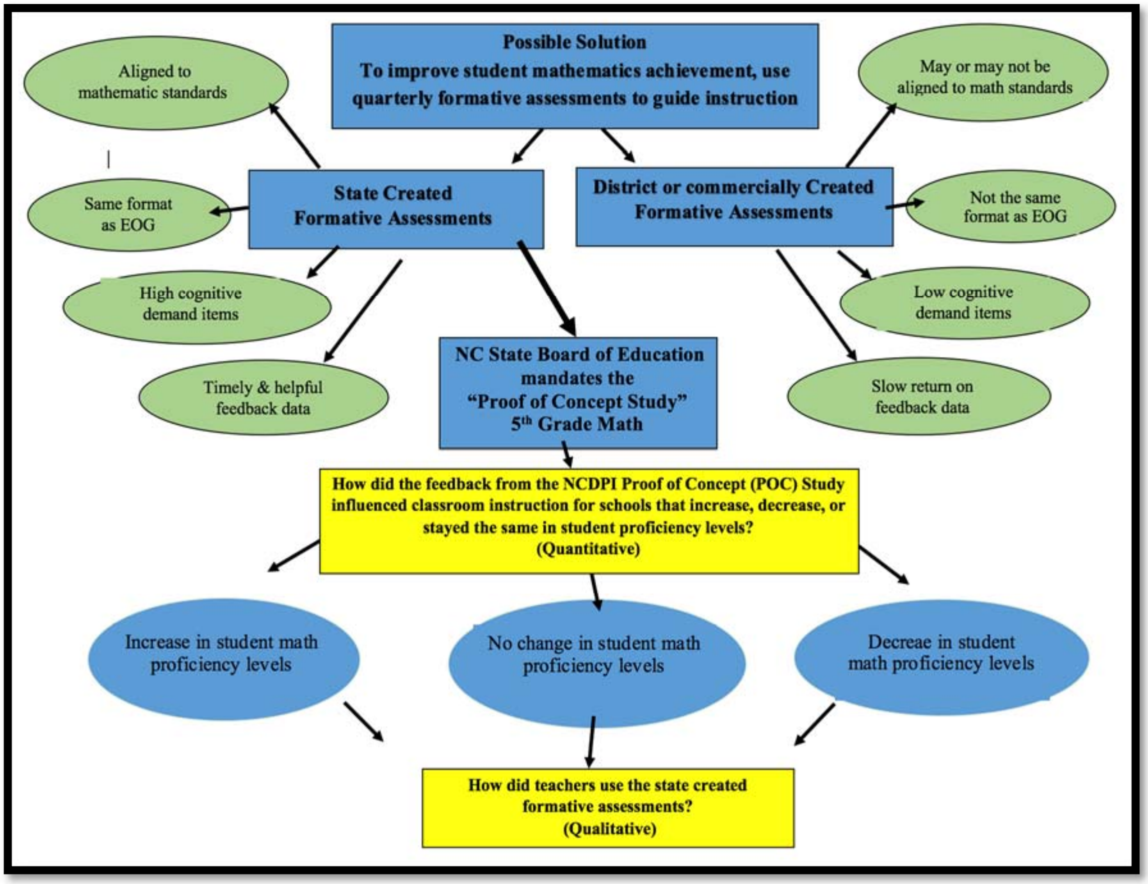

Figure 1. Conceptual framework of this study.

Most Significant Research

Formative assessments have helped teachers by providing insight into students' understanding of a concept. When teachers understand what students know and where they are struggling, teachers can make necessary "just in time" (Novak & Patterson, 2010) instructional adjustments. They can re-teach a concept or skill, try alternative instructional approaches, or provide additional experiences for practice. These strategies can improve students' academic success (Heritage, 2010; Joyner & Muri, 2011).

Formative assessment feedback should be provided by conferencing with a student and providing specific comments on the assigned task (Fox, 2015). According to Fox (2015), there should be more student and teacher interaction with the content standards; the end of unit test or high-stakes assessment should not be the first time a student receives feedback about their understanding of the concept. Through formative assessment teachers can support student learning of content standards.

Formative assessment is by no means straightforward. Educators should not only assess "for learning" through high-stakes summative assessments, but educators are encouraged to use assessment "of learning" or, in other words, formative assessments (Joyner & Muri, 2011; Stiggins, 2002). There should be a balance of assessing "for learning" and "of learning" (Stiggins, 2002). High-stakes mandatary assessments which exist across the nation hinder the effective implementation of formative assessment according to Paris, Lawton, Turner, and Roth (1991). Teaching for understanding is better than rote recall, many teachers attempt to increase student scores on high-stakes assessments through memorization of algorithmic procedures which result in a lack of higher-order thinking, the type involved in formative assessment. Therefore, it appears there is widespread belief that the memorization of procedures results in higher test scores than teachers endeavoring to improve their teaching skills using formative assessment, resulting in improved student learning (Paris et al., 1991). There are many factors to consider when using formative assessment to improve student learning.

Teachers must use formative assessments as one factor in improving student learning. Teachers have been attempting to use formative assessments for instructional improvement according to Goertz et al. (2009) and Frohbieter et al. (2011). Formative assessments were useful but the assessments were not adequate when it came to informing instructional improvement. There was little evidence linking assessments to assisting teachers in developing a deeper understanding of students' mathematical thinking, which many be identified as a precursor to instructional improvement (Goertz et al., 2009; Frohbieter et al., 2011). Teachers' abilities to understand assessment data play a substantial role in how they used the result of the assessments to improve their teaching and ultimately student learning (Goertz et al., 2009; Frohbieter et al., 2011) Even though formative assessments can be useful in improving student learning, teachers must understand how to purposefully and effectively use the feedback data to improve instruction.

Assessments are powerful tools that can affect student learning when they provide timely information directly related to what teachers have taught. This timely feedback (Hattie, 2012; Shanahan, Hyde, Mann, & Manrique, 2005) allows teachers to constantly monitor teacher impact on students and receive feedback about their teaching and how it can be tweaked to obtain the best possible results. There were substantial gains in student learning and an even stronger impact on helping students who have learning disabilities and low-achieving students noted in Black and Wiliam's (1998a) review of 250 studies on the use of formative assessments. Formative assessment that provided timely information was found to improve external mandated assessments (Wiliam, Lee, Harrison, & Black, 2004). These improvements were small, but if replicated across the entire district, would raise scores from the twenty-fifth percentile to the upper half.

These data suggest teachers do not, as Paris et al. (1991) reported, have to choose between getting good test results and teaching well. Formative assessments have been shown to positively influence all students' learning.

Rigorous standards and assessments related to high-quality classroom instruction are a must to impact student learning. The rationale for challenging rigorous standards (Conderman & Hedin, 2012; O'Shea, 2005) is that they promote quality curricula which in turn lead to effective teaching and enhanced learning for students. Knowing what to teach is not sufficient (Shanahan et al., 2005). Teachers must know what is to be taught, the clear goals for students, and how to measure the progress being made towards reaching student goals. Teachers must understand the intent of the standards and the level of conceptual understanding a student should attain to be proficient (O'Shea 2005). Thus this relationship (standards to assessments) substantiates the necessity for rigorous standards and effective use of formative assessments.

It is abundantly clear from the research that learning is determined by what teachers and students do in the classroom. Using formative assessments effectively in the classroom can be difficult for teachers because these assessments require teachers to think strategically about the relationship between instruction and assessments. Educators must examine the feedback as a means to promote learning and students must be an active partner in the learning process. These shifts take time, patience, and a commitment on everyone's part so that the culture of learning can support the formative assessments process. Through this formative assessment process, students will think more deeply about their learning and teachers will think more deeply about their teaching, hopefully leading to creating a positive impact on student achievement.

Closing Thoughts on Chapter II

Even though formative assessments are being promoted as powerful improvement tools, many educators lack the understanding and direction about how to best implement them. Through research, we know the use of formative assessments to improve student learning is sometimes lost in the classroom. Formative assessments must align to challenging and rigorous content standards and serve as an example of what students should know and be able to do. Teachers must be provided with support on how to use the feedback data to adjust classroom instruction if there are to be significant gains in student learning.

There have been studies conducted by researchers to build a deeper understanding of the impact on students and teachers when using formative assessments. Some researchers note how assessments can hinder thoughtful classroom instruction because of teachers focusing only on rote recall procedures to increase assessments scores. Most of the studies about formative assessments that researchers reference points out the potential for powerful improvement and positive effects on students' learning if teachers understand how to use the formative assessment process. When teachers use the feedback from formative assessments effectively, they can constantly monitor their instructional impact on students and at the same time receive feedback about their teaching and how it can be tweaked to obtain the best possible results—improvement in student learning.

CHAPTER III

SOLUTION AND METHOD

Proposed Solution and Justification

The State Board of Education's POC Study data were used to explore one of the possible solutions to the problem of minimal increases in student mathematics proficiency levels. This POC Study reviewed the use of state-provided formative quarterly assessments aligned to the NC mathematics standards. These assessments contained cognitivley demanding items and were in the same format as the high stakes state EOG assessments. Formative assessment feedback was provided in a useful and timely manner. Fifth-grade teachers in 48 schools were selected from around the state to use the quarterly formative mathematics assessments. The goal was to have teachers implement the state provided assessments to guide classroom instruction throughout the school year to significantly impact student mathematics achievement. The 2015-2016 results of the state EOG mathematics assessment proficiency levels helped determine the success or failure of the POC Study, state provided quarterly formative assessment approach.

The state-provided, quarterly formative assessments have the potential to create a powerful feedback loop for classroom instruction. This feedback loop could then lead to targeted instruction to improve student learning. If the assessments provide the feedback loop (Silver & Smith, 2015; Wiliam & Leahy, 2015) to improve student learning then this would justify the state's creation of quarterly assessments and the study of how teachers use the feedback. However, according to many formative assessments researchers, the use of this feedback loop could represent a dramatic change in both mindset and teaching practice for many (Frohbieter et al., 2011; Silver & Smith, 2015; Wiliam & Leahy, 2015). This dramatic change was one of the potential weaknesses for the intended outcomes for the state provided quarterly formative assessments in mathematics.

The focus of this study was on the gap in formative assessment research. There was little existing research on how formative assessments are actually used to guide classroom instruction (Goertz et al., 2009; Heritage, Vendlinski, & Herman, 2009). The focus of much research about formative assessment is on teaching practices, not the use of formative assessment feedback to adjust or modify teaching practices. The findings in this ROS study will assist in filling this gap in the research, focusing on the use of formative assessments on teaching practices. There is a need to assist educators in making sound decisions about how to effectively implement quarterly formative assessments to guide instructional teaching practices to improve student achievement.

Study Context

Understanding the context is needed to better focus this ROS study. The Common Core State Standards were adopted by NC in 2010 and implemented in 2011. When these new, more demanding standards were implemented, student test scores dropped as anticipated and the test scores across the state of NC have shown minimal increase in student proficiency ever since, according to the Performance and Growth of NC Public Schools Executive Summary. In response, the State Board of Education decided to create quarterly assessments aligned to the state standards. These assessments were comprised of items that met the following criteria: were cognitively demanding, allowed for prompt and useful feedback to teachers, and were designed in the same format as the high-stakes EOG assessments. The quarterly assessments feedback data consisted of content standards assessed by each item, depth of knowledge for each item, class percent correct by item, school percent correct by each item, correct answer, student response, class mean, and school mean. The creation and implementation of the state quarterly assessments were called the POC Study and examined fifth-grade mathematics quarterly assessments conducted during the 2015-2016 school year. Through the POC Study, a series of segmented assessments captured a picture of student achievement throughout the school year. A critical part of the POC Study was to determine the operational and technical feasibility of this model. The NC Department of Public Instruction (NCDPI) created two groups, a POC Pilot Study group that was administered the quarterly assessments with a modified EOG, and a comparison group that was only administered the modified EOG. To ensure that results could be generalized to the entire state, the NCDPI identified a stratified random sample of schools based on four demographic variables (region, ethnicity, gender, and economically disadvantaged status) and a school-level achievement variable, the mean scale score on the EOG assessments. The POC Pilot Study group, (see Figure 2) included 48 schools (3,906 students) and the comparison group consisted of 45 schools (4,034 students) for Grade 5 mathematics classrooms from across the state of NC. The sample size was determined based on the minimum number of test takers needed to do an item analysis of the EOG and modified

EOG results. Comparing EOG data results of each group helped determine the effectiveness of the NCDPI created assessments to increase student mathematics achievement.

A committee of district leaders, teachers, and higher education staff assisted in the implementation of the POC Study. This committee not only represented various educational levels but also included representation from various districts across the state. The participants on the committee were brought together to determine which mathematics standards would be assessed each quarter. This same group also decided what feedback would be provided for teachers after each quarterly assessment. Some of the feedback decided upon included: content standards assessed by each item, depth of knowledge for each item, class percent correct by item, school percent correct by each item, correct answer, student response, class mean, and school mean. It was important to capture a variety of participants to serve on this committee so that various perspectives where represented and considered throughout the POC Study. District leaders and teachers were also provided with an optional one day face-to-face professional development session and webinars were conducted to support the implementation of the quarterly formative assessments. Educational leaders involved in this process hoped that the implementation of the quarterly assessments would result in a feedback loop used to build and tailor instruction to support student learning.

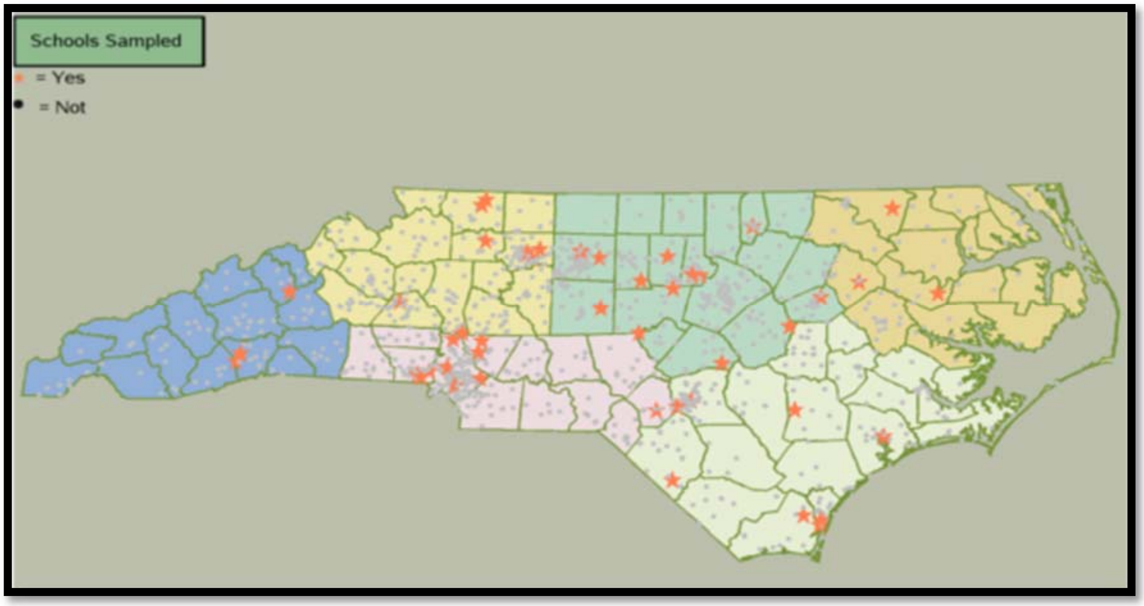

Figure 2. Schools participating in POC Study.

Participant Selection for this Study

A purposeful sample was recruited for the qualitative portion of this study. A purposeful sample strategy was used (cf. Creswell, 2012; Robinson, 2014). The selection of schools was noted with green bars (see Figure 3). Participating schools were ranked by growth rates in proficiency level scores. Once the schools were ranked, two schools from each of the three strata were selected. It was anticipated that only one school would be necessary but a second school was selected to ensure that data saturation was ensured. The sample size consisted of a total of six schools: two schools that increased in proficiency level scores, two schools that maintained approximately the same level in proficiency level scores and two schools that decreased in proficiency level scores. The purposeful selection strategy criteria included the use of the state-created quarterly assessments data, no drastic change in student population, no change in mathematics teachers, and no change in administrator during the 2014-2015 and 2015-2016 school years. The selected schools met all the criteria for the qualitative phase of the study. Pseudonyms were used for the teacher participants.

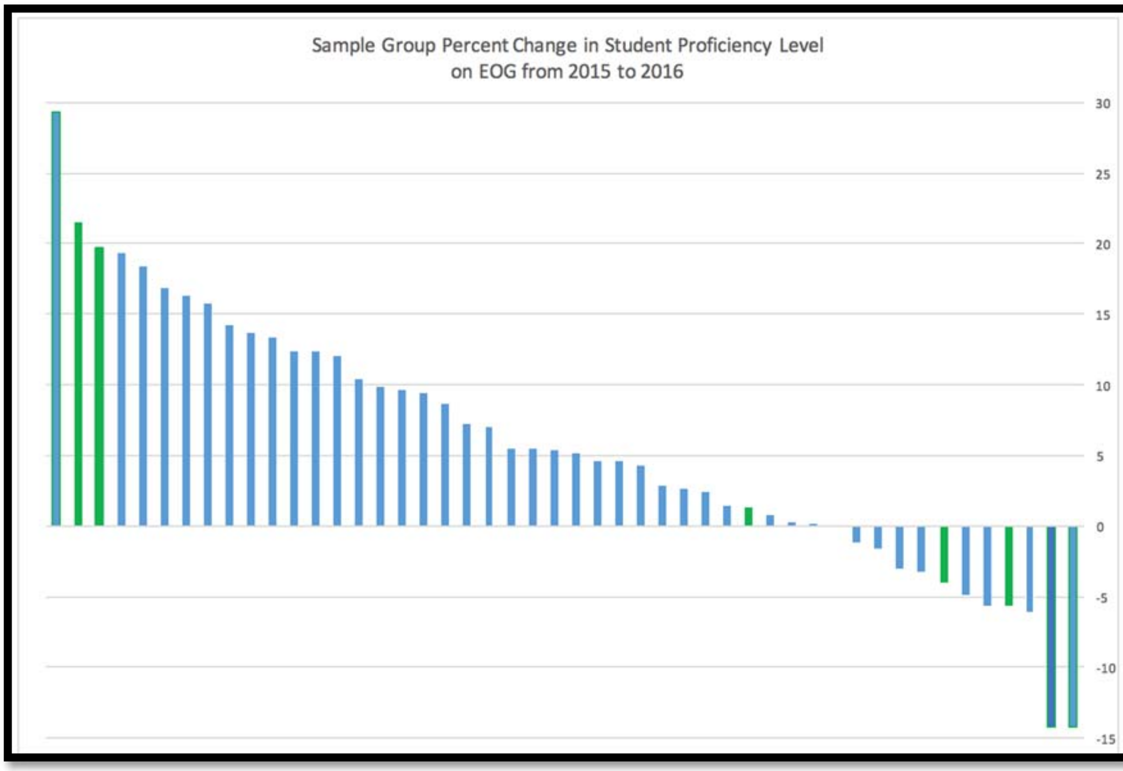

Figure 3. Change in student proficiency levels.

Student Proficiency Level Scores Increased

There was a 29.3 percent increase in student proficiency level scores in one school, noted in Figure 3. This school did not meet all the purposeful sample strategy criteria therefore, teachers from this school were not interviewed. When talking with the principal she said the teachers did not use the quarterly assessment feedback data. The school was selected to be part of the mandated POC Study, they administered the quarterly assessments but the fifth-grade teachers did not refer to or use the feedback data, therefore, this school did not meet the purposeful selection strategy criteria.

*School 1***.** Student proficiency level scores increased in school 1 by 21.5 percent. This school was located in the north central region of the state where is housed grades 3-5. It was a title I school and 73% of the students were low income. This school met all the purposeful sample strategy criteria There was minimum change in student population. The principal had been the administrator for a total of 3 years. There was a total of four fifth grade teachers. Each teacher taught in a self-contained classroom and they each taught mathematics the year before the POC and the year of the POC. When I visited the school the following school year, there were only two of the four teachers remaining; one was out on maternity leave and the other teacher had moved. There were two teachers remaining who were interviewed from School 1, Linda and Mia.

*School 2***.** Student proficiency level scores increased in school 2 by 19.7 percent. This school was located in the Sandhill region of the state where it housed grades K-5. It was a title I school and 73% of the students were low income. This school met all the purposeful sample strategy criteria. There was minimum change in student population. The principal had been the administrator at this school a total of 3 years. There are five fifth grade teachers who team teach in a two-person team and a three-person team. Two of the five teachers teach math. One of the two mathematics teachers met the criteria of being at the school during the two years being compared. This teacher, Mindy, served on a three-person team and taught the year before the POC Study and the year during the POC Study. The other mathematics teacher left the school during the POC year and was on maternity leave in the spring thus, did not meet the teacher criteria.

Student Proficiency Level Scores Remained About the Same

The two schools whose student scores maintained their previous level of student proficiency for two consecutive years were numbered 3 and 4. These two schools met all the purposeful sample criteria. Schools 3 and 4 were also comparable in that their grade level proficiency scores were relatively close the year before the POC Study (see Table 1). Student proficiency levels scores showed minimum to no change.

*School 3***.** Student proficiency levels remained about the same in school 3, it increased 1.3 percent. This school was located in the western region of the state where it housed grade K-5. It was a title I school and 37% of the students were low income. This school met all the purposeful sample strategy criteria. There was minimum change in student population. The principal had been the administrator a total of 3 years. There was a total of four fifth grade teachers who were departmentalized, with one teacher teaching all the mathematics for the grade level. Kristen, the mathematics teacher, taught the year before the POC Study and the year during the POC Study.

*School 4***.** Student proficiency level scores remained the same in school 4. This school was located in the north central region of NC where it housed grades K-5. It was a title I school and 56% of the students were low income. There was minimum change in student population. The principal had been the administrator at this school a total of 9 years. There are three fifth grade teachers who were departmentalized so that one teacher taught mathematics to all fifth graders. The teacher, Kristy, met the criteria of having taught mathematics the year before the POC Study and the year during the POC Study. However, she is now teaching a different grade level at the same school.

Student Proficiency Level Scores Decreased

There were 11 schools with scores that decreased in student proficiency levels. Noted in Figure 3, there was a school where student proficiency levels showed a decrease by as much as 14.2 percent. After talking with various principals of the schools that deceased in proficiency levels, it was found that most schools did not meet the purposeful selection strategy criteria. They did not meet the purposeful selection criteria of the same mathematics teacher teaching the year before the POC Study and the year of the POC Study. The two schools with decreasing student proficiency levels that met the purposeful selection strategy criteria were Schools 5 and 6.

*School 5***.** Student proficiency levels scores decreased in school 5 by 4 percent. This school was located in the southeast region of the state where it housed grade K-5. It was a title I school and 37% of the students were low income. This school met all the purposeful sample strategy criteria. There is a total of four fifth grade teachers who team teach, consisting of two teams. There was minimum change in student population during the two years being compared, however usually every three years there is a large change in student population. The principal was the administrator for the last 3 years and was leaving at the end of the school year. Two of the four teachers teach math, and both math teachers taught the year before the POC Study and the year during the POC Study. The names of the two teachers interviewed were Amay and Emma.

*School 6***.** Student proficiency level scores decreased 5.7 percent in school 6. This school was located in the piedmont-triad region of the state where is housed grade 3-5. It was a title I school and 62% of the students were low income. This school met all the purposeful sample strategy criteria. There was minimum change in student population. The principal was the administrator at this school a total of 2 years. There is a total of five fifth grade teachers who make up two teams. Two of the five teachers teach mathematics. There is a two- and three-person team. The two-person team mathematics teacher taught the year before the POC Study and the year during the POC Study. The three-person team teacher who taught three math classes was on medical leave in the fall during the POC year so she did not meet the teacher criteria. The teacher interviewed from this school was Anna.

While there is variability in the schools selected, each school met all the criteria of the purposeful sample strategy. Only the teachers that were at the school during the two years being compared met the teacher criteria and where interviewed for the study. During the 2014-2015 and 2015-2016 school years, the identified six schools reviewed the feedback from the state-created quarterly assessments, had the same student population, principal and mathematics teacher(s). The variability of selected schools assisted in the understanding of the differences in teachers' use of the feedback of the same assessments to guide classroom instruction.

All the schools selected for this study received federal Title 1 funds. In NC, Title I funds are provided to schools with the highest percentages of students from low-income families. Title I is designed to support state and local school reform efforts tied to challenging state academic standards in order to reinforce and amplify efforts to improve teaching and learning for students farthest from meeting state standards. All six schools met the criteria to receive Title I funds supporting the comparability of the selected schools.

Information about selected schools that was important to the study was collected and placed in Table 1. Some data collected included grade level proficiency (GLP) scores for the two years being compared, the difference between the two years, the total number of students in the school, and the percentage of low income students. The two schools in Table 1 which had the greatest increased in GLP scores, had the lowest GLP scores initially. The fourth column in Table 1 lists the change in GLP scores from 2015-2016. There was a difference of 27.2% from the largest to the smallest change in GLP scores. The total number of students in the schools are contained in the fifth column. This population ranged from the school with the smallest number of students (n = 267) to the school with the most number of students (n = 748). The sixth column included the percentage of low income student in the school. The next column included ethnic composition of the school population. Table 1 also includes information signifying if the school is served with federal Title I funds. The compiled collected data in Table 1 assists in comparing schools used in this ROS study.

Table 1

Information about Selected Schools (Mbella, K., Zhu, M., Karkee, T., & Lung, H., 2016)

	Fifth Grade Student Proficiency Level Scores			School Demographics			
School	**2014-15**	**2015-16**	**Change from 2015 to 2016**	**Total Number of Students**	**Low Income Students**	**Ethnic Composition**	**Title I Funds**
Student proficiency level scores increased							
School 1 Grades 3-5	50%	71.5%	21.5%	262	73%	White 60% Black 31% Other 9%	Yes
School 2 Grades K-5	48.5%	71.2%	19.7%	572	71%	White 53% Black 42% Other 5%	Yes
Student proficiency level scores remained about the same							
School 3 Grades K-5	81%	82.3%	1.3%	536	37%	White 85% Black 6% Other 9%	Yes
School 4 Grades K-8	73.1%	73.1%	0%	292	56%	White 75% Black 18% Other 7%	Yes
Student proficiency level scores decreased							
School 5 Grades K-5	67.9%	63.9%	-4%	748	37%	White 68% Black 25% Other 7%	Yes
School 6 Grades 3-5	76.5%	70.8%	-5.7%	458	62%	Black 67% White 19% Other 14%	Yes

Note: Data included in this table was retrieved from North Carolina Public Schools www.ncpublicschools.org/accountability/reporting

Research Plan

Quantitative and qualitative data were collected to provide insight into different perspectives and limitations. A quantitative approach affords analysis of a large collection of data; however, individual voices will be lost. A qualitative approach focuses on a smaller collection of data and affords the ability to provide rich contexts but generalizability is lost. In a mixed methods approach, the researcher combines quantitative and qualitative approaches, providing respective strengths which can compensate for the weakness of the other research approach (Creswell & Plano-Clark, 2011). Mixed methods offers a multiple approach to finding the answer to research questions (Johnson & Onwuegbuzie, 2004). The collection of quantitative and qualitative data can draw on the strengths of both types of research data.

An explanatory sequential mixed methods design was used during this study. The explanatory design contains two clear phases (Creswell & Plano-Clark, 2011; Ivankova, Creswell, & Stick, 2006). The first phase consists of collecting and analyzing quantitative data. Based on a need to further understand the results of the quantitative data, a researcher may use the information from the quantitative data to identify individuals from a sample. During the second phase, the qualitative data are collected and analyzed to help clarify the initial quantitative results. The collected qualitative data builds directly on the quantitative data results. The explanatory sequential mixed methods design supports this ROS study because there is a need in this problem to seek a comprehensive explanation of the results from the quantitative data.

Figure 4 illustrates the various phases in the explanatory sequential mixed methods design used in this ROS study. In the quantitative data phase, extant data from schools participating in the 2015-2016 POC Study was examined. These data included 2015-2016 and 2014-2015 POC Study proficiency level scores in mathematics from the state EOG assessment. These data were collected and analyzed through *t*-tests and effect size in order to compare means. Based on a need to further understand the quantitative results from the extant data, the qualitative phase of the study was conducted. In this phase, as illustrated in the oval in Figure 4, after careful analysis of the quantitative results, an interview protocol was developed. A purposeful selection of schools was determined which included schools with increased student mathematics proficiency scores, those that remained the same, and those that decreased in student proficiency levels. Interview questions were developed in this step of the design. Then the qualitative data were collected with the help of audio-taped, in-depth, one-on-one semi-structured interviews (cf. Creswell, 2014). During the qualitative data analysis, the interviews were coded and examined for themes (e.g., Creswell, 2014), followed by a within-case and cross-case analysis to identify important themes (e.g., Creswell, 2014). The final phase in the sequential mixed methods design ended with an interpretation and explanation of the quantitative and qualitative results which is represented in the last oval at the bottom of Figure 4.

Phase	Procedure	Product
Quantitative Data Collection	• Extant 2015-2016 Proof of Concept (POC) Study Proficiency Level scores in mathematics from the State End-of-Grade Assessment • 2014-2015 Proficiency Level scores in mathematics from the State End-of-Grade Assessment	• Numeric data
Quantitative Data analysis	• Difference between proficiency levels from the two years being compared • *t*-test • Effect size	• Comparisons
Interview Protocol Development	• Purposefully selecting 6 schools • Develop Interview questions • Two schools that increased in proficiency level scores • Two schools that maintained the approximately the same level in proficiency level scores • Two schools that decreased in proficiency level scores • Develop Interview questions	• Cases (six schools - 5th grade math teachers) • Interview protocol
Qualitative Data Collection	• Record one-on-one, in-depth, in person semi-structured interviews	• Transcripts • Antidotal notes
Qualitative Data Analysis	• Coding and thematic analysis • Within- and Cross-case theme development	• Codes and themes • Similar and different themes
Integration of the Quantitative and Qualitative Results	• Interpretation and explanation of the quantitative and qualitative results	• Discussion • Implications • Future research

Figure 4. Explanatory sequential design study diagram.

Data Collection Methods

Quantitative

The EOG proficiency level scores (extant data) were used in the quantitative phase of this study. These data were requested from the NC Department of Public Instruction Accountability Department for the 2015-2016 POC Study for analysis and the EOG scores for 2014-2015 school year. It is important to comprehend how the NC EOG student score is reported in order to understand the student proficiency levels used in this study. According to the NCDPI Division of Accountability, on the EOG a student can score 1 – 5 proficiency level. Levels 1 and 2 denote students with limited to partial command of knowledge and skills at that grade level. Level 3 identifies students who demonstrate a sufficient command of knowledge and skills at that grade level. Levels 4 - 5 identifies students who demonstrate solid and superior command of knowledge and skills at that grade level and are identified as career and college ready. The student proficiency level scores retrieved were averages of levels 3-5, students who demonstrated at least sufficient command of grade level knowledge. These averages scores were used in the quantitative phase of this ROS study.

Paired *t*-tests and effect size were used in the quantitative phase of this ROS study. A *t*-test compares two means to determine if they are different from each other (Salkind, 2014). In this study, *t*-tests were used to determine whether the means of the student proficiency levels differ. The first *t*-test was used to determine if there was a statistically significant difference in the mean percent proficiency between the POC Pilot Study and comparison group on the 2016 EOG during the POC Study. A second *t*-test was used to determine if POC had an impact on student outcomes. The *t*-test was appropriate because the test scores are on a continuous scale, and the test scores are normally distributed. Random samples are assumed before using *t*-tests, which are not typically possible in education (Ferguson, 2009; Salkind, 2014). However, the sample (POC Pilot Study group) used in this ROS study are representative of the state in general. A difference-in-difference design was employed to compare the impact of the program, or in this case, the use of state-created quarterly assessments on student mathematics achievement in the POC Pilot Study group over time as compared to the comparison group (Somers, Zhu, Jacob, & Bloom, 2013). Because a *t*-test is an analysis of two groups, this justifies using this test in this study (Salkind, 2014). These tests of significance will require educators to consider the null hypothesis: the mean percent proficient on the EOG scores for the POC Pilot Study group is not significantly different from the mean percent proficient on the EOG scores for the comparison group. In addition to the *t*-test, effect sizes were computed to determine the importance of the differences between the groups. Effect sizes provide an indication about the relative importance of the findings and the magnitude of the differences (Ferguson, 2009; Salkind, 2014).

Qualitative

Semi-structured interviews were used during the qualitative data collection which was needed to further understand the results of the quantitative data. The most common type of interview used in qualitative research is semi-structured interviews which are appropriate when trying to determine the why, or reasons for behavior, and they provide the interviewer flexibility (Doody & Noonan, 2013; Fylan, 2005). These interviews can be simple spontaneous conversations sparked by a predetermined list of open-ended questions that are used to guide the interview (Doody & Noonan, 2013; Fylan, 2005). The conversations are free to vary or explore a new path if it emerges. A disadvantage to semi-structured interviews is that novice researchers, like myself, may be unable to identify where to ask additional questions which could potentially exclude some relevant data. Researcher should build a rapport with the participants and actively listen as they seek to answer the research questions. Semi-structured interview questions used in this ROS study (see Appendix A) were developed to help build that understanding that cannot be provided through quantitative data alone. Semi-structured interviews were used to find out about teachers' experiences, their views and attitudes about the quarterly formative assessments process.

The quantitative and qualitative data worked together in this study to explain the bigger picture of the use of state-created formative assessments. Without both phases of the mixed methods design the research was not clear. The first phase helped to identify selected schools so a deeper investigation could be done to better understand the collected data which in turns helped to answer the quantitative and qualitative guiding research questions.

When selecting participants to interview for this ROS study a purposeful sample strategy was used. Schools with various growth levels in proficiency level scores were selected to build a more comprehensive understanding of the differences in how teachers used feedback from the formative assessments (Creswell, 2012; Robinson, 2014). The sample size consisted of a total of six schools: two schools that contained students who increased in proficiency level scores, two schools whose students that maintained approximately the same level in proficiency level scores and two schools whose students decreased in proficiency level scores. The purposeful selection strategy criteria included the use of the state-created quarterly assessments data, no change in student population, mathematics teachers, and administrator during the two years being compared.

Several steps were included in the qualitative phase of this ROS study. Once the six schools were selected, permission from the various districts and school-site administrators, and teacher participants was obtained. After permission was received, school visits were held to conduct audio-taped semi-structured interviews (Creswell, 2014; Doody & Noonan, 2013) with participating teachers. The interview process was handled with care to ensure candid responses and to be sensitive to the educators involved, a task that required ethical and interpersonal care (Guba, & Lincoln, 1994). All participating teachers were informed of the study's goals, what participation entailed, its voluntary nature, how anonymity is protected and any other necessary information to help them reach an informed decision to participate (Robinson, 2014). There was a visit to each school where semi-structured interviews (Creswell, 2014; Fylan, 2005) were conducted with each teacher. Data were collected through in-depth, one-on-one, audiotaped interviews with selected teachers about their use of the assessment feedback in classroom instruction. Content analysis and coding of transcribed interviews and field notes were used to identify specific themes (Creswell, 2014; Stake 2010) and describe trends in the data of within and cross-case comparison (Creswell, 2014; Stake 2010) of teachers' strategies. Follow-up included informal conversations and emails when needed for clarifications. These steps provided the information needed to collect and analyze data for the qualitative phase of this ROS study.

Mixed Methods Data Analysis

A mixed methods data analysis strategy can be helpful to employ during a research study. Strategies used during the conduction of this ROS study consisted of identification through quantitative data and then further investigation through the qualitative data collected to enhance understanding. A researcher must clarify and refine the inquiry interpretations (Caracelli, & Greene, 1993). Through mixed methods data analysis, there is opportunity to create a fresh insight and new perspective on the data.

Data analysis were applied at multiple points in the quantitative phases of the study. Data sources included collecting the extant EOG mathematics scores for fifth-grade during the POC Study and the pre-existing fifth grade EOG scores from schools participating in the POC Study. The raw data were analyzed for trends to determine which schools increased or decreased in mathematical student proficiency levels. *T*-tests and effect sizes were used to determine if there were statistically significant differences between the POC Pilot Study and the comparison groups. Analyzing the quantitative data consisted of examining the database to determine which teachers were to be interviewed to gain more insight into the use of quarterly formative assessments.

Data analysis was also employed during the qualitative phases of the study. After the analysis from the database of teachers, one-on-one, in-depth, semi-structured interviews (Creswell, 2014) with purposefully selected teachers were conducted. Interviews were audio-recorded, transcribed and systematically coded (Creswell, 2014). Themes were created, findings represented, and the answers to research questions were assessed. Support for findings was gleaned from reviews of the extant literature and new questions were created based on the findings. The qualitative phase of this ROS study provided many opportunities to analyze the data.

Timeline

Table 2 illustrates the timetable for this study. It includes the data, event, audience, and action taken to collect and analyze data.

Table 2

Timeline of Study

Date	Event	Audience	Action
May 2015	State Board of Education mandated POC Study	District Superintendents	Superintendents informed of POC Study
May 2015	Meeting of teachers held to develop a list of standards that should be assessed at each quarterly assessment	Teachers from across the state	Created list of standards assessed each quarter
July 2015	Memo provided to Local Education Agencies (LEA) participating in the POC Study	Selected schools	Teachers Informed of POC Study
August 2015	Created and delivered professional development and support materials for POC. Participants may attend one of the three trainings available throughout the state	Teachers, principals, & district leaders	Created, delivered PD, and support documents
Sept 2015	Worked with the accountability department to write, edit and review assessment items for quarterly assessments	Accountability Department	Quarterly assessments created
Oct 2015	Schools administered state-created assessments and follow-up survey given	Teachers	Assessment and follow-up survey

Table 2 Continued

Date	Event	Audience	Action
January 2016	Second state-created assessments and follow-up survey administered	Teachers	Assessment and follow-up survey
March 2017	Third state-created assessments and follow-up survey administered	Teachers	Assessment and follow-up survey
June 2016	State mandated high-stakes EOG assessments administered	Teachers	EOG assessments
July 2016	Received survey feedback and analyzed data to create interview questions		Create interview questions
September 2016	IRB approval		IRB
October 2016	Received student proficiency level scores of schools participating in the POC Study		Quantitative Analyses *t*-tests & effect size
November 2016	Prepared purposefully selection list of schools and acquired permission to interview teachers	Schools	Selection of schools and teachers
February 2017	Proposal hearing held with ROS Committee		Proposal approved
March & April 2017	Began semi-structured one-to-one, in-depth-interviews with teachers	Teachers	Teacher Interviews
May 2017	Qualitative data analysis completed		Themes and coding
June & July 2017	Wrote up results		ROS
August 2017	Submitted to Chairs		ROS
September	Submitted to Committee		ROS
September	Make revisions		ROS
October	Submit to committee and defend		ROS

Reliability and Validity Information

Reliability and validity are paramount for a robust study. Reliability in quantitative research refers to the stability of a measure over time and if the results of the study can be replicated with a similar methodology (Creswell, 2014; Heale, & Twycross, 2015). Validity in quantitative research determines if the measurement is accurate and if it truly measures what it is intended to measure (Creswell, 2014; Golafshani, 2003; Heale, & Twycross, 2015). To ensure reliability in qualitative research, analysis of trustworthiness is imperative, a consistency of data confirmed through verified examination. The concept of validity in qualitative research refers to some qualifying check or measure of the research (Golafshani, 2003). The researcher must work to improve the quality of the study through careful consideration and measurement of reliability and validity.

Reliability and validity are critical in quantitative research. The quantitative phase of this study uses the NCDPI End-of-Grade assessment scores. Reliability is the stability of a measure over time, the consistency of the measurement. The EOG, is the instrument used in the same way, under the same conditions, with the same subjects, so the measurements strive to be consistent. The NC Testing Program Technical Report (2016) from DPI notes that it uses an adapted validation framework endorsed by the standards in a coherent process. Thus the state of NC accountability department gathered, evaluated, and documented relevant evidences checking the reliability and validating the use of test scores.

Reliability and validity are vital in the qualitative phase of this research. Validity is a strength of qualitative research when determining whether the findings are accurate, obtaining rigor through verification (Creswell, 2014; Morse, Barrett, Mayan, Olson, & Spiers, 2002). The following steps were taken to minimize potential validity threats. A thorough case study database and protocol was created so others can follow the procedure. Transcriptions were reviewed and checked for accuracy. Time was spent each week in the field to develop an in-depth understanding from teachers to convey details about how the formative assessment was used lending credibility to the findings. When collecting data, the school's proficiency level scores from the quantitative phase were used to assist in the selection of school to follow up on the findings. Major themes found in the data were the basis for the analysis, and options were weighed to decide if follow-up was needed. There were few reliability concerns about coding because there was only one coder examining the data in this study. Therefore, there was consistency of data analyses. Reliability and validity were considered throughout the qualitative phase of this research.

Bias is a challenge for qualitative researchers or even impossible to completely eliminate. Bias can affect the investigation and distort the measurement process (Chenail, 2011; Sica, 2006). According to Chenail (2011), when collecting qualitative data, the researcher can be the greatest threat to trustworthiness if time is not spent on preparation for the interview process. The researcher must take time to reflect back over the interview process and identify personal feelings arising during the questioning or identify prior assumptions about the participants. The researcher must stay humble and develop an appreciation for the task of sharing one's knowledge about the topic. Despite the researcher's best attempt, interviewing the interviewer has its limitations (Chenail, 2011; Sica, 2006). Researchers may remain blind to their biases and the challenges biases bring to the research.

Throughout the interview process, I understood the potential danger of bias. I took measures to be aware of my personal bias as much as possible by taking the time to reflect over the interview process, identifying personal feelings and prior assumptions about the teachers being interviewed. I was humbled and appreciated the willingness of teachers to share their thinking and experience. Even though it was not my decision to create the quarterly formative assessments it was my job to implement them and support teachers throughout. I felt the more I learned from the teachers, the more support I could provide to assist our state in moving forward. I concentrated on collecting data from the teachers and their use of the quarterly formative assessments, trying to eliminate any personal bias.

If the results of a study are to be meaningful, there must be reliability, validity, and acknowledgement of potential bias. Otherwise, interpretation drawn from both quantitative and qualitative data cannot be used to generalize any findings, and the study could become meaningless and a waste of time and effort. To prevent interpretation issues, both quantitative and qualitative data sets were used to answer the research questions while establishing reliability and validity throughout this ROS study.

Closing Thoughts on Chapter III

One proposed solution to the problem surrounding minimal increases in student mathematics proficiency levels could be the creation of high quality state-created quarterly assessments and the effective use of them in the classroom by mathematics teachers. The NCDPI created the POC Study to determine if high-quality formative assessments would, in fact, increase student mathematics proficiency. The state created assessments are aligned to the NC mathematics standards, contain cognitively demanding items, provide useful, and timely feedback, and use the same format as the high stakes state EOG assessments which helps make them high-quality assessments. However, formative assessment can only impact student achievement if teachers understand how to use the feedback data to adjust classroom instruction. The proposed solution of the creation of these assessments aligned with professional development can only improve the problem if the assessments are appropriately designed and teachers know how to use them effectively.

To learn more about the use of the assessment feedback data in the classroom, a purposeful selection strategy and a variation in growth levels of proficiency scores were used to select participants. The purposeful selection strategy criteria included the use of the state-created quarterly assessments data, no change in student population, mathematics teachers, and administrator during the 2014-2015 and 2015-2016 school years. A difference in growth levels in proficiency level scores was used to assist in the understanding of the differences in teachers' use of the feedback of the same assessments to guide classroom instruction. Both aspects of selection and variation are important to fully understand and gather more information about the use of the assessment feedback data in the classroom.

An explanatory sequential mixed method design which has both a quantitative and qualitative phase was used to analyze the proposed solution to the problem. During the quantitative phase, the extant data from schools participating in the POC Study were collected and analyzed through *t*-tests and effect sizes. Then to better understand the quantitative results the qualitative phase of the study was conducted. The qualitative phase consisted of in-depth, one-on-one semi-structured interviews (cf. Creswell, 2014). which were coded and examined for themes (e.g., Creswell, 2014), followed by a within-case and cross-case analysis to identify important themes (e.g., Creswell, 2014). The explanatory sequential mixed method design ended with interpretation and explanation of the quantitative and qualitative results. This approach allowed for the best collection and analysis of meaningful data.

Challenges exist in all research and the explanatory mixed method design is no different. Creswell and Plano-Clark (2011) expose some of the challenges, limitations of this design. Limitations are influences that cannot be controlled but should be mentioned because it might influence the results. One such limitation that can hinder this type of research includes the researcher's role in the study and the introduction of bias into the findings and data integration. The researcher assumed two roles in this study, the researcher and supporter of the quarterly formative assessments implementation. Having these two roles, could have hindered the research results.

CHAPTER IV

ANALYSIS AND RESULTS

Overview of the Data and Analysis

When reflecting on research question one for this ROS study, there were several pieces of data and analysis that had to be considered. Question 1: Did the use of the feedback from the NCDPI Proof of Concept (POC) Study improve student outcome for schools that increased, decreased, or stayed the same in student proficiency levels? This question was used to help determine which schools to visit in order to collect additional data about how the feedback influenced classroom instruction. The quantitative data included extant EOG mathematics proficiency level scores from the 2015-2016 POC Study and pre-existing 2014-2015 fifth grade EOG scores from schools participating in the POC Study. The raw EOG scores were analyzed for trends to determine differences in mathematical student proficiency level scores which were used in the purposeful school selection. *T*-test and effect sizes were employed to determine if there were statistically significant differences and to compare the changes over time between the POC Pilot Study and comparison groups. Through the collection of the quantitative data and analysis, the first research question was answered for this ROS study.

The qualitative data collection and analysis were examined to assist in answering the second research question in this study. Question 2: How did teachers use state created formative assessments? The purpose of this question was to garner more insights into the use of quarterly formative assessments. After the purposeful school selection based on examination and analysis of the quantitative data, one-on-one, in-depth, semi-structured interviews were conducted. Interviews were audio-recorded, transcribed and systematically coded to determine themes. The qualitative data collection from the semi-structured interviews and analysis provided insight into answering the second question in this ROS study.

Results of the Research

The results gathered from the conduction of this ROS study were based upon the quantitative and qualitative methods described in the overview. Both quantitative and qualitative findings are important and bring significant understanding to the potential solution to the problem – use of formative assessments to help alleviate the minimal increase in student's mathematics achievement. The use of both quantitative and qualitative methods helped to provide stronger results in this study.

Analysis of Quantitative Data

In the first phase of this ROS, the question that guided the study was: Question 1: Did the use of the feedback from the NCDPI Proof of Concept (POC) Study improve student outcome for schools that increased, decreased, or stayed the same in student proficiency levels? During this quantitative phase of the study, the random stratified sample achieved similarity between the POC Pilot Study and comparison groups. The first *t*-test was conducted to compare the POC Pilot Study and comparison groups 2016 EOG student proficiency level scores. There was not a statistically significant difference in the scores for the POC Pilot Study group (M=62.22, SD=16.19) and comparison group (M=61.21, SD=18.22) proficiency level scores; t (91)=0.78, p = 0.44. These results suggest the first year of implementation of the state created quarterly formative mathematics assessments did not have an effect on the EOG student proficiency level scores. To determine if the POC Study had an impact on student outcomes, a difference-in-difference design was employed which compared the average change over time in an outcome variable for the treatment (POC Pilot Study) group compared to the average change in time for the comparison group (Somers et al., 2013). The second *t*-test was conducted to compare differences from 2015 to 2016 EOG student proficiency level scores of the POC Pilot Study group and comparison group. The differences from year to year resulting in the impact of the state-created quarterly assessments on student mathematics achievement was being compared. There was no statistically significant difference in the student proficiency level scores for the POC Pilot Study group (M=5.84, SD=9.05) and comparison group (M=6.91, SD=12.11) scores; t (91)=0.63, p = 0.53. These results suggest the differences in each group were similar. Each group used assessments, the group that used the state created assessments made no statistically significant gains over the control group. Therefore, we cannot reject the null hypothesis: the mean percent proficient on the EOG scores for the POC Pilot Study group was not significantly different from the mean percent proficient on the EOG scores for the comparison group. An effect size of 0.36 was consistent with the finding of no statistically significant difference in the means. There was no statistically significant difference as noted by the *t*-test.

The data noted in Table 3 were used to assist in the identification of schools used in this ROS study. In Table 3, the results display the differences in average mathematics student proficiency level scores from each school in the POC Study from 2015 to 2016. The range of differences in GLP percent from 2014-2015 to 2015-2016 school year was 43.5, the difference with the greatest increase was 29.3 and difference with greatest decrease was 14.2. These data were used to assist in the purposeful selection of schools that used the state-created, quarterly formative assessments. It was necessary to determine which schools had students with increased proficiency level mathematics scores, which schools remained stable, and which schools had decreased to obtain a variety of comparable schools. Using a sampling of a variety of schools would assist in better understanding the differences in how mathematics teachers used the feedback from the quarterly formative assessments.

Table 3

School Proficiency Level Scores from 2015 to 2016

POC Study School	2014-2015 (GLP) Percent	2015-2016 (GLP) Percent	Difference from 2015-2016
Did not meet interview criteria	32.7	62	**29.3**
School 1	50	71.5	**21.5**
School 2	51.5	71.2	**19.7**
	20.8	40.1	**19.3**
	20.8	39.2	**18.4**
	64	80.8	**16.8**
	61.8	78.1	**16.3**
	60.8	76.5	**15.7**
	47.7	61.9	**14.2**
	62.2	75.9	**13.7**
	60.9	74.2	**13.3**
	42.4	54.8	**12.4**
	37.5	49.9	**12.4**
	61.9	73.9	**12**

Table 3 Continued

POC Study School	2014-2015 (GLP) Percent	2015-2016 (GLP) Percent	Difference from 2015-2016
	69	79.4	**10.4**
	40	49.8	**9.8**
	54.4	64	**9.6**
	61.2	70.6	**9.4**
	40	48.6	**8.6**
	61.4	68.6	**7.2**
	77.1	84.1	**7**
Average	51.3	65.5	**14.1**
	51	56.5	**5.5**
	30.9	36.4	**5.5**
	44.6	50	**5.4**
	63.9	69.1	**5.2**
	52.1	56.7	**4.6**
	67.4	72	**4.6**
	69.7	74	**4.3**
	22.2	25.1	**2.9**
	56.3	58.9	**2.6**
	87	89.4	**2.4**
	67.2	68.6	**1.4**
School 3	81	82.3	**1.3**
Did not meet interview criteria	61.4	62.2	**0.8**
	43.6	43.8	**0.2**
	37	37.1	**0.1**
School 4	73.1	73.1	**0**
Did not meet interview criteria	83.1	81.9	**-1.2**
Did not meet interview criteria	44.7	43.1	**-1.6**
Did not meet interview criteria	68.1	65.1	**-3**
Did not meet interview criteria	62.5	59.3	**-3.2**
School 5	67.9	63.9	**-4**
Did not meet interview criteria	25.6	20.7	**-4.9**
Did not meet interview criteria	85.7	80.1	**-5.6**
School 6	76.5	70.8	**-5.7**
Did not meet interview criteria	60.6	54.5	**-6.1**
Did not meet interview criteria	93.8	79.6	**-14.2**
Did not meet interview criteria	51.6	37.4	**-14.2**

Analysis of Qualitative Data

Qualitative methodological techniques were used to guide the second phase of the ROS study answering: Question 2: How did teachers use state created formative assessments? Data from teacher interviews were collected, coded, and themes identified (Creswell, 2014). During this phase, several themes emerged when analyzing the transcripts from the semi-structured, one-on-one, in-depth mathematics teacher interviews. Through the analysis of the qualitative data, four major themes were identified: 1) use of and utilization of the formative assessments process (teachers and administrators), 2) use of collaboration to analyze feedback data to modify or tweak classroom instruction, 3) teacher beliefs about teaching and learning, and 4) teacher as a reflective practitioner. Grouping the evidence helped to reflect on the broader perspectives of the teachers and their successes while using the quarterly assessment data to guide classroom instruction. The qualitative phase also included a within- and across-case analysis (Creswell, 2014; Stake 2010) developed based on the semi-structured interviews where participants were assigned pseudonyms for reporting results. The qualitative methodological techniques were paramount in answering the second research question in this ROS study.

Within-case Analysis

Student proficiency level schools increased.

*School 1***.** The mathematics proficiency levels of the students in School 1 increased by 21.5 percent. There were a total of four self-contained fifth grade teachers at this school. All four teachers met the purposeful selection criteria: taught in the school the year before the POC and the year of the POC. However, when I went to the school to interview the teacher the falling year, one teacher had moved and one was out on maternity leave. So the two remaining teachers, Linda and Mia were interviewed. Linda had taken time out to raise her children and worked in a daycare setting before returning to the classroom, so she had been teaching in a school system for six years and had additional educational experiences. Mia had 13 years of teaching experience. The School 1 principal always reviewed the quarterly assessment feedback data and was a big advocate of the research being conducted in the POC study. Both teachers attended the POC summer professional development and had received additional formative assessment training through the district, conferences, or classes.

School 1 teachers expressed thoughts throughout the interview which led me to believe they truly understood the importance, valued, and utilized the formative assessment process. “You can really differentiate your instruction and sometimes it’s something so simple that, if you can just fix that, they get it. It’s almost like zooming in on where the needle in the haystack might be.” The teachers at this school worked collaboratively to plan and review results of school and state-created quarterly assessment feedback data. These teachers used error analysis of student responses from feedback to identify student understandings. These teachers also used assessment feedback data to change and adapt their instruction.

Here are some of the teacher reflections. Mia said,

> We get together to talk about the assessments results and we try to decide why the students scored what they did, and we were really good about our math intervention block; it was based on all of our assessments. And we would literally, ok, break up

> the kids according to who knew what, and then go from there with either enrichment and acceleration, or review and remediation.

> Linda said, "Are you going to keep beating a dead horse or are you going to be wise enough to move on and maybe spend more time on another standard? So that will improve your instruction because you will be wise enough to change your pacing".

> Linda said, "You can really tell if they are way off track or maybe there was just some little thing they didn't get, or maybe it was just reading the problem…. You can also see if they had some kind of misconceptions or they had not a clue."

Productive teacher beliefs in School 1 were evident. In the *Principles to Action: Ensuring Mathematical Success for All* (NCTM, 2014), the authors write about productive beliefs and how they can affect instructional practice, hindering students access to high quality mathematical content and practices (Leinwand, 2014). Teachers continuously supported and encouraged students in their learning efforts through their product beliefs.

> Mia said, "Students must take ownership of their learning. I expect students to self-analyze, reflect on their work - I always encourage them to go back and look and see why they missed the problem. And if they can figure out why they missed it, it's one thing. But if they still don't understand then you write a note out to the side so we can talk about it together".

The teachers in School 1 were also reflective in their teaching practices. They were open and willing to learn from each other as professional throughout the formative assessment process, as evident in their comments:

Mia said, "I know that I need to go find out what my team is doing. Maybe they can give me some pointers. That was very, very helpful."

Linda said, "I think I'm doing a better job at instruction, I'm using a lot more problem based materials, as opposed to like before I would be one of those 'well I need to have them doing it with an algorithm."

Mia said, “I didn’t feel like I was including enough rigor. They have to make sense of the problem.”

Mia said, this process has “helped me when I look at resource, made me a little pickier of what I select when choosing questions for my students, better quality tasks that truly align to the standards.” These comments support the idea of productive teacher beliefs in School 1.

School 2. Student proficiency levels in School 2 increased 19.7 percent. This school had a total of five fifth grade teachers who team taught, a two-person team and a three-person team therefore, so two of the five teachers taught math. One of the two mathematics teachers was out of school during part of the POC year for maternity leave and did not meet the purposeful selection strategy criteria. The other mathematics teacher met the purposeful selection strategy criteria, Mindy. She served on the three-person team and taught the year before and the year during the POC Study. Mindy was interviewed and had 22 years of teaching experience. She received the formative assessment training from her district’s mathematics coordinator who attended the POC summer professional development. According to the teachers, the district mathematics coordinator was highly engaged at the school level, constantly providing professional development and highly supportive with the implementation of the POC process. The principal of this school was a supporter of data-driven instruction. The school has a Professional Learning Community (PLC) data wall which was used during team planning. Mindy said things such as “You have to do formative assessment to know where your kids are and to help them move forward." Her comments led me to believe she truly understood the importance and valued the formative assessment process.

The teachers in school 2 worked collaboratively to plan and review results of school and state-created quarterly assessment data. The teachers also used the assessment data to change and adapt their instruction. Minday said, "We realized we just had to beef it up, we had to - the results are right there, you know they're having trouble with that so you have to hit those standards." When planning each week, the math teachers looked at the data results to do an error analysis, they pulled questions and "we put them on a spiral review – we call it their bell ringer. This is one way our instruction has changed due to the data feedback result from the quarterly assessments for this school." Teachers in School 2 worked collaboratively to plan weekly.

The beliefs of the teacher in School 2 can be considered as productive. The mathematics teacher's expectation changed for students during the implementation of the state-created formative assessments. She now expected mathematics learning to focus on developing an understanding of concepts and procedure through reasoning and discourse.

> Mindy said, "It is okay to make mistakes, growth mindset, students must have ownership of their learning. . . . We make them (students) accountable too. They have to show their work. Expectations have gotten higher, we want them to actually be able to explain their thinking, their reasoning and that's an expectation."

The interviewed teacher in School 2 was reflective in her teaching practices. Mindy said, "We focus more on application not just computation but making sense of problems." Teachers realized the assessment items were high cognitive demanding and wanted their classroom instruction to mirror this type of mathematics rigor.

> Mindy said, “We needed to take it a step further with classroom instruction…. So those deeper, more rigorous items used on quarterly formative assessments has changed my tasks and things used in the classroom to build a deeper understanding, more rigor, and higher expectations.”

Student proficiency level scores remained about the same.

*School 3***.** There was a 1.3 percent increase in student proficiency levels in School 3. The student scores in this school were at about the same levels of proficiency in mathematics as the year before. The four fifth grade teachers at this school were departmentalized so one teacher, Kristen, taught mathematics to all fifth graders. Kristen had 20 years of teaching experience. She met the purposeful selection strategy criteria; she taught mathematics the year before and the year during the POC Study. She attended the POC summer professional development along with a district level staff member. When talking about the formative assessments process it was not clear from Kristen’s expressed perceptions if she truly understood the formative assessment process. She said she liked the quarterly assessments because she wanted her students exposed to the “really rigorous, hard ones.”

> Kristen said, “The more of those you can give us the better because it would be nice for them to at least be familiar. . . . I feel like that - not memorizing answers because you’re not, you can’t - but it’s kind of teaching them the format and they’re learning and it’s actually showing their math learning”.

Because teachers only teach one content area in School 3, they did not collaborate when content planning or when reviewing results of school and state-created quarterly mathematics assessment data. The teachers did meet together to discuss student progress or concerns when needed. Kristen said she did use the assessment data to change her instruction. “Re-teaching the hard parts with the error analysis was huge. We (teacher and students) did more talking about the wording of the questions.”

Teacher beliefs in this school seemed less productive, a focus on practicing test items. Kristen said,

> We just don’t have enough time, I believe, to practice test items like they need to be, we correct every question. And I let the kids do it, we might put that up on the board and discuss it, but I always give them their test books back and we write all over them.

Kristen was somewhat reflective about her teaching practices, referencing student impact on learning and how she could modify instruction. Kristen said,

> When a problem (test item) is difficult, I definitely want students to kind of see what my thinking is, and sometimes they’ll share their thinking. But they talk a lot more in here and use the white boards. Since the POC, we’ve done more and more of that because it seems to impact student learning. . . . I also think we may need to spend more time with manipulatives.

*School **4**.* Student mathematics proficiency levels remained constant at School 4. There were three fifth grade teachers at this school. They were departmentalized so there was one teacher, Kristy, who taught mathematics to all fifth graders. She had 11 years of teaching experience. She met the purposeful selection strategy criteria, she taught fifth grade mathematics the year before and the year during the POC Study. However, when interviewed she was teaching a different grade level in the same school.

Kristy attended the POC summer professional development and was currently working on her Elementary Mathematics Add-on Licensure. She had not taken the formative assessments course included in that program until after the POC Study. She expressed thoughts throughout the interview which led me to believe that she now (after the POC Study) truly understood the importance of and the value of the formative assessment process. This was not her thinking about formative assessment when teaching fifth grade during the POC year! Kristy said,

> When we get our results from the district, it's like weeks later and you've already began teaching something else, you know? So, it's pointless. So, if it's going to be formative it needs to be immediate. . . . Every kid doesn't have to master it right away, that's not expected, you're gonna be continuously going back and re-teaching, spiraling, and not holding kids back that are ready to move on.

Kristy did not work collaboratively to plan mathematics instruction because she was the only fifth grade teacher teaching mathematics content. She did not review feedback results on the school's and state's-created quarterly assessment data with anyone. Kristy did say she used the assessment data to change her instruction. Kristy said,

> The biggest thing I think changed for me was how I used those reports that you guys (DPI) gave us to go back and re-teach and use for interventions and things like that. Before that I really don't feel like we had anything to go by. I was just kind of pulling what I could as I went.

After Kristy's formative assessments class, her beliefs about the use of formative assessment had changed. Kristy said,

> I feel like had I been in that assessment class before the POC, I would have talked to students more. I don't feel like I went over the data report well with them. If I could go back and do it again, give students ownership of the data, I would sit them down and say, 'Look these are our standards,' because I know how to talk to kids about standards now and I would have said, 'Look where we need to work.' And I would want each individual student to know their strengths and weakness. Whereas at POC time I just used the standards to go back and say, 'Ok I need to make sure I hit these things again in my spiral review, my warm-up, I need to hit these things again in my centers, I need to go back and re-teach.' But if I could go back, I would do it all differently. Woohoo that class changed my world.

Kristy was reflective about teaching practices. She realized how her thinking had changed and where she needed to improve in her teaching and learning practices. She realized even though the feedback told her what the students know and do not know, she did not know what her next steps should be with instruction. Kristy said,

> I think I did assessments in the past but I didn't really do them. They became more summative than formative for me. . . . The assessments were aligned to the mathematics standards which helped me to better understand the standards. And I can see which ones I might be weak in teaching, that I need to go back to.

Student proficiency level scores decreased.

*School 5***.** Mathematics student proficiency levels decreased 4 percent in School 5. There were a total of four fifth grade teachers in this school. The teachers team taught so two of the four teachers taught mathematics, Amay and Emma. They both met the purposeful selection criteria, taught at the school the year before and the year of the POC. Amay taught for 17 years and Emma had 7 years of teaching experience. Both teachers attended the POC summer professional development with their principal. Neither teacher elaborated on their understanding of formative assessment or the potential benefits of the formative assessment process. These teachers focused on the advantages of using the quarterly assessments feedback to teach test taking strategies as evidenced by this statement, "I think it helps them to be cautious in looking for those careless mistakes."

The teachers at this school worked collaboratively most of the time with their team teacher but less frequently with the mathematics content teacher. In School 5, the mathematics teachers spent some time reviewing the results of the state-created quarterly assessment data. The teachers said they did not use the assessment feedback data to change their classroom instruction. Here are examples of their comments about collaboration and use of feedback to modify instruction: Emma said, “We checked and made sure we were on the same page.” Emma said,

> What are we doing next? She’s usually a little bit ahead of me, so I’m kind of the one that’s like, “Where am I going with this next?” But I look at my plans and I know I’m going to get through everything.

> Amay said,
> I would have to say that the quarterly assessments didn’t change my instruction much, the pacing of standards assessed. . . . So, I think going one-to-one (one computer per student) had a bigger impact on change in my instruction than this test did.

Teacher beliefs in this school seemed to be unproductive which could have limited student access to mathematics practices as illustrated in their comments: Emma said, “I can’t force you to put forth the effort. And at the end of the day if they don’t want it, it’s like their choice.” Emma said,

> I tell them up front at the beginning of the year, by the end of the year I want you to at least know that, even if you don’t like math that you can persevere through it. Emma said, I’m going to show you this, we’re going to practice it, but if you don’t understand this, that’s OK. I think a lot of the picture stuff (models) which I know it did show up on the POC tests, but, that stuff, I know I personally am not a visual person, and so, I’ve been fine.

The teachers in School 5 demonstrated minimal reflection on their own teaching and learning practices. Most of their conversation focused on teaching of test taking strategies to students when using the quarterly formative assessments, not on modifying teaching practices to build a deeper understanding of the content standards. Amay said, “The formatting and the vocabulary are almost identical to EOG.” “Look guys, just because your answer’s there doesn’t mean that it’s right because that’s a common mistake.” Amay said,

We go through the tests with the students. We encourage them to do their work in the

> book so that when we review it they can see their mistakes. And they really appreciate that feedback because then they can see, 'Oh I just made a careless mistake,' or if they had no clue.

*School 6***.** The scores in School 6 decreased by 5.7 percent in the area of mathematics student proficiency levels. There were five fifth grade teachers who team taught in a two-person team and a three-person team. Two of the five teachers taught mathematics. One of the mathematics teachers was out of school for most of the POC year due to medical illness so she did not meet the purposeful selection strategy criteria. The other mathematics teacher met the purposeful selection strategy criteria. This teacher, Anna, served on the three-person team and taught the year before and the year during the POC Study. Anna had 33 years of teaching experience, all at the same school in different grade levels. She received formative assessment training from her co-worker who attended the POC summer professional development. She expressed ideas throughout the interview which led me to believe she did not truly understand the formative assessment process. Anna said, "We do quizzes throughout and when you get to the end of a unit you would do a formative assessment." Anna said,

> We are not supposed to use it as grading purposes but I wish that we could. Because I feel like if we're going to spend all this time on it that, even though, I thought some of the questions were unfair, I think we should be able to. I never told my students whether I would or wouldn't use it for a grade.

Then Anna said she worked collaboratively to plan with other teachers in her grade level and reviewed results of assessment feedback data. "We plan extensively every Wednesday for probably three hours, analyze data and that type of thing." However, this teacher felt the assessment data did not change her instruction, "not my presentation of instruction just pacing of standards." "I don't have time to go back right now and do it again. I wish I could be that person that's like, 'Oh I took assessments and it just transformed my whole everything.''"

There was little evidence gathered from the interview in School 6 to support productive teacher beliefs. This teacher felt she must guide students step by step through the mathematical tasks as evidenced through the following statements, "These children who cannot read don't understand questions being asked, they struggle. All this information, I would make them underline or rectangle the question being asked." "Well it's been a wakeup call for students—with the use of visual models and it's even hard for me."

Anna demonstrated minimal reflection on her teaching practices. There seemed to be a major focus on test taking strategies not about adjusting instructional pedagogies to meet the needs of the students. Anna said,

> The assessment helps me to know I've got to provide, even though I don't like number lines with division, I need to make sure they have more opportunities with it. . . . So, what we ended up doing, you know, after we saw in the format of the test, the bulleted format, then we started practicing more in that way. But when we're doing small group instruction based on ability, you know, we practice this format more, because they had to get used to it.

Cross-case Analysis

After conducting a cross-case analysis, four major themes were solidified and continually appeared throughout the analysis of the data collected in all six schools. The following themes emerged: 1) use of and utilization of the formative assessments process (teachers and administrators), 2) use of collaboration to analyze feedback data to modify or tweak classroom instruction, 3) teacher beliefs about teaching and learning, and 4) teacher as a reflective practitioner using the state-created quarterly formative assessments. These major themes were found in the cross-case analysis.

The first major theme that appeared after analyzing the data was teachers' and/or administrators understanding or misunderstanding of the formative assessment process. In the two schools where students showed an increase in mathematics proficiency levels, the teachers had a solid understanding of the purpose of formative assessments and how to use data to guide classroom instruction. According to the teachers, the principals at these two schools demonstrated that they were advocates of data driven instruction and used data to drive school decision making. The administrators made it a priority to review the quarterly assessment feedback data and supported decisions made by the teachers to improve instruction for students. One principal used the data for an after-school tutorial program and the other used it to update the school student data wall. The two schools where scores remained about the same on student mathematics proficiency levels contained mathematics teachers who had some idea about the formative assessments process but the same amount of support was not evident from the administration. At the two schools where student proficiency levels decreased, teachers seemed to struggle in their basic understanding of formative assessment. The teachers at both schools talked more about using the quarterly assessments to teach test taking strategies rather than guide their classroom instruction. One teacher even wanted to use the quarterly assessment as a grade. In the first major theme, there were apparent understandings and misunderstandings by the teachers about the formative assessment process.

The second major theme that appeared throughout the analysis of the teacher interview data was teachers' use of collaboration to analyze feedback data in order to modify or tweak classroom instruction. In the two schools where student mathematics proficiency levels increased, teachers worked collaboratively with other teachers and administrators to analyze formative assessment feedback data in order to adjust classroom pedagogies to focus on students' strengths and weaknesses. When planning each week, teachers used their analysis of the quarterly assessments feedback data to guide classroom instructional strategies. They used error analysis to determine which standards they should focus on for interventions and for enrichment. They expressed the idea that the use of the formative assessments feedback changed their classroom instructional pedagogies significantly. In the two schools where the student proficiency levels in mathematics remained the same, there were only one mathematics teacher at fifth-grade level. The schools had three or four teachers in fifth grade however, the schools chose to departmentalize so when planning or analyzing the feedback from the quarterly assessments there were no opportunities for collaboration with other mathematics teachers. Both teachers claimed assessment data did allow for modification of their instructional strategies. They used data to determine which standards they needed to re-teach so students would have a better chance at grasping important and necessary mathematical concepts and understanding. At the two schools where student mathematics proficiency levels decreased, the teachers appeared to collaborate mostly with their team teacher and not as much with the other mathematics teachers at the school when planning instruction. "We (the other math teacher) checked and made sure we were on the same page." Teachers in both of the schools said the quarterly assessments did not change their instructional strategies to a great extent but rather only modified their pacing of the standards. "I don't have time to go back right now and do it again. I wish I could be that person that's like "Oh I took assessments and it just transformed my whole everything." The use of collaboration to analyze feedback data in order to modify or tweak classroom instruction was the second major theme that emerged through this ROS study analysis.

The third major theme that appeared after the analysis of the data from the teacher interviews was the productive or unproductive teacher beliefs about teaching and learning. In the *Principles to Action: Ensuring Mathematical Success for All* (NCTM, 2014), the authors write about teacher beliefs impacting decisions regarding teaching mathematics which impact students' perceptions towards mathematics. Teacher's beliefs can be productive or unproductive. Productive and unproductive beliefs should not be considered as good or bad. However, teachers' beliefs can affect instructional practice, hindering students access to high quality mathematical content and practices (Leinwand, 2014). In the two schools where students showed an increase in mathematics proficiency levels, the teachers, based on their answers to interview questions, appeared to have productive beliefs about teaching and learning. They expected students to take ownership of their learning, to self-analyze, to reflect on their work. Mathematics teachers at both of these schools appeared to create an environment where it was safe to make mistakes but learn from those mistakes. Students are expected to explain and justify their thinking and reasoning through high cognitive demanding tasks. At the two schools where student mathematics proficiency levels remained consistent, mathematics teachers appeared to hold fewer productive beliefs about formative assessment use. These teachers focused on students correcting questions on their quarterly assessments not as much on change of classroom instruction. These mathematics teachers would have some discussions about the items as a class or by working in small groups depending on the feedback data. In two schools where student mathematics proficiency levels decreased, the mathematics teachers held beliefs about formative assessments that seemed unproductive. "I tell them up front at the beginning of the year, by the end of the year I want you to at least know that, even if you don't like math that you can persevere through it." "I'm going to show you this, we're going to practice it, but if you don't understand this, that's OK." "Well it's been a wakeup call for students with the use of visual models and it's even hard for me." The productive or unproductive teacher beliefs about teaching and learning was the third major theme that emerged throughout the teacher interviews.

The last major theme that appeared during the analysis of the teacher interview data was the teacher as a reflective practitioner of teaching and learning practices. In the two schools where the students demonstrated an increase in mathematics proficiency levels, the teachers were extremely reflective about their teaching and learning practices and their willingness to create changes to assist in the improvement of student mathematics proficiency levels. One teacher spoke about working with other teachers on her team to receive pointers to improve instruction. Other teachers talked about using high cognitive demanding tasks, increasing the rigor, and using items that truly aligned to the standards.

They also discussed the importance of selecting better quality tasks or other resource materials for classroom instruction. Teachers made adaptations within their teaching practices, focusing more heavily on application of concepts and not just concentrating on computational algorithms. After using the data from formative assessments, these teachers expected students to make sense of problems and to build a deeper understanding of the standards. Teachers' expectations of student learning had greatly increased. In the two schools where mathematics student proficiency levels remained about the same, teachers were somewhat reflective as evidenced from the interview data. Both teachers interviewed in these schools realized the importance of students talking through the high cognitive demanding tasks and they additionally felt students needed to spend more time with manipulatives. These mathematics teachers also realized a benefit in the assessments because they were able to help students build a better understanding of the mathematics standards. Teachers also explained that they had a better understanding of the intent of the mathematics standards through the use of the quarterly formative assessments. Kristy, the teacher who just completed the formative assessments graduate class, was excited about everything she had learned in the class but at the same time disappointed she had let the opportunity to use the quarterly assessments effectively go by without actively applying her newly obtained knowledge for the betterment of her students. In the two schools where students decreased in their mathematics proficiency levels, there seemed to be teachers who reflected little on their own mathematics teaching practices. Most of the conversation focused on the teaching of test-taking strategies when using the quarterly assessments and encouraging students to do their work in the book so that "they can see their careless mistakes." These mathematics teachers valued assessments because the "formatting and the vocabulary are almost identical to EOG." When the teachers saw the bulleted format of the test, "we started practicing more in that way." Mathematics teachers at both of these schools said it did not change their instructional practices, merely their pacing of standards to align to the quarterly assessments. Teachers a one school started the implementation of one-on-one computers the same year as the state-mandated quarterly assessments so their focus was on that implementation rather than the use of formative assessments. These mathematics teachers seemed quite comfortable with the results they obtained from the students at their school and did not appear to realize the need for any change to occur. Being a reflective practitioner was the last major theme that appeared during teacher interviews.

Reflecting back over the research question, "How did teachers use state-created formative assessments?", it is evident some teachers/schools knew how to use the state-created quarterly formative assessments while others did not. Students at Schools 1 and 2 demonstrated huge increases in mathematics student proficiency levels. The mathematics teachers and administrators truly understood the formative assessment process. They used the formative assessment data as evidence of learning and to adjust classroom instruction. Teachers in both of these schools spoke about differentiating instruction to remediate and enrich student learning. The teachers worked collaboratively with their colleagues and their students. The teachers, administrators, and students learned from each other. These teachers held productive and positive beliefs concerning formative assessments. They demonstrated reflective practices about teaching and learning when reflecting on their use of formative assessments and how it relates to improvement of student mathematics proficiency levels. The teachers/schools that increased in mathematics student proficiency levels effectively used the state-created formative assessments.

There are still many unanswered questions. How is it that faculty in all six of these schools were exposed to the DPI professional development about the use of the quarterly formative assessments feedback and yet walked away with such different and varied notions and ideas about the formative assessment process? Which of the four themes that surfaced from the qualitative interview data had the largest positive impact on student growth in mathematics learning? The two schools that remained about the same in student proficiency levels had only one mathematics teacher per grade, so there was no one to plan with – what effect does having only one mathematics teacher per grade have on student learning? Why did some schools decrease in student proficiency levels? Few schools referenced mathematics learning progressions or how to use that research in decision-making processes for remediation or enrichment in their mathematics classrooms. Are these educators even aware of the learning progression research within the field of mathematics education? These unanswered questions definitely leave room for further research.

Interaction Between the Research and the Context

Through this action research study, I have attempted to demonstrate that formative assessment can improve student learning when assessment feedback is used as a guide to change and improve classroom instruction. The NC schools who participated in this study that demonstrated substantial growth in student proficiency levels were staffed with teachers and administrators who understood the formative assessments process. The teachers embraced the continuous feedback data so that they could adjust and modify their mathematics classroom instructional strategies to meet students' needs which ultimately improved student mathematics proficiency levels.

Operational issues that arose during this study consisted of finding schools that met the purposeful selection criteria. There were many schools where the teachers had not consistently taught fifth grade mathematics for the two connective years under investigation. A few schools had administrators who chose not to fully take part in the POC Study due to alternative district initiatives so thus they did not use the quarterly formative assessments feedback. Administrators in these particular educational settings merely administered the assessments as mandated by the NC State Board of Education. Therefore, finding schools that met the purposeful selection criteria was an operational issue.

The stakeholders' reactions to the use of state-created formative assessments varied. Some schools mandated to be part of the POC Study that used the quarterly formative assessments feedback realized the benefit for implementing and engaging in the formative assessments. Some schools embraced the opportunity and recognized the tremendous potential it could have on student proficiency levels while others did not. Those that welcomed the opportunity, the stakeholders, administrators, and teachers felt students were stronger in their mathematics content knowledge and were better prepared for NC's high-stakes EOG mathematics assessment. During my school visits, most of the teachers I spoke with throughout this study hoped the state-created formative assessments continued and would expand to other grade levels. However, there were other schools that still want to use the costly commercially made assessments they have purchased which in many cases align to their textbook. They do not want to use the state-created quarterly assessments. NC education stakeholders are very passionate and feel very strongly about their freedom to choose when it comes to these formative assessments.

I encountered little to no resistance during the conduction of this study. Teachers welcomed the opportunity to share their thinking and perceptions about the NC state-created quarterly assessments. These participant educators felt honored and valued during the conduction of this study. They appreciated the fact that someone from the NC Department of Public Instruction was interested in learning from them to make the assessment process more effective for all teachers. Several teachers did, however, express a dissatisfaction with the pacing of the standards being assessed and some of the assessment items that used visual models such as number lines. On the whole, little resistance was experienced during this ROS study.

Information from this study was shared with several educational leaders at DPI and changes have been made. Information from this action research study was shared with the director of the Accountability Division, the director of the Standards, Curriculum and Instruction Division at the NC DPI, and the NC State Board of Education (Appendix B). The NC director of the Accountability Division was pleased with the research findings from this ROS study. This director has already adopted some changes to the assessments. One such change is the allotted amount of time for the assessments; in the future students will be provided allotted time similar to the EOG assessment. Some of the items used on the quarterly formative assessments have been modified because of feedback from teachers interviewed. This mathematics assessment also will be implemented in fourth through sixth grade during the 2017-2108 year and third through eighth grade the subsequent year. The Standards, Curriculum and Instruction director is supporting a committee which is creating a pacing like document for districts. The optional pacing guide is being created by teachers, district leaders, and higher education staff from across the state. The information from this study has triggered many changes among educational leaders at NCDPI.

Using the results from this study, the Standards, Curriculum and Instruction Division will be better able to formulate decisions about how to best support teachers with the use of prompt feedback from the state-created quarterly assessments. One of the teachers interviewed, Kristy was extremely reflective, she realized how her thinking had changed and where she needed to improve in her teaching and learning practices. She realized even though the feedback told her what the students know and do not know, she did not know what her next steps should be with instruction. As the elementary mathematics consultant, I have created a Next Steps document (Appendix C) to support teachers with feedback data. My goal in creating this document was to assist teachers in answering the question: Now that you know what students know or do not know, what do you do? The intended purpose of the Next Steps document is to provide instructional support materials for teachers which may be used with students to help them move toward mastery of particular mathematical concepts. This Next Steps Document is not intended to be an exhaustive list of materials. Teachers are the most knowledgeable about the needs of their students and should use their professional judgment when making instructional decisions in their mathematics classrooms. Using the state-created formative assessments to guide instruction empowers teachers to fully understand what students know. These assessments assist teachers in determining the best instructional next steps to guide student understanding. DPI must provide support for teachers with the use of feedback from the state-created quarterly mathematics assessments.

A suggestion for further study would be to examine the POC Study schools use of state-created quarterly assessment data longitudinally after year two. That informational data should be publically available in late Fall 2017. This information will further provide understanding about the value or lack of value of teacher use of formative assessments and their effect on the student mathematics proficiency level scores across the state of NC. This would be an interesting follow-up study.

Summary

With the analysis of the results, through this research I gained, deeper and more comprehensive understanding from the quantitative and qualitative data collected concerning the problem of the minimum increases shown in student mathematics proficiency scores at elementary schools in NC. Both research questions were deemed necessary to better understand the possible solution (state-created quarterly formative mathematics assessments) to the problem. However, there was a major focus on the qualitative aspects in this study to answer the question, how did teachers use state created formative assessments? Having a deeper understanding of the problem and finding the answer to this research question guided my work as the state mathematics consultant.

Through the within- and cross-case analysis major themes emerged which helped to answer the qualitative research question. The themes were: 1) use of and utilization of the formative assessments process (teachers and administrators), 2) use of collaboration to analyze feedback data to modify or tweak classroom instruction, 3) teacher beliefs about teaching and learning, and 4) teacher as a reflective practitioner. In the schools that showed an increase in mathematics student proficiency levels there was consistent evidence of these four themes throughout the interview process. The teachers had a solid understanding of the purpose of formative assessments. Teachers collaborated to analyze quarterly assessment feedback in order to modify and adapt classroom instructional strategies. These teachers felt formative assessments feedback significantly changed their classroom instruction. The teachers possessed productive beliefs about formative assessments and their effect on teaching and learning in their classrooms. These teachers expected students to take ownership of their learning, self-analyze, and be reflective learners. Their students were expected to explain their mathematical thinking and reasoning. These particular teachers were extremely reflective about their teaching practices and their willingness to make changes to help improve student learning. Teachers discussed the use of high cognitive demanding tasks and increasing rigor. They also realized the importance of selecting better quality mathematical tasks and support materials for classroom instruction. These teachers made changes within their teaching pedagogies, focusing more on application of mathematical concepts rather than merely computational fluency. These educators now expected students to make sense of mathematical problems and build deeper understandings of the standards. Answers to the research question evolved from the major themes that arose during teacher interviews.

CHAPTER V

CONCLUSIONS

Summary of Findings from Chapter IV

Teachers are faced with the constant challenge of facilitating learning for all their students who present a variety of instructional needs. Teachers understand they must focus on practices that can make the biggest difference in student learning. Analyzing the results and findings show that there are specific practices that make substantial differences in student learning. Teachers must understand formative assessment to support with student learning, otherwise formative assessments are used as a summative assessment and no change in instruction takes place. Working collaboratively is imperative when analyzing formative assessments feedback data so effective modifications can be introduced and classroom instruction can be changed. Teachers' beliefs and being a reflective practitioner also played a huge part in student learning. Building a culture which embraces the formative assessment process can make a difference in student learning. Small changes in instructional practices can lead to significant changes in student learning.

Discussion of Results in Relation to the Extant Literature

As noted in the extant literature, to increase student mathematics achievement there must be rigorous standards, challenging curriculum, and effective instruction. Many of the results discovered through this ROS study supports this thinking about student learning. To increase student mathematics achievement measured through mathematics proficiency levels, the state adopted the rigorous Common Core State Standards. However, rigorous standards alone are not enough. The rationale for challenging standards is that it promotes quality curricula which, in turn, leads to effective teaching and enhanced learning for students (Shanahan et al., 2005). Rigorous assessments should be implemented along with high-quality classroom instruction to impact student learning (Conderman & Hedin, 2012; O'Shea, 2005). Teachers must know what is to be taught, the intent of the standards, and the level of conceptual understanding a student should attain to be proficient (O'Shea 2005). The teachers in this study whose students made substantial proficiency level growth discussed having a better understanding of the standards after implementing the quarterly assessments. Teachers expressed they "upped their game" by choosing more effective resources to guide their instruction. Also, the teachers' expectations for their students became more rigorous. These teachers now expected students to possess a deeper understanding of the concept by explaining and justifying their thinking. Through rigorous standards, challenging curriculum, and effective instruction there was an increase in student mathematics achievement.

Formative assessments must align to the mathematics standards so it can guide classroom instruction. Teachers felt the state-created quarterly assessments were highly aligned to the standards; in the past district or commercial made assessments did not always align. According to Joyner and Muri (2011) when aligned with standards, formative assessments can provide insights into student understanding. When teachers understand what students know and where they struggle, teachers can adjust and adapt their instruction. They are able to re-teach a concept, attempt alternative instructional approaches tried by other teachers, or provide additional learning experiences (Joyner & Muri, 2011; Wiliam, Lee, Harrison, & Black, 2004). The teachers in this study who made substantial student proficiency level growth spoke about truly knowing what students know or did not know about the mathematics standards from the formative assessments feedback data because it aligned to the standards: “It’s almost like zooming in on where the needle in the haystack might be.” They used alternative instructional approaches such as small group instruction, resources that are more closely aligned to the standards and high cognitive demanding items to meet the needs of various learners. When formative assessments are aligned to the mathematics standards there is opportunity for effective classroom instruction.

Attempting to use formative assessments is not enough, there must be change in instruction to build a deeper understanding of the mathematics. In the literature, many teachers attempted to use assessments for instructional improvement just like the teachers in this study; however, they found the assessments were useful but they were not adequate when it came to informing instructional improvement (Goertz et al., 2009; Silver & Smith, 2015; Wiliam & Leahy, 2015). Just like the teachers in this study whose students made low or no proficiency level growth, there was little evidence linking assessments to assisting teachers in developing a deeper understanding of students’ mathematical thinking, which is a precursor to instructional improvement (Goertz et al., 2009; Silver & Smith, 2015; Wiliam & Leahy, 2015). Teachers’ abilities to understand assessment data plays a substantial role in how they used the result of the assessments. Goetz et al. (2009) found many of their teachers focused on procedural skills rather than on building conceptual understanding of the standard. As noted in the results, the teachers with a decrease in student proficiency level growth spoke mainly about building procedural understanding, not using conceptual models or representations. They used the assessments predominantly as a test taking strategy builder rather than as a way to increase students mathematical thinking. Extant literature showed that teaching for understanding is more effective than rote recall; many teachers attempted to maximize student scores with rote recall procedures which results in a lack of higher-order thinking for students (Heritage, 2007; Joyner & Muri, 2011; Paris et al., 1991). Change in instruction to build a deeper understanding of the mathematics can come through the use of formative assessment if teachers understand how to use the formative assessments feedback data.

The actual use of formative assessment seems to be a gap in the literature. In many cases, the growing body of research on assessments paints a rosy picture, leading to increased student achievement. However, much of the research focuses on classroom instructional practices of how to formatively assess, not on the use of the assessments themselves (Goertz et al., 2009; Heritage et al., 2009). The teachers in this study whose students made substantial proficiency level growth had a solid understanding of the purpose for formative assessments and how to use data to guide classroom instruction. They utilized formative assessments to build a deeper understanding of the standards themselves. The teachers used formative assessments to collaboratively plan with other teachers and administrators. They used error analysis to determine which standards they should focus on for interventions and for enrichment. Through their analysis of the formative assessment feedback data, they modified and tweaked classroom instruction by re-teaching misunderstandings of certain concepts using different manipulatives, creating small group instruction, and formulating a spiraling type review of various mathematics concepts. They expressed that the use of the formative assessments feedback changed their classroom instruction significantly. By utilizing formative assessments, teachers realized students' desires to make sense of problems and explain their thinking and reasoning in order to build deeper mathematical understandings. Teachers' use of assessments helped them make changes within their teaching practices by focusing more intently on application, not just computation. Teachers also realized they had to modify their instruction by providing high cognitive demanding tasks daily. Through the use of the assessments, these teachers became more reflective about their teaching practices and their willingness to make changes to help improve student proficiency levels. These formative assessments were used in a variety of ways by the teachers to improve student mathematics learning. Hopefully, this study will highlight the use of the formative assessments and add to the current literature on this topic.

Implications for Practice

There is considerable research and many factors affecting student mathematics learning. Research claims formative assessment can increase student achievement (Goertz et al., 2009; Heritage, 2007; Wiliam et al., 2004). However, many teachers think assessment is synonymous with high-stakes standardized tests. Formative assessment is a fundamental process used to continuously gather evidence about student learning so instruction can be adapted to reach the desired learning goal (Heritage, 2007; Wiliam et al., 2004). From this study we can conclude that teachers made substantial student proficiency level growth had a solid understanding of the purpose of formative assessments and how to use the data to guide classroom instruction to improve student mathematics learning.

When thinking about implications for practice one should consider the school with the greatest gains in student proficiency level scores. The one school whose student proficiency level scores increased 29.3 percent had greater gains than any other school in the POC Study. This school did not meet all the purposeful sample strategy criteria because the teachers did not refer to or use the feedback data from the state-created quarterly assessments. However, when talking with the principal, she attributed the increase in student proficiency level scores to the new standards-based mathematics program the district purchased and implemented. The district's focus for the year was mathematics and they provided professional development to all teachers and administrators in the district. The principal hired a mathematics coach (doctoral student) to assist and support teachers with the implementation of the standards-based mathematics program. The mathematics standards-based program, professional development for teachers and leaders, or the mathematics coach could be possible factors that influenced the 29.3 increase in the student proficiency level scores. This is something to consider when thinking about implications for practice in the future for educational leaders.

The potential of state-created quarterly mathematic formative assessments must be shared with all educators in the state of NC to improve teaching and learning practices. Teachers who were concerned about the districts assessments because they did not align with the state's rigorous mathematics standards must be told. Teachers worried because district assessment items are low cognitive demanding must be told. Teachers who feel the district assessments are just one more district mandate and do not buy into this process must be told. It is important to reach out to district leaders who say their teachers do not value or understand how to use the results of assessments to formatively guide classroom instruction. We must reach out to all educators across the state to inform them about how state-created quarterly formative assessments are available as an option for everyone. These assessments are highly aligned to the standards, have high cognitive demanding items, provide timely and useful feedback, and are in the same format as the high-stakes EOG. Professional development must be provided to support the understanding and the purpose of formative assessments. There is a potential opportunity for all teachers to learn and grow just as the teachers who made substantial student proficiency level growth as substantiated from this ROS study.

There is a need for high quality educators in NC. The use of formative assessment can help develop high quality educators. Hamre and Pianta (2005) found a high-quality educator closes achievement gaps in students; an average teacher continues them. These researchers also found in the classrooms of the most effective teachers, students from underprivileged backgrounds learn at the same rate as those from privileged backgrounds. According to Wiliam (2009), when students are taught by the most effective teachers, the rate of learning almost doubles. NC must continue to develop and support high-quality teachers and one way to do this is through helping these educators truly understand how to use formative assessments.

Lessons Learned

All of the teachers I interviewed were very passionate about teaching, and they were not the least bit shy about sharing their true thoughts and opinions. I was surprised they were all so receptive to using the quarterly formative assessments because they were mandated by the state of NC for the POC Study. They were eager to talk about their experiences and appreciated the opportunity to provide input into the formative assessment process. Participant feedback is invaluable as we move forward in this process to make it stronger and more effective. The opportunity to learn how teachers used the feedback data from their quarterly assessments to guide classroom instruction was immeasurably valuable. I also realized that the teachers whose students made substantial proficiency level growth had a solid understanding of the purpose of formative assessments and how to use the data provided to guide classroom instruction to improve student mathematics learning. Many of these teachers believe formative assessment can truly have a huge positive impact on students' mathematics learning. When teachers understand how to use the data from the assessments formatively, the impact on student achievement will continue to grow allowing for positive change across the whole state.

Recommendations

I strongly recommend based on the results gathered from this ROS that teachers need to receive formative assessment professional development to build a solid understanding of the purpose of formative assessments and how to use data to guide classroom instruction to improve student mathematics learning. The teachers in this study whose students made substantial increases in proficiency levels possessed a deep understanding for the formative assessments process. Teachers need to own this deep understanding; they also need to become more aware of the impact of their beliefs on their pedagogical practices and begin to reflect on those closely. I believe this played a role in their willingness and openness to change their teaching strategies and pedagogies. The teachers in schools whose students decreased in proficiency levels seem to be over-confident making statements such as, “I know what I am doing, I don’t really need these formative assessments except for test taking strategies.” These mathematics teachers did not demonstrate an understanding of the power or the potential that formative assessments can have in increasing student mathematics achievement. So, is it teachers’ beliefs or the lack of understanding about formative assessment that prevents teachers from changing their instruction which often leads to improvement in student scores and understanding? I recommend both issues be further evaluated.

I recommend administrators and central office staff be actively engaged in the formative assessment professional development process for their teachers. Teachers must recognize the dedication of their educational leaders if they are to buy in and value this process. Administrators and district staff support is crucial to the success of formative assessment implementation; in addition, they will need to be patient as fundamental shifts in teaching practices take place. Administrators and central office staff must commit to being a partner in learning and in providing high quality formative assessment professional development.

I recommend the state of North Carolina Department of Public Instruction continue to provide the state-created quarterly formative assessments as an option for districts aiding with access and equity. They must provide support for districts by delivering quality resources such as formative assessment research, clarifying for educators the relationship between instruction and assessment. NC DPI must be active partners in this process.

Closing Thoughts

As the “optional” state-created quarterly formative assessment move to other grade levels this year, it is imperative teachers understand what formative assessment is and how to use it effectively in the classroom. If the assessments are implemented, the focus for that school should be on that implementation only with professional development which the research in this ROS supported. Superintendents, district leaders, and/or principals will choose if the “free” assessments will be used in their schools. However, with millions of dollars cut from the state’s education budget, minimal support will be provided for teachers starting this formative assessment process. Hopefully, this will not be just another example of how something which could potentially be a game changer in student learning will probably bring about more frustration for teachers who are already overwhelmed with the daily expectations of teaching.

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APPENDIX A

SEMI-STRUCTURED INTERVIEW QUESTIONS

1. When told you were to participate in the study, how did you feel about giving the quarterly formative assessments?

2. Did you use math formative quarterly assessments prior to the POC Study? If yes, explain, how they were used, created by district, school, or teacher?

3. What was the most challenging thing about giving the assessments?

4. Did you feel the assessments were aligned to the mathematics standards? Did you feel it helped your students prepare for the EOG?

5. Where you surprised by the result of the assessment? Did you think it would impact student performance?

6. How did you use the results from the assessments?

7. Did it change (impact) your instruction, if so how? What was your biggest change in instruction once you received the results of the assessment?

8. What did you like best about the reported results?
   - Content standards assessed by each item
   - Depth of knowledge for each item
   - Class percent correct by item
   - School percent correct by each item
   - Correct answer
   - Student response
   - Class mean
   - School mean
   - Did not find the information useful
   - Did not receive class item report

9. Would you like to use the assessments again this year? Why or Why not?

10. If you were to use the assessments again this year would you use them differently?

11. What type of support would you like from the State's Curriculum and Instruction Mathematics Consultant (me) to support you with the use of the formative assessments?

Additional comments or feedback…

APPENDIX B

Public Schools of North Carolina

What was learned from teachers participating in the Proof of Concept Study

Kitty Rutherford
NC State Board of Education

Through research we know to increase student mathematics achievement we need:

- rigorous standards;
- standards-aligned assessments; and
- talented educators that
  - maintain and communicate high expectations for students,
  - understand the content standards,
  - use pedagogy that develops conceptual, understanding of mathematics, and
  - use data to inform instruction

Public Schools of North Carolina

State Created Quarterly Assessments

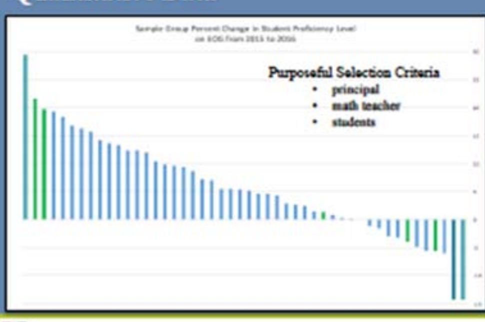
- Aligned to the state's rigorous mathematics standards
- Includes high cognitive demanding items
- Provides prompt and useful feedback
- Uses the same format as the End-of Grade assessment

Public Schools of North Carolina

- Did student proficiency levels increase in schools that participated in the NCDPI Proof of Concept (POC) Study?
- How are teachers using state created formative assessments to guide classroom instruction to improve student proficiency scores?

Public Schools of North Carolina

Quantitative Data

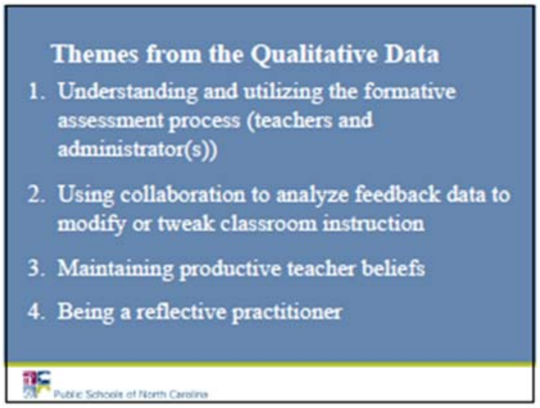


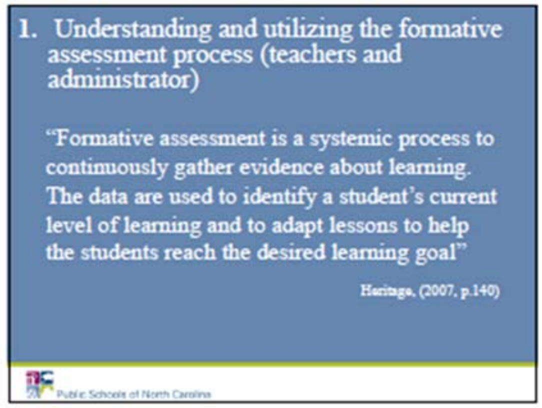
Public Schools of North Carolina

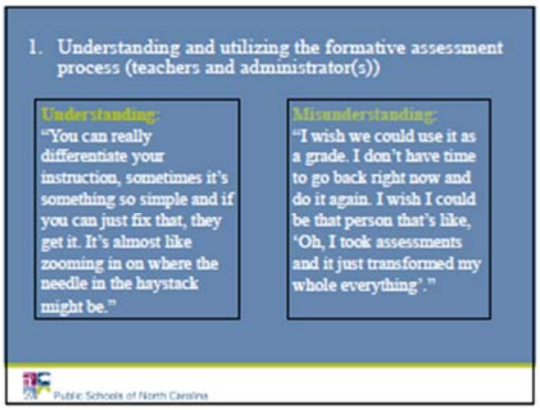
Schools Selected

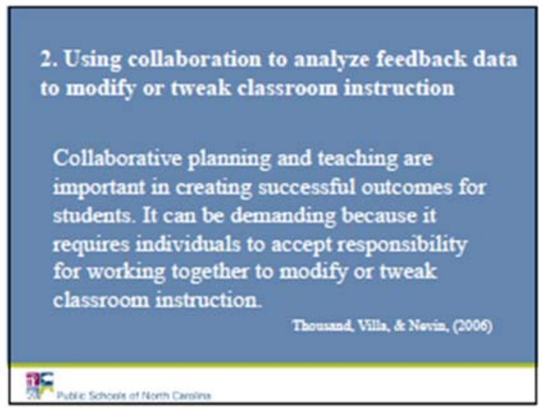
School	2014-2015 Percent of 3-5 students Grade Level Proficient (GLP)	2015-2016 Percent of 3-5 students Grade Level Proficient (GLP)	Percent Change in 5th Grade Student Proficiency Levels on EOG from 2015-2016
School 1 Grades 3-5	50	71.5	21.5
School 2 Grades K-5	48.5	71.2	19.7
School 3 Grades K-5	81	82.3	1.3
School 4 Grades K-8	73.1	73.1	0
School 5 Grades K-5	67.9	63.9	-4
School 6 Grades 3-5	76.5	70.8	-5.7

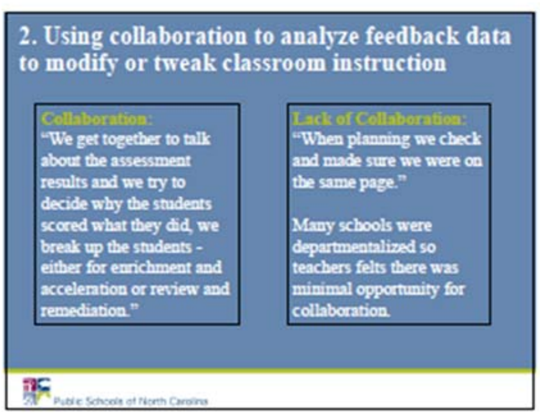
Public Schools of North Carolina

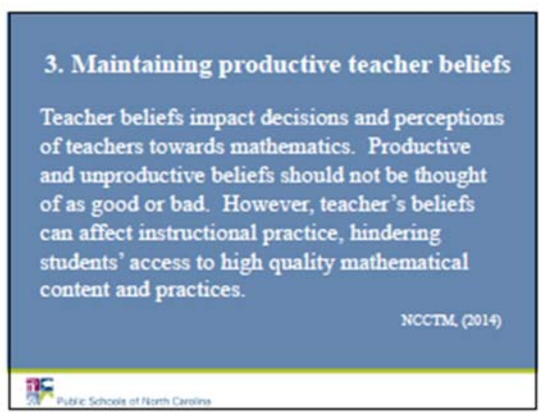

Themes from the Qualitative Data
1. Understanding and utilizing the formative assessment process (teachers and administrator(s))
2. Using collaboration to analyze feedback data to modify or tweak classroom instruction
3. Maintaining productive teacher beliefs
4. Being a reflective practitioner
Public Schools of North Carolina

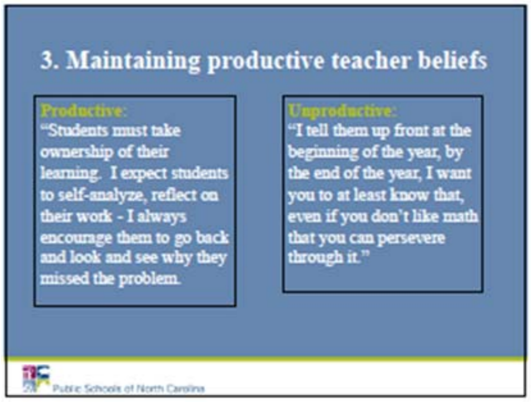

1. Understanding and utilizing the formative assessment process (teachers and administrator)
"Formative assessment is a systemic process to continuously gather evidence about learning. The data are used to identify a student's current level of learning and to adapt lessons to help the students reach the desired learning goal"
Haritage, (2007, p.140)
Public Schools of North Carolina

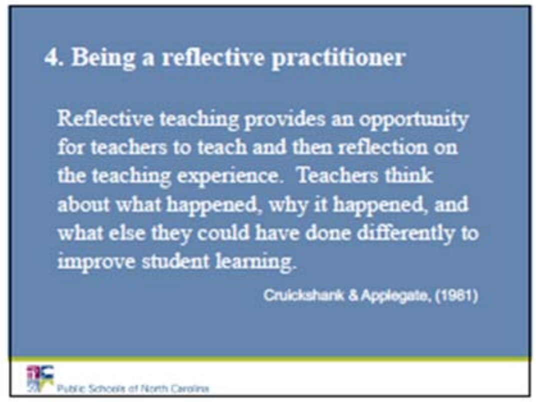

1. Understanding and utilizing the formative assessment process (teachers and administrator(s))
Understanding:
"You can really differentiate your instruction, sometimes it's something so simple and if you can just fix that, they get it. It's almost like zooming in on where the needle in the haystack might be."
Misunderstanding:
"I wish we could use it as a grade. I don't have time to go back right now and do it again. I wish I could be that person that's like, 'Oh, I took assessments and it just transformed my whole everything'."
Public Schools of North Carolina

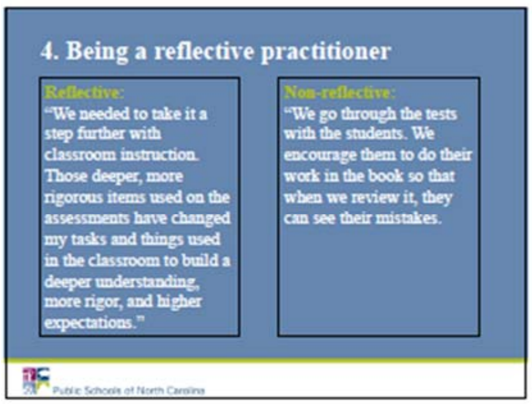

2. Using collaboration to analyze feedback data to modify or tweak classroom instruction
Collaborative planning and teaching are important in creating successful outcomes for students. It can be demanding because it requires individuals to accept responsibility for working together to modify or tweak classroom instruction.
Thousand, Villa, & Nevin, (2006)
Public Schools of North Carolina

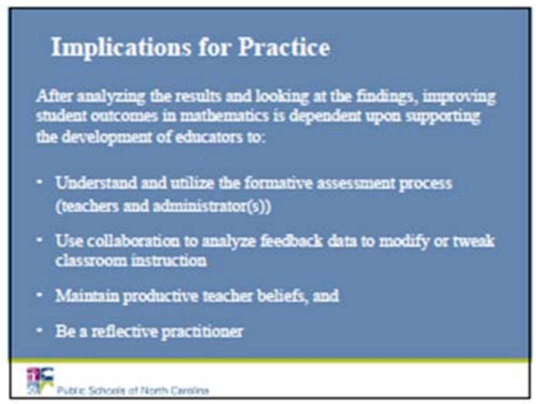

2. Using collaboration to analyze feedback data to modify or tweak classroom instruction
Collaboration:
"We get together to talk about the assessment results and we try to decide why the students scored what they did, we break up the students - either for enrichment and acceleration or review and remediation."
Lack of Collaboration:
"When planning we check and made sure we were on the same page."
Many schools were departmentalized so teachers felts there was minimal opportunity for collaboration.
Public Schools of North Carolina


3. Maintaining productive teacher beliefs
Teacher beliefs impact decisions and perceptions of teachers towards mathematics. Productive and unproductive beliefs should not be thought of as good or bad. However, teacher's beliefs can affect instructional practice, hindering students' access to high quality mathematical content and practices.
NCCTM, (2014)
Public Schools of North Carolina


3. Maintaining productive teacher beliefs
Productive:
"Students must take ownership of their learning. I expect students to self-analyze, reflect on their work - I always encourage them to go back and look and see why they missed the problem.
Unproductive:
"I tell them up front at the beginning of the year, by the end of the year, I want you to at least know that, even if you don't like math that you can persevere through it."
Public Schools of North Carolina


4. Being a reflective practitioner
Reflective teaching provides an opportunity for teachers to teach and then reflection on the teaching experience. Teachers think about what happened, why it happened, and what else they could have done differently to improve student learning.
Cruickshank & Applegate, (1981)
Public Schools of North Carolina


4. Being a reflective practitioner
Reflective:
"We needed to take it a step further with classroom instruction. Those deeper, more rigorous items used on the assessments have changed my tasks and things used in the classroom to build a deeper understanding, more rigor, and higher expectations."
Non-reflective:
"We go through the tests with the students. We encourage them to do their work in the book so that when we review it, they can see their mistakes.
Public Schools of North Carolina


Implications for Practice
After analyzing the results and looking at the findings, improving student outcomes in mathematics is dependent upon supporting the development of educators to:
• Understand and utilize the formative assessment process (teachers and administrator(s))
• Use collaboration to analyze feedback data to modify or tweak classroom instruction
• Maintain productive teacher beliefs, and
• Be a reflective practitioner
Public Schools of North Carolina


What Questions do you have?
Public Schools of North Carolina

APPENDIX C

My desire is for NC educators to reference The Next Step document to further develop their understanding of how mathematics standards can demonstrate the progress of student learning. The Next Step document was created with the use of various learning progressions. Learning progressions are an active process of building and modifying ideas and concepts. These progressions demonstrate a possible path or set of paths from prior knowledge that students hold to more sophisticated reasoning; progressions can illustrate the "likelihood," not regimented steps or psychological stages and can include predictable landmarks and obstacles (Clements & Sarama, 2007; Duncan & Hmelo-Silver, 2009; Duschl, Maeng, & Sezen, 2011). Mathematics standards are not isolated concepts; these progressions can help make connections between standards which, in turn, can assist in building students' understanding by linking concepts within and across grade levels. These learning progressions also can help one to identify gaps in a student's knowledge by tracing a standard back through its logical pre-requisites (Sztajn, Confrey, Wilson, & Edgington, 2012). I have been working with a district to pilot The Next Steps materials which can be used after the quarterly formative assessments in helping teachers realize the progressions of student learning.

Next Steps for NC Check-In

Next Steps…

After giving an assessment now what? Assessments are designed to assess student proficiency on selected standards from the North Carolina Standard Course of Study for Mathematics during the school year. An assessment is like a snapshot- it provides a picture of a student's performance at one point in time. This snapshot is combined with other "pictures" to create a comprehensive photo album of a student's mathematics performance (Joyner, 2012). Therefore, an assessment is designed to provide evidence of students' independent work and should be included with other information gathered about the student.

An assessment is **not** intended to provide a complete picture of a student's mathematics understandings. When determining overall student proficiency levels, an assessment should be combined with additional documentation such as student products, formative assessment tasks, checklists, notes, and other anecdotal information.

In addition, the teacher needs to look beyond whether an item's answer is correct or incorrect by looking carefully at the types of mistakes that were made. The teacher needs to pay particular attention to what the student *does* and *does not* understand. Both are equally important in determining the **next instructional steps**. Some mistakes that children make come from a lack of information. At other times mistakes reflect a lack of understanding. There is logic behind students' answers. The teacher must look for the reasons for the responses and identify any misconceptions that may exist.

This document provides "**Next Step"** for students taking the **NC Check-Ins** with a focus on the "Major Work of the Grade" mathematics standards. These standards are provided because curriculum, instruction, and assessment at this grade must reflect the focus and emphasis of the grade. Not all of the content in this grade is emphasized equally. The content standards for the grade is not a flat, one-dimensional checklist. There can be strong differences of emphasis even within a single domain. Some clusters require greater emphasis than others based on the depth of the ideas, the time they take to master, and/or their importance to future mathematics, or the demands of college and career readiness. An intense focus on the most critical material at this grade allows depth in learning, which is carried out through the Standards for Mathematical Practice. Saying that some things have greater emphasis is not to say that anything in the standards can safely be neglected in instruction. Neglecting material will leave gaps in student skill and understanding and may leave students unprepared for the challenges of a later grade.

Major Work of Fifth Grade	
Major Clusters	**Supporting/Additional Clusters**
Number and Operations in Base Ten Understand the place value system. Perform operations with multi-digit whole numbers and with decimals to hundredths. **Number and Operations—Fractions** Use equivalent fractions as a strategy to add and subtract fractions. Apply and extend previous understandings of multiplication and division to multiply and divide fractions.	**Operations and Algebraic Thinking** Write and interpret numerical expressions. Analyze patterns and relationships. **Measurement and Data** Convert like measurement units within a given measurement system. Represent and interpret data. **Geometry**

Measurement and Data Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.	Graph points on the coordinate plane to solve real-world and mathematical problems. Classify two-dimensional figures into categories based on their properties.

The intended purpose of the **Next Steps** document is to provide instructional support materials for teachers which may be used with a student to help them move toward mastery of the mathematical concept. It is not intended to be an exhaustive list of materials. Teachers are the most knowledgeable about the needs of their students and should use their professional judgment when making instructional decisions. Using NC Check-Ins as formative assessments to guide instruction, empowers teachers to understand what students know, which assists them in determining the best instructional **next steps** to guide student understanding. When thinking about the expectations of the standards, please reference the unpacking document: Unpacking for 5th Grade .

This document was created with the use of various learning progressions. Our wish is for educators to reference these resources to assist them in future understandings of how mathematics standards progress in learning. Learning progressions are an active process of building and modifying ideas. It demonstrates a possible path or set of paths from prior knowledge to more sophisticated reasoning; it can state the "likelihood," not regimented steps or psychological stages and can include predictable landmarks and obstacles. Mathematics standards are not isolated concepts; these progressions can help make connections between standards which in turn can assist in building students' understanding by linking concepts within and across grade levels. These learning progressions can also help one to identify gaps in a student's knowledge by tracing a standard back through its logical pre-requisites.

Please visit these Progression Resources
Standards Mapper - UCLA Curtis Center
Achieve the Core – Coherence Map
Learning Trajectories – NCSU
Progressions - CCSS Writing Team

A Proficiency Rubric below can be used to determine if a student is or if the student is **Not Yet** there, **Progressing** toward the standard, or **Meets the Standard**.

- Students that are "**Not Yet"** meeting standards are those that show minimal understanding of the standard assessed. Conceptual understanding still needs to be developed.
- Students in the "**Progressing"** toward the standard category are those that demonstrate an inconsistent understanding of the standards. They may be able to accurately complete the majority of a task, but not the task in its entirety.

- A student that "**Meets Standard"** is one that shows proficiency and full understanding of the concept assessed. These students demonstrate conceptual understanding and flexibility in problem-solving.

Mathematics Proficiency Levels

This rubric may be used to guide teachers in identifying proficiency level.

SELDOM	**Not Yet** Limited Performance and Understanding Exhibits minimal understanding of key mathematical ideas at grade level Rarely demonstrates conceptual understanding Seldom provides precise responses Seldom uses appropriate strategies Consistently requires assistance and alternative instruction Uses tools inappropriately to model mathematics
INCONSISTENT	**Progressing** **Not Yet Proficient in Performance and Understanding** Inconsistently uses tools appropriately and strategically Demonstrates inconsistent understanding of key mathematical ideas at grade level Demonstrates inconsistent conceptual understanding of key mathematical ideas at grade level Inconsistent in understanding and application of grade level appropriate strategies Depends upon the assistance of teacher and/or peers to understand and complete tasks Needs additional time to complete tasks Applies models of mathematical ideas inconsistently
CONSISTENT	**Meets Standard(s)** **Proficient in Performance and Understanding** Consistently demonstrate understanding of mathematical standards and cluster at the grade level Consistently demonstrates conceptual understanding Consistently applies multiple strategies flexibly in various situations Understands and fluently applies procedures with understanding Consistently demonstrates perseverance and precision Constructs logical mathematical arguments for thinking and reasoning Uses mathematical language correctly and appropriately
BEYOND	**Beyond Standard(s)** **Advanced in Performance and Understanding** Consistently demonstrates advanced conceptual mathematical understandings Consistently generates tasks that make connections between and among mathematical ideas Consistently applies strategies to ***unique*** situations Consistently demonstrates confidence to approach tasks ***beyond*** the proficiency level for grade Consistently initiates mathematical investigations

Number and Operations in Base Ten

Understand the place value system.
5.NBT.1 Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.
5.NBT.2 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.

Not Yet

(possible gaps in learning)

Standard	Instructional Support
Generalize place value understanding for multi-digit whole numbers. **4.NBT.1** Recognize that in a multi-digit whole number, a digit in one place represents ten times what it represents in the place to its right. *For example, recognize that 700 ÷ 70 = 10 by applying concepts of place value and division.*	**4th Grade Tasks:** Coin Collection Adding Zeros Packaging Soup Cans Value of the Bills **4th Grade Lessons for Learning:** Building 10,000… page 5 **4th Grade Games:** Place Value Pirates… page 86
Understand decimal notation for fractions, and compare decimal fractions. **4.NF.6** Use decimal notation for fractions with denominators 10 or 100.	**4th Grade Tasks:** Where am I now? How much farther? Is the Tire Full Yet? **4th Grade Lessons for Learning:** Show What You Know: Multiple Representations of Decimals and Fractions…page 59
Understand decimal notation for fractions, and compare decimal fractions. **4.NF.7** Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g., by using a visual model.	**4th Grade Tasks:** Who Jumped Farther? Making Punch **4th Grade Lessons for Learning:** Running the Race… page 64

	4th Grade Games: Deci-Mill Dunk… page 63 Deci-Moves… page 64 Corn Shucks… page 65

Progressing

(additional practice with standard needed)

Standard	Instructional Support
Understand the place value system. **5.NBT.1** Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and $^{1}/_{10}$ of what it represents in the place to its left.	**5th Grade Tasks:** Value of a Digit Danny & Delilah Value of a Digit Comparing Digits
Understand the place value system. **5.NBT.2** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.	**5th Grade Tasks:** Veronica's Statement Distance from the Sun **5th Grade Lessons for Learning:** Building Powers of Ten… page 5 Value of Bills… page 9 Mass of Supplies…pages 13 Between the Stars…page 17

Mastered

(possible enrichment or extensions)

Academically and/or Intellectually Gifted Instructional Resource Project

5.NBT.1 Grayville: Exploring an Alternative Number System

Number and Operations in Base Ten

Perform operations with multi-digit whole numbers and with decimals to hundredths.
5.NBT.5 Fluently multiply multi-digit whole numbers using the standard algorithm.

Not Yet

(possible gaps in learning)

Standard	Instructional Support
Use place value understanding and properties of operations to perform multi-digit arithmetic. **4.NBT.5** Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.	**4th Grade Tasks:** Multiplication Strategies Who Has a Bigger Garden? College Basketball Attendance **4th Grade Lessons for Learning:** Multiply Using the Distributive Property… page 12 Strategies for Multiplying Multi-digit Numbers…page 23
Generalize place value understanding for multi-digit whole numbers. **4.NBT.2** Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two multi-digit numbers based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.	**4th Grade Tasks:** Arranging Students Juice Pouches **4th Grade Lessons for Learning:** Build A Number… page 8 Roll and Compare… page 17 **4th Grade Games:** Digit Ski… page 16 Appalachian Steps… page 18
Use place value understanding and properties of operations to perform multi-digit arithmetic. **4.NBT.4** 4. Fluently add and subtract multi-digit whole numbers using the standard algorithm.	**4th Grade Tasks:** Filling the Auditorium How Much Liquid? **4th Grade Games:** Climbing Chimney Rock… page 23 Valuable Digit!!… page 24
Use the four operations with whole numbers to solve problems. **4.OA.3** Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent	**4th Grade Tasks:** Remainders How Many Teams? Making Gift Bags Enlarging the Yard How Many Cookies Do We Have? **4th Grade Lessons for Learning:** Multi-Step Multiplication… page 1

these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.	
Progressing (additional practice with standard needed)	
Standard	**Instructional Support**
Understand the place value system. **5.NBT.1** Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.	**5th Grade Tasks:** Value of a Digit Danny & Delilah Value of a Digit Comparing Digits
Perform operations with multi-digit whole numbers and with decimals to hundredths. **5.NBT.5** Fluently multiply multi-digit whole numbers using the standard algorithm.	**5th Grade Tasks:** Number of Pages? Field Trip Funds **5th Grade Lessons for Learning:** Multiplying Multi-Digit Whole Numbers Using the Standard Algorithm #1: Background… page 42 Multiplying Multi-Digit Whole Numbers Using the Standard Algorithm #2: Background–Decomposing Numbers…page 46 Multiplying Multi-Digit Whole Numbers Using the Standard Algorithm #3: Developing the Standard Algorithm…page 49 Multiplying Multi-Digit Whole Numbers Using the Standard Algorithm #4: Estimation…page 57 **5th Grade Games:** Multiplication Mix-up…page 21 Double Dutch Treat… page 23
Mastered (possible enrichment or extensions)	
Academically and/or Intellectually Gifted Instructional Resource Project 5.NBT.5 The Multiplication Trick	

Number and Operations -Fractions

Apply and extend previous understandings of multiplication and division to multiply and divide fractions.
5.NF.3 Interpret a fraction as division of the numerator by the denominator ($a/b = a \div b$). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem. *For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among 4 people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two whole numbers does your answer lie?*

Not Yet
(possible gaps in learning)

Standard	Instructional Support
Represent and solve problems involving multiplication and division. **3.OA.1** Interpret products of whole numbers, e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each. *For example, describe a context in which a total number of objects can be expressed as 5 × 7.*	**3rd Grade Tasks:** Zeke's Dog Football Game Road Trip Ants! **3rd Grade Lessons for Learning:** Playing Circles and Stars… page 1 **3rd Grade Games:** Double Up!...page 3 Tic-Tac-Toe Array…page 4 Snakes Alive, Go for Fives?...page 7 Raging Rectangles…page 8 Multiple Madness…page 9 Multiple Madness II…page 10 No Leftovers Wanted?...page 11 Whose Winning Products?...page 12
Understand properties of multiplication and the relationship between multiplication and division. **3.OA.6** Understand division as an unknown-factor problem. *For example, find 32 ÷ 8 by finding the number that makes 32 when multiplied by 8.*	**3rd Grade Tasks:** Sharing Pencils Fair Tickets **3rd Grade Lessons for Learning:** Counting Around the Class…page 16 **3rd Grade Games:** Find the Unknown Number...page 24
Use the four operations with whole numbers to solve problems. **4.OA.2** Multiply or divide to solve word problems involving multiplicative comparison, e.g., by using	**4th Grade Tasks:** Selling Candy Clothing Prices Fund Raiser

drawings and equations with a symbol for the unknown number to represent the problem, distinguishing multiplicative comparison from additive comparison.[1]	Buying Music **4th Grade Games:** Best Math Friends Game… page86
Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit. **4.MD.2** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.	**4th Grade Tasks:** **Mass:** Weighing the Books **Time:** Getting Ready for School **Length:** Getting Ready for School **Length:** Adding Up and Comparing Our Jumps II

Progressing

(additional practice with standard needed)

Standard	Instructional Support
Apply and extend previous understandings of multiplication and division to multiply and divide fractions. **5.NF.3** Interpret a fraction as division of the numerator by the denominator ($a/b = a \div b$). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers, e.g., by using visual fraction models or equations to represent the problem. *For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among 4 people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two numbers does your answer lie?*	**5th Grade Tasks:** Knot-Tying Project Donation Boxes Candy Conundrum **5th Grade Fraction Unit:** Lesson 1: Servings at the Fifth Grade Ice Cream Party… page 6 Lesson 2: Collecting Recyclables…page 14-20 Lesson 3: Servings at the Fifth Grade Ice Cream Party…page 26 **5th Grade Games:** Corn Chucks…page 5

Mastered (possible enrichment or extensions)
Academically and/or Intellectually Gifted Instructional Resource Project 5.NF.3 & 5.NF.4 The Lemonade Business

Measurement & Data

Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition.

5.MD.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement.

A cube with side length 1 unit, called a "unit cube," is said to have "one cubic unit" of volume, and can be used to measure volume.

A solid figure which can be packed without gaps or overlaps using *n* unit cubes is said to have a volume of *n* cubic units.

5.MD.4 Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.

5.MD.5 Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.

Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication. **(not assessed)**

Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real world and mathematical problems.

Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real world problems.

Not Yet

(possible gaps in learning)

Standard	Instructional Support
Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects. **3.MD.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. (Excludes compound units such as cm^3 and finding the geometric volume of a container.)	**3rd Grade Tasks:** Weighing Fruit Measuring Water **3rd Grade Lessons for Learning:** Exploring Measurement for Mass of Objects and Liquid Volume…page 131 **3rd Grade Games:** Metric Measure Up...page 73
Geometric measurement: understand concepts of area and relate area to multiplication and to addition. **3.MD.5** Recognize area as an attribute of plane figures and understand concepts of area measurement. A square with side length 1 unit, called "a unit square," is said to have "one square unit" of area, and can be used to measure area. A plane figure which can be covered without gaps or overlaps by *n* unit squares is said to have an area of *n* square units.	**3rd Grade Tasks:** Antonio's Garden Maggie's Jewelry Box **3rd Grade Area & Perimeter Unit:** Lesson 1: Ordering Rectangles…page 7 Lesson 2: Rectangle Comparison…page 11 Lesson 3: Tiling a Tabletop…page 15 Lesson 4: Geoboard Areas…page 18 Lesson 5: Rectangle Comparison II…page 20
Understand properties of multiplication and the relationship between multiplication and division. **3.OA.5** Apply properties of operations as strategies to multiply and divide.[2] *Examples: If 6 × 4 = 24 is known, then 4 × 6 = 24 is also known. (Commutative property of multiplication.) 3 × 5 × 2 can be found by 3 × 5 = 15, then 15 × 2 = 30, or by 5 × 2 = 10, then 3 × 10 = 30. (Associative property of multiplication.) Knowing that 8 × 5 = 40 and 8 × 2 = 16, one can find 8 × 7 as 8 × (5 + 2) = (8 × 5) + (8 × 2) = 40 + 16 = 56. (Distributive property.)*	**3rd Grade Tasks:** Patterns on the Multiplication Chart Prove it! **3rd Grade Games:** Math Basketball…page 83

Geometric measurement: understand concepts of area and relate area to multiplication and to addition. **3.MD.7** Relate area to the operations of multiplication and addition. Find the area of a rectangle with whole-number side lengths by tiling it, and show that the area is the same as would be found by multiplying the side lengths. Multiply side lengths to find areas of rectangles with whole-number side lengths in the context of solving real world and mathematical problems, and represent whole-number products as rectangular areas in mathematical reasoning. Use tiling to show in a concrete case that the area of a rectangle with whole-number side lengths *a* and *b* + *c* is the sum of $a \times b$ and $a \times c$. Use area models to represent the distributive property in mathematical reasoning. Recognize area as additive. Find areas of rectilinear figures by decomposing them into non-overlapping rectangles and adding the areas of the non-overlapping parts, applying this technique to solve real world problems.	**3rd Grade Tasks:** All Areas Micah and Nina's Rectangle **3rd Grade Area & Perimeter Unit:** Lesson 4: Geoboard Areas…page 18 Lesson 6: Mowing for Money…page 25 Lesson 7: Sticker Stumper…page 29 Lesson 9: Estimate and Solve Customary Units…page 34 Lesson 10: Estimate and Solve Metric Units…page 38 Lesson 11: Breaking Apart Arrays I…p. 42 Lesson 12: Breaking Apart Arrays II...p. 45 Lesson 13: Finding the Areas of Complex Figures I…page 49 Lesson 14: Finding the Areas of Complex Figures II…page 53 Lesson 15: Finding the Area of Complex Figures III…page 58 **3rd Grade Games:** Raging Rectangles… page 8 Cut a Rug… page 77
Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit. **4.MD.3** Apply the area and perimeter formulas for rectangles in real world and mathematical problems.	**4th Grade Tasks:** Area & Perimeter Exploration Putting Down Carpet Fencing Yards Making a Dog Pen **4th Grade Lessons for Learning:** Build a Pen for Your Dog...page 70 **4th Grade Games:** I Get Around…page 74 Raging Rectangles…page 77

Progressing (additional practice with standard needed)	
Standard	**Instructional Support**
Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition. **5.MD.3** Recognize volume as an attribute of solid figures and understand concepts of volume measurement. A cube with side length 1 unit, called a "unit cube" is said to have "one unit cube" of volume, and can be used to measure volume. A solid figure which can be packed without gaps or overlaps using *n* unit cubes is said to have a volume of *n* cubic units.	**5th Grade Tasks:** Carter's Candy Company Jeremy's Wall **5th Grade Lessons for Learning:** Filling Boxes… page 81 **5th Grade Games:** Volume Shape Fame…page 54
Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition. **5.MD.4** Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.	**5th Grade Tasks:** Measure a Box Build a Box **5th Grade Lessons for Learning:** Candy Box…page 84 **5th Grade Games:** Mine Craft Volume…page 54
Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition. **5.MD.5** Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume. **a.** Find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Represent threefold whole-number products as volumes, e.g., to represent the associative property of multiplication. **b.** Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real world and mathematical problems. **c.** Recognize volume as additive. Find volumes of	**5th Grade Tasks:** Partner Prisms Volume Argument Transferring Teachers Taller Than PNC Plaza Draw Your Own Figure Sears Tower **5th Grade Lessons for Learning:** Exploring Volume as Additive…page 87 Finding Volume Using a Formula page…91 Representing and Finding Volume…page 98 Volume as Additive… page 104 **5th Grade Games:** Packing Blocks…page 50 Mine Craft Volume…page 54

solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real world problems.	
Mastered (possible enrichment or extensions)	
Academically and/or Intellectually Gifted Instructional Resource Project **5.MD.1, 5.MD.3, & 5.MD.5 The Basketball Court Lesson**	

Questions regarding this curriculum support document, please contact Kitty Rutherford.

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