2018

Assessment for Feedback and Achievement Growth for Middle School Math Students

Katie Jo Pemberton
Walden University

Walden University

College of Education

This is to certify that the doctoral study by

Katie Pemberton

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Jesse Richter, Committee Chairperson, Education Faculty
Dr. Amy White, Committee Member, Education Faculty
Dr. Jennifer Keeley, University Reviewer, Education Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2018

Abstract

Assessment for Feedback and Achievement Growth for Middle School Math Students

by

Katie Jo Pemberton

MA, University of Idaho, 2011

BAE, Eastern Washington University, 2005

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

October 2018

Abstract

Inconsistent math assessment practices do not accurately represent and communicate student mathematics achievement. Because of inconsistencies in assessment practices, local middle school mathematics teachers in an urban school district in the northwestern United States piloted the use of multiple formative assessments. The purpose of this study was to compare mathematics achievement, growth, and course percentage grades for students who have multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. Theoretical foundations originated from Black and Wiliam, supporting the use of formative assessment for a positive impact on student learning. A quantitative, ex post facto quasi-experimental design was used. The research question focused on the statistical differences in course percentage grade, state standardized testing score, and growth score on state standardized math tests between groups of students who were allowed multiple formative assessment options and those who were not. Data were analyzed using an independent samples *t* test and a one-way MANOVA, which showed a statistically significant difference for student course percentage grade. Findings were used to produce a 3-day professional development program supporting teachers' use of formative assessment in mathematics classes. The findings will inform educational stakeholders' decisions regarding the use of multiple assessment attempts and differences between this specific formative assessment strategy and student mathematics assessment performance to promote positive social change. Positive social changes may include increased awareness of how multiple assessments may affect student growth, course percentage grades, and state testing scores.

Assessment for Feedback and Achievement Growth for Middle School Math Students

by

Katie Jo Pemberton

MA, University of Idaho, 2011

BAE, Eastern Washington University, 2005

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

October 2018

Dedication

This work is dedicated to my husband and daughter because of the unwavering support and encouragement they have given me throughout this doctoral experience. Additionally, I dedicate this work to my family, students, and colleagues who have inspired my teaching and shared this educational journey with me.

Acknowledgments

There are many people who have shared this educational journey with me and that I would like to thank. My committee chair, Dr. Jesse Richter, was always helpful in providing feedback and encouragement, and made the final stages of my doctoral goals possible. Thank you to Dr. Amy White, my second committee member, for providing advice and direction to improve my proposal and working with me to develop a solid methodology. I am grateful to Dr. Jennifer Keeley, my University Research Reviewer, for provided guidance and specific direction for improvement. My professors at Walden University taught me to find my own scholarly voice through research and writing. Thank you to my parents, Mark and Karen Copeland, who taught me the value and importance of hard work and perseverance. To my daughter, Ellie Pemberton, you challenge and inspire me to be the best version of myself. Most importantly, I would like to thank my husband, Eric Pemberton, your love and encouragement motivated me every day.

Table of Contents

List of Tables

Section 1: The Problem

Introduction

The educational community recognizes formative assessment as an integral part of the learning process, yet how to bridge the gap between the theory behind the benefits of formative assessment and actual implementation into classroom instruction is an area of need. Recent assessment changes and the adoption of Common Core State Standards have increased awareness of assessment practices and the need for quality and effective formative assessment. In response to these assessment changes and pressures that teachers and local administration are under, the middle school math department in the district began piloting the use of multiple assessment attempts as a formative assessment practice.

A school district located in the northwest region of the United States is one of the larger districts in the state (District Profile, 2016). The mathematics department wrote new curriculum during the 2014 school year and adopted new K-12 mathematics materials during the 2015 school year. Additionally, the middle school sixth- to eighth-grade math department wrote common summative assessments for each unit of study. However, supporting students and how to most effectively use formative assessment practices to support student growth and learning is an area needing further attention according to the instructional coach for the district (personal communication, March 24, 2016). Piloting the use of multiple assessment attempts was the local teachers' response to needed formative assessment information. Multiple assessments consist of different versions of the assessment in which students may retake an assessment to improve their overall understanding of the material tested and the grade percentage associated with that assessment. This study inspects the use of these multiple assessment attempts as a mathematics formative assessment strategy in response to the local problem of inconsistent assessment practices.

The Local Problem

There is a problem in an urban Northwest school district with assessment practices in math not accurately representing and communicating students' mathematics achievement and aligning to their performance on the state test. This problem has affected students of this urban district because students' math assessment and overall course percentage may not be an accurate representation of their understanding of mathematics (instructional coach, personal communication, March 24, 2016). Despite recent curriculum rewrites and alignment efforts with Common Core State Standards, considerable variation in assessment practices still exist at the local level. For example, as identified through district math department meetings, during the 2014-2015 school year some teachers in the district chose to use weighted categories, with homework as 50% of a student's grade and test scores as 50%. Other teachers in the district gave homework 20% of the grade and tests 80% of the grade. Additionally, multiple in-class assessment attempts with formative assessments were not used in middle school math courses during the 2014-2015 school year as they were in the 2015-2016 school year. For example, prior to the 2015-2016 school year, students were not allowed reassessment opportunities and provided with feedback to improve their performance. Teachers created their own classroom assessment policies and procedures for assessing student knowledge and individually decided how to communicate that understanding through course percentage grades. Additionally, common assessments were not used prior to the 2015-2016 school year. Each teacher created their own assessments with fluctuating degrees of difficulty and alignment to learning objectives and standards. The overall lack of consistency in how students' mathematical knowledge is assessed creates problems in accurately determining whether or not students are meeting mathematical standards and are performing at grade level.

The district is exploring formative assessment practices and the use of multiple assessment attempts as a possible solution (instructional coach, personal communication, September 1, 2016). However, disagreement about how to address assessment inconsistencies remains. As supported and encouraged by the local district, middle school math teachers are beginning to investigate and increase their background knowledge of the issue of assessment inconsistency through a collaborative book study of O'Connor (2009) and working with a grading consultant (assessment consultant, personal communication, March 22, 2016). With the goal of improving formative assessments and creating consistent assessment policies, new evaluations focus on alignment with new state standards. Additionally, common unit math assessments are now used at the middle school level. A lack of consistency and agreement of how to implement these common formative assessments makes it unclear if students are meeting standards or not.

Local teachers question whether allowing reassessment options and focusing on feedback through formative assessments will foster significant growth on the state standardized mathematics test (instructional coach, personal communication, March 24, 2016). With assessment practices in question and the local district seeking some form of consistency to communicate proficiency and alignment with the state standardized test, an investigation into assessment practices will provide needed information. District leadership members encourage teachers to try new formative assessment practices; yet no formal research exists at the local level (assessment consultant, personal communication, March 22, 2016).

Beyond the local level, the impact of formative assessment practices is an area of great interest in the education profession (Black, 2015). In a discussion of students' mathematical performance across the United States, Boaler (2016) detailed results from the Program for International Students Assessment (PISA), in which the United States ranked 36th out of 65 countries (Boaler, 2016). The poor performance in mathematics is cause for concern and needed investigation of how to improve students' understanding and mathematical thinking. As students continue to struggle in mathematics, researchers must focus on viable solutions for improving mathematics understanding and performance. Boaler (2016) suggested viewing mistakes as learning opportunities and creating a mathematics culture and classroom that embraces mistakes, such as using formative assessment strategies.

Doubet (2012) described benefits for using formative assessment to differentiate instruction and meet the needs of all learners. However, DeLisle (2015) warned the practice of implementing and embedding formative assessments for learning by creating meaningful connections between formative and summative assessment is difficult to achieve. An investigation of assessment practices and comparing growth in state testing for students enrolled in math courses with new assessment practices compared to those with traditional assessment practices could provide needed insight.

Rationale

The rationale for the examination of assessment practices are the concerns regarding the use of multiple formative assessment attempts to accurately and effectively assess and improve student learning in mathematics. Local teachers continue to question the use of multiple assessments as a means to improve students' learning (instructional coach, personal communication, March 24, 2016). The study is warranted as local leadership and administration are asking teachers to carefully consider how they assess student learning and teachers left wondering if the use of multiple assessments is effective (assessment consultant, personal communication, March 22, 2016). Furthermore, current studies on formative assessment studies add merit to this investigation by recommending an examination of specific formative assessment practices (Black, 2015; Marsh, Farrell, & Bertrand, 2016; Seaton, 2013). Investigating the specific use of multiple assessment attempts as a formative assessment practice is justified based on the identified local need as well as the recommendations from researchers beyond the local level. Comparing growth in state testing, standardized test scores, and course percentage grades for students enrolled in math courses with new assessment practices compared to those with traditional assessment practices may provide needed insight into a specific form of formative assessment for education stakeholders.

The purpose of this study is to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. To remedy inconsistent assessment practices, teachers in this urban district are piloting methods that focus on growth and feedback for student learning through formative assessment practices. Teachers involved in the pilot program are using the first attempt on a test as a formative assessment for feedback with the hope that this feedback for learning and multiple assessment attempts will increase student growth and achievement. This study may provide useful knowledge and address the gap in formative assessment practices through the examination of a specific reassessment strategy (Black, 2015; Marsh, Farrell, & Bertrand, 2016; Seaton, 2013). Therefore, the purpose of this study is to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts.

Definition of Terms

Formative assessment: "Assessment that involved gathering data for improving (Dixon & Worrell, 2016, p.153), or as described by Black and Wiliam (2010), "activities undertaken by teachers—and by their students in assessing themselves—that provide information to be used as feedback to modify teaching and learning activities" (p. 82).

Job-embedded collaboration: Time provided to teachers for regular collaboration during contract hours or during regular school hours.

Multiple assessments: Assessments given during the learning process that can be taken more than once. Students may retake these mathematics assessments after they have worked through the process of correcting mistakes and received formative feedback from their teacher. In the classroom, multiple assessments are given to the whole group with emphasis on peer and teacher feedback through small-group work. The teacher then works with students during class instruction time through a variety of instructional methods. Students will then complete another version of the assessment with emphasis and focus on the improvement from the first attempt to the next and any subsequent attempts that may be needed to demonstrate understanding of the standards tested on a particular assessment (instructional coach, personal communication, March 24, 2016).

State Standardized Achievement Test (SSAT): One of the dependent variables presented in this study are specific to the area of mathematics. The state standardized mathematics test score is referred to as the SSAT score because it is specific to the state test used by the district from the Smarter Balanced Assessment Consortium ("*the district's State Department of Education*", 2016).

SSAT growth score: Measures a student's yearly improvement in the area of mathematics and will serve as the dependent variable as detailed in the methodology section ("*the district's State Department of Education*", 2016).

Second-semester mathematics course percentage: The reported course percentage is used as the final dependent variable as detailed in the methodology section. Individual teachers use the Skyward (2017, Version 05.16.10.00.09) —grading program to report the second-semester mathematics grades (middle school counselor, personal communication, May 19, 2016).

Significance of the Study

Inconsistencies in assessment implementation can cause teachers to question traditional assessment practices. A comparison of new and traditional assessment methods may help determine if reassessment coupled with formative classroom assessments is related to student mathematical growth and achievement. This study addresses the local problem by examining a possible relationship between new reassessment practices implemented during the 2015-2016 school year and student growth in mathematics. This study is unique in that it examines how formative and reassessment practices may be related to student growth in middle school mathematics. Examining assessment practices piloted by some teachers during the academic year in connection with standardized testing results has the potential to inform future assessment and grading policies. Turner (2014) supported the use of reassessment and formative assessments. However, measuring the association of assessment and student achievement has not yet been completed at the local district level.

The findings of this study may lead to recommendations for specific and consistent assessment practices. Understandings from this study should aid mathematics teachers in deciding on consistent classroom assessment practices. Teachers, students, and administration may gain insights about consistency in assessment and a focus on meaningful formative assessment for student growth. Turner (2014) described the benefits to creating partnerships in the classroom assessment process with all stakeholders and detailed research findings with profound achievement gains when successful formative assessment practices are used. Ultimately, this study has the potential to provide stakeholders with information regarding whether or not the use of reassessment in mathematics classes is related to significant gains in student mathematics achievement and growth. School personnel may make more informed decisions concerning assessment practices and policies with information gained from the study of assessment practices.

Research Question and Hypotheses

The type of assessment, multiple formative assessments, or lack of, will serve as the nominal, independent variable in this study with three separate dependent variables. State mathematics standardized test scores are scaled scores, growth scores from the state standardized mathematics test scores, and the second-semester mathematics course percentage will serve as the dependent variables, measured on an interval scale. Turner (2014) and Wormeli (2011) supported the use of formative assessment for student achievement, and multiple assessment attempts to measure a student's current level of understanding. Furthermore, the theoretical framework presented in this study supports the use of formative assessment for student learning. Therefore, a significant difference between assessment methods is hypothesized. The research question in this quantitative study is:

RQ: How does the use of multiple assessment attempts with formative feedback compare to not using multiple assessment attempts in terms of students' mathematics achievement, growth, and course percentage grades?

H_o : Students enrolled in math classes using multiple assessment attempts with formative feedback will not have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

H_a : Students enrolled in math classes using multiple assessment attempts with formative feedback will have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

Review of the Literature

This section of the study addresses the research strategies and general problem of assessment inconsistencies. The review of literature presents the theoretical framework of Black and Wiliam (1998) surrounding the use of formative assessment, questioning, and student readiness to learn as related to assessment, providing the theoretical foundation for this project study. The review of literature presents, defines, compares, contrasts, and connects formative and summative assessment, while providing multiple perspectives emphasized in current formative assessment literature. Finally, the review examines technology connections with formative assessment in the classrooms of today.

Research Strategies and Overview

The review of literature presented centers on the topic of formative assessment. Research for this study presents an overview of current, peer-reviewed formative assessment studies. A total of 95 sources were examined with 56 peer-reviewed current articles meeting the search criteria and informing this current study. Additional historical articles and sources are also cited throughout the review of literature. During the research process, key words of *formative assessment*, *assessment*, *assessment for learning*, *assessment of learning*, *math assessment*, *formative assessment and professional development, teacher preparation and formative assessment*, *teachers' and students' perceptions of formative assessment*, and *formative assessment and technology* were used. I used the keywords presented while searching databases from the Walden Library, which include Education Source, Education Research Complete, ERIC, and Google Scholar. While this quantitative study presented is specific to the content area of mathematics at the middle school level, the review of research was broader, to develop a full and complete picture of current peer-review formative assessment studies. Studies from around the world and a variety of content areas, as well as grade levels from elementary through college, informed the current formative assessment study. Finally, I examined studies relating to formative assessment practices with the use of technology.

The analyzed body of literature will provide a comprehensive overview of formative assessment practices both supporting the use of formative assessment in the classroom and supporting the need for further research into specific strategies and evidence of the effectiveness of formative assessment (Black, 2015). Following the theoretical foundation of formative assessment practices, the review of literature begins with a brief history of formative assessment origins; the research provides a background of the term *formative assessment*. Furthermore, an examination of formative assessment as related to, and supporting summative assessment is presented. Additionally, the literature review presents an analysis of the use of formative assessment as assessment for learning and self-regulated learning. Advances in technology in the area of formative assessment are also showcased in this literature review to provide perspectives of 21-

century classroom assessment practice. Finally, an examination of teachers' and students' perceptions of formative assessment practices with a comparison of formal and informal formative assessment completes the review of literature and informs the current project study. With a wealth of formative assessment studies calling for research into specific formative assessment strategies, the current study may provide the educational community with information surrounding the use of multiple assessment attempts in mathematics.

Theoretical Foundation

A renewed interest in effective formative classroom assessment practices is gaining attention in the field of educational research (Box, Skoog, & Dabbs, 2015). With pressures from high-stakes testing and continued efforts toward education reform, education stakeholders are searching for ways to improve student learning and ultimately performance on summative and high-stakes testing. With the focus of this study on formative assessment practices, the seminal work of Black and Wiliam (1998) served as a basis for investigating formative assessment practices. Black and Wiliam (2010) described formative assessment as "activities undertaken by teachers—and by their students in assessing themselves—that provide information to be used as feedback to modify teaching and learning activities" (p. 82).

The theoretical framework for this study is based on Black and Wiliam (1998) and their conclusion regarding the importance of formative assessment for effective teaching. Black and Wiliam (1998) argued that formative assessment is the cornerstone of effective teaching and improving student achievement and after completing a meta-analysis of 250 formative assessment publications presented a theory that formative assessment greatly improved positive student learning outcomes. In their review of pertinent formative assessment literature, Black and Wiliam (1998) examined examples of formative assessment, teacher and students' perspectives and their role in formative assessment use, strategies of formative assessment, and the importance of feedback. After this examination and meta-analysis, Black and Wiliam (1998) published a groundbreaking study, which concluded positive student improvements of one half to one full standard deviation with the use of formative assessment. The purpose of this study comparing mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts aligns with the theory that formative assessment has a positive impact on student learning. Black and Wiliam (1998) informed this study with their meta-analysis of formative assessment studies. The present study investigates a specific formative assessment practice through the use of multiple assessments thus connecting it directly to Black and Wiliam (1998) and the role of formative assessment in the classroom for improving student learning. Furthermore, the theory of the positive impact of formative assessment presented by Black and Wiliam (1998) would predict a statistically significant difference between the assessment methods presented in the research question and explored in the hypotheses of this study. The work of Black and Wiliam (1998) also connects to Stiggins and Chappuis (2005), Chan et al. (2014), and Akpan et al. (2012) with the idea of involving students in the process of assessment for learning. This theory of the importance of student involvement in the learning process originated from Sadler (1989). In his work with formative assessment, Sadler (1989) argued that any assessment could be considered formative if feedback is used for learning; however, when students are involved in the process of feedback and learning, then they are working to close their individual achievement gap and meeting a specified learning goal. The theoretical framework detailed by Black and Wiliam (1998) served as a catalyst for assessment studies since first published and provided the basis for the assessment research question and hypotheses of this study by addressing the local problem of determining if new assessment practices can predict greater growth for student achievement in middle school mathematics classes.

The process and purpose of formative assessment is used for learning and adjusting teaching to meet the needs of the learner (Dixson & Worrell, 2016). Black and Wiliam (1998) presented the importance of formative assessment for student achievement. Black (2015) called for future studies of classroom formative assessment that provide detailed evidence of use, adding support and for the current studies' examination of formative assessment through multiple assessment attempts.

Review of the Broader Problem

Current studies regarding formative assessment recognize the evidence presented by Black and Wiliam (1998) as a foundation for future assessment research and the benefits of improved formative assessment practices. According to Phelan et al. (2012), "when efforts are made to strengthen formative assessment, learning gains—typically measured by an increase in test scores—occur" (p. 211). The current and renewed interests in formative assessment practices are related to summative and high-stakes test scores. Formative and summative assessments should work in unison, even though these styles of assessment have become viewed as working against each other (Lau, 2016, p. 509). Lau (2016) advised abandoning the traditional view of assessment due to accountability pressures and suggested connecting the two styles; formative and summative assessment (p. 523). The idea of synergy between formative assessment and learning as reported through summative assessment was also supported by DeLisle (2015) and connected directly with the research questions in this study. The research question in this study examines whether significant differences exist with growth, standardized test scores, and course percentage grades in the content area of mathematics, between classes using multiple formative assessment attempts and those not using the multiple assessments.

Background of Formative Assessment and Feedback

The seminal work of Black and Wiliam (1998) informed a plethora of formative assessment studies. However, Scriven (1967) was initially considered to coin the term *formative assessment* and make the distinction between the two styles of assessment. According to Lau (2016), the term formative assessment comes from the phrase “formative evaluation,” which was first used by Scriven during the design and improvement of education curriculum. The concept of feedback as part of the assessment process separates formative from summative assessment, with feedback considered a significant part of the cycle of learning. Involving students in the process of learning and feedback during formative assessment is an important step in working to achieve mastery of a standard or objective (Sadler, 1998). Frequent, meaningful feedback specific to a student's area of struggle or individual need may reduce the amount of time and perseverance needed on the part of the student toward developing mastery of a subject (Bloom, 1968). Providing opportunities for students to monitor and modify their work during the learning process as pointed out by Sadler (1989) directly connects to the investigation of multiple assessment opportunities presented in the current study. Encouraging students to play an active role in the formative assessment process as they work toward mastery of a standard is discussed as having a positive impact on student learning; with the use of quality and direct feedback pointed out by Black and Wiliam (1998).

While the concept of formative assessment and terminology is not new in the educational community, the effective use of formative assessment and examining specific strategies in an era of high-stakes testing is an area with great research potential. Drawing on historical learning and assessment theories of Black and Wiliam (1998) and Sadler (1989, 1998) in formative assessment grounds the current study and informs the need for a specific examination into strategies to implement formative assessment practices into today's standards-based 21-century classrooms.

Assessment Inconsistencies

This broader problem of inconsistent assessment practices was brought to light with pressures from high-stakes testing and the accountability era as well as an identified need for a balanced approach to assessment (Box, Skoog, & Dabbs, 2015; Lysaght & O'Leary, 2013). Furthermore, the local problem of assessment inconsistencies may be part of a greater educational problem in teacher preparation programs not adequately preparing future teachers to enter the classroom ready to assess student learning and respond to student needs (Ateh & Wyngowski, 2015; Lysaght, 2015). The studies carefully selected for this literature review add to the support for this current formative assessment study by answering the call for a detailed examination into specific formative assessment practices as related to learning and student growth (Black, 2015; Hopfenbeck, Flórez Petour, & Tolo, 2015; Hudesman et. al., 2014).

Formative and Summative Assessment Synergy

Formative assessment has gained attention in the field of education and has become associated with a *good* form of assessment (Lau, 2016). Since the findings of Black and Wiliam (1998) study were published with detailed conclusions of the positive impact formative assessment can have on learning, summative assessment has gained a reputation as a *bad* form of assessment (Lau, 2016). However, in a review of assessment literature, Lau (2016) cautioned education stakeholders against separating the two styles of assessment suggested embracing them as working together. This balanced approach of assessment styles working in unison is used by DeLisle (2015) in a mixed methods study of formative assessment practices revealed the difficulties of implementing formative assessment strategies and concluded that synergy between formative and summative assessment was rarely achieved (DeLisle, 2015). While recent studies have advocated for these two assessment methods to work together, the literature presents these methods as separate entities (Dixson & Worrell, 2016; Lau, 2016). This study explores a possible connection and synergy (Lau, 2016; DeLisle, 2015) between multiple formative assessments and summative results and notes it is important to have a clear understanding of the differences and similarities between these two types of assessments.

Differences Between Formative and Summative Assessment

When done in the phase of learning and improving based on feedback, assessment is considered formative. However, when done at the conclusion of learning and as a measurement of learning success, assessment is considered summative. Providing multiple opportunities for students to improve their learning and understanding is a key distinction between formative and summative assessment. Formative assessments allow teachers to monitor students' improvement and growth toward specific learning goals. Additionally, this formative style of assessment can be used before, during, and after the instructional process has occurred (Conderman & Hedin, 2012). Summative assessments provide critical data regarding student achievement, but this data is after learning takes place giving summative assessments "the disadvantage of identifying problems when it is too late to resolve them" (Akpan et al., 2012, p. 84). The distinction between formative and summative assessments was creatively described using a cooking analogy: "When the cook tastes the soup, that's formative evaluation; when the guests taste the soup, that's summative evaluation" (Stake, as cited in Lau, 2016, p. 511). The analogy implies the importance of using formative assessments to make corrections and address any misconceptions before summative evaluations.

Formative and summative assessments differ in the intended purpose of the assessment. Dixon and Worrell (2016) described these two assessments as tools for teachers to use in response to the pressures from Common Core State Standards (2014) and the No Child Left Behind Act (2002) in helping students to achieve (p. 153). Furthermore, the standards-based movement is causing stakeholders to reevaluate how student achievement is measured, with careful consideration given to mastery learning through formative assessment practices (Shippy, Washer, & Perrin, 2013). Summative assessments are used to report the results of learning and classroom instruction, which is thought of as the assessment of learning. On the contrary, formative assessments are thought of as assessments for learning in which data is gathered using a variety of techniques and then used by teachers and students during the actual process of learning and to drive future instruction (Conderman & Hedin, 2012; Dixon & Worrell, 2016).

Assessment is now considered a part of the teaching and learning process as well as an evaluation of the effectiveness of the educational process (Akpan, et al., 2012; Bal, 2012; Lau, 2016). In response to assessment pressures, formative assessment, also referred to as assessment for learning, is part of a complex system of assessment reform and should be examined from the perspectives of multiple stakeholders (Flórez Petour, 2015; Stitt & Pula, 2014).

Multiple Perspectives of Formative Assessment

A balanced approach in assessment practices and involvement from both the teacher and learner is a clear theme in the current body of formative literature as presented in multiple perspectives regarding formative assessment (Bal, 2012; Box et al., 2015; Chiang & Lin, 2014, Doubt, 2012; Jonsson, Lundahl, & Holmgren, 2015; Petcovic, Fynewever, Henderson, Mutambuki, & Barney, 2013). Presenting an idea of a balanced approach to assessment Stitt and Pula (2014) connected the idea of careful consideration in how assessments impact students' motivation and their overall course grade in an era of standard-based grading. Stitt and Pula advocated for the use of both formative and summative assessments and stated, "Teachers and students should cultivate a classroom that includes both subjective and objective assessment—a classroom where biases can be minimized because both types of assessment can be used a checks and balances for one another" (p. 25). The literature provides support for the use of formative assessment based on presented research from multiple stakeholder perspectives with ample involvement from, and stressing the important role of students (Marsh, Farrell, & Bertrand, 2016).

Students' perspective. Research in the area of student perspectives and what students think about assessment practices point to favorable outcomes for the use of formative assessments in the classroom from a wide variety of student age groups. With traditional roles of students and teachers shifting in recent years, students are becoming more involved and playing an active role as part of assessment practices (Bal, 2012; Núñez-Peña, Bono, & Suárez-Pellicioni, 2015; Turner, 2014). Therefore, the related research discussed formative assessment perspectives from multiple age groups of students.

In a study of college-aged and preservice teachers, Bal (2012) concluded that students preferred involvement in the assessment process and being informed about how they would be assessed with the ability to showcase their thinking and critical reasoning through assessment procedures (p. 479). However, inconsistencies in assessment practices can mislead students and confuse them about how to show reasoning and improvement (Chiang & Lin, 2014; Petcovic et al., 2013). In a study of college assessment practices in a physics class, Petcovic et al. (2013) determined that how faculty scored individual student work varied greatly when they were asked to provide feedback and grade two different student explanations to a physics problem. The authors found a statistically significant difference in how student work was assessed and concluded inconsistent assessment practices may send students a mixed message about whether reasoning and learning are valued or correct answers. However, involving students in the assessment and goal-setting process revealed positive results (Smithson, 2012).

Benefits of formative assessments for students include drawing their attention to specific areas that they need to dedicate time and attention to improving (Phelan et al., 2012). In an examination of a formative assessment program for prealgebra students, Phelan et al., (2012) concluded a positive impact on learning based on the strong effect sizes from examining formative assessment scores, referred to as "checks for understanding" (p. 227). With student involvement in the formative assessment process, increased motivation and self-efficacy were discussed in the relative literature. Meusen-, Joosten-ten Brinke, and Boshuizen, (2016) found an increased motivation and self-regulation for sixth-grade students participating in formative assessment with writing. Formative assessment was touted as developing self-regulation among primary school students (Meusen-Beekman et al., 2016).

Perceptions of formative assessment from younger elementary students regarding motivation through formative assessments studied by Smithson (2012) found student involvement in the assessment process, specifically in setting improvement goals to be a strong motivator and means for improving performance for the third-grade students in the study. Additionally, Cowie and Moreland (2016) conducted interviews with middle school students between ages 11 and 12 years studying biotechnology. These 11- to-12-year-old students were motivated and involved in the assessment process through an authentic and formative group assessment task. Furthermore, the students reported their thinking and reasoning being pushed to improve as the teacher gave feedback in the form of questions for further investigation (Cowie & Moreland, 2016). Students shared their perspectives by describing their teachers' instructional strategy as giving them options in their learning and helping them extend an idea (Cowie & Moreland, 2016) demonstrating the shared responsibility of learning through formative assessment practices.

A further inspection of shared assessment responsibility was conducted by Marsh et al., (2016) in the area of formative assessment feedback and data-use combined with student motivation. In an examination of pedagogical practices, the authors found one third of the teachers using assessment practices that may diminish motivation for learning due to the focus on performance as opposed to learning and growth, providing additional support for student involvement. Process-oriented feedback revealed positive results for student achievement when compared to grade-oriented feedback (Harks, Rakoczy, Hattie, & Besser, 2014). However, Cotton (2017) pointed out a difference between students' and teachers' ratings of formative assessment use within the classroom and presented differences in perception with students rating teachers better than teachers rated themselves with formative assessment practices. The literature indicates the role and perspective the teacher plays in formative assessment practices is worth examining.

Teachers' perspective. The shared responsibility and involvement from multiple stakeholders is a shift away from traditional forms of assessment and a move toward modern assessment practices (Jonsson, Lundahl, & Holmgren, 2015; Roscoe, 2013; Taras & Davies, 2013). Creating a partnership between learners and teachers through providing multiple opportunities for learning and feedback may be helpful for both the instructor and student (Owen, 2016). Additionally, to avoid teachers being overconfident they are teaching the required material, only to be surprised by summative results; formative assessment may provide needed feedback for scaffolding instruction. In a reflection of her recent formative assessment study, Owen (2016) stated, "As summative assessment measures go, this has taught me one very important lesson: that what we think we are teaching our students is not necessarily what they are learning" (p. 168).

In a study aimed at understanding the role of assessment, feedback, and grading, Mitton-Kukner, Munroe, and Graham (2015) examined how their feedback practices as instructors impacted the learning of their pre-service teaching students during an assessment course. The researchers concluded the need to provide pre-service teachers with more meaningful assessment practices that moved their thinking more in line with an assessment to foster improved learning as opposed to summative grading. Doubet (2012) detailed a middle school's effort to increase the use of formative assessment practices and revealed teachers' positive perspectives in helping to differentiate instruction based on formative data to meet the needs of all learners. In an analysis of middle school teachers' discussion about formative assessments, Doubet reported that teacher responses indicated that formative assessment improved perceptions about students and helped teachers to efficiently differentiate instruction. In a mathematics-specific example, Seaton (2013) further explained the value of teachers' feedback on frequent mathematical assignments that were low-stakes in which students felt comfortable to show reasoning and possibly make a mistake (pp. 964-965).

A specific formative strategy of partial marking and giving quality feedback to all students without a major additional time burden from a teachers' perspective was explored by Seaton with positive results. Adding to the idea of providing students with feedback, Pittaway and Dowden (2014) analyzed written feedback on assessments. Concerns about how to provide students with written feedback in reflection of professional practice when one of the instructors stated, "providing written feedback to students is indeed challenging, but at the same time it is satisfying and rewarding" (Pittaway & Dowden, 2014, pp. 206-207). This challenge of finding time to implement formative assessment feedback is addressed in studies of 21st-century tools used specifically for formative assessment practices that will provide student-involved feedback without an extra time burden on teachers.

Formative Assessment With Technology

With an emphasis on the role technology plays in the 21st-century classroom, coupled with assessment practices, this review of literature summarizes current research relating to formative assessment with technology. In an examination of current studies related to mathematics education, technology-enhanced formative assessment practices were found to have a positive impact on student achievement (Hannah, James, & Williams, 2013; Shirley & Irving, 2014; Reeves, Gunter, & Lacey, 2017). The use of technology provided teachers and students with instant feedback on their current level of instruction and assisted teachers by providing data to better differentiate instruction and meet the needs of individual students (Martin, Polly, Wang, Lambert, & Pugalee, 2015). In a quantitative study, Martin et al.'s (2015) data analysis revealed a "statistically significant increase in teacher practice to be more student centered" (p. 3) when internet-based formative assessment tools were used. This study analyzed teachers' use and perceptions of the Assessing Mathematics Concepts Anywhere (AMC Anywhere) program, designed to enhance number sense concepts at the elementary level. Supporting the use of technology enhanced formative assessment practices, Grosas, Raju, Schuett, Chuck, and Millar (2016) pointed out students' feedback asking for formative assessments in an electronic format. In an era that requires digital literacy in the classroom, examining the use of online formative assessment tools and electronic feedback is warranted (Oseterbur, Hammer, & Hammer, 2015; Spector et al., 2016).

In a study of another technology-enhanced formative assessment program, Connected Classroom Technologies (CCTs), Shirley and Irving (2014) discussed an analysis of interviews and observational data with middle and high school mathematics teachers and students, revealing further support of technology-enhanced formative assessment. The CCTs provided the teachers and students in the study with timely feedback. Teachers were able to make future instructional decisions, and students gained insight into areas of mathematics they needed to improve upon (Shirley & Irving, 2014).

Further support for technology-enhanced formative assessment comes from a study of college students and the use of computer-aided assessment (CAA) in engineering mathematics courses. Hannah, James, and Williams (2013) noted a statistically significant correlation between student's final grade and the time spent using CAA. Students were allowed multiple attempts on quizzes in the CAA program and showed improved scores from their first attempt (Hannah et al., 2013). However, while the researchers discussed improved results with the use of the CAA program, they cautioned that students demonstrating weaker mathematical skills were not able to catch up to peers with stronger skills when using the CAA program. The use of technology for practice and assessment purposes must be within the reach of students' individual understanding to make the practice meaningful and successful (Shumway & Jordan, 2016; Tucker, Moyer-Packenham). Thus, it is important to do further research into specific formative assessment practices such as the use of multiple assessment opportunities and student feedback for achievement growth for students of all ability levels.

Implementation of Formative Assessment

While the intention and purpose of formative assessment remain unchanged, the way in which educators implement formative assessment practices varies. Cowie and Moreland (2015) described this variation in formative assessment "ranges along a continuum from planned for and formal to contingent and informal" (p. 248). However, whether planned or informal, researchers advocate for the involvement of students and the importance of this involvement during the assessment process (Chan, Graham-Day, Ressa, Peters, & Konrad, 2014; Chen et al., 2012; Davis & Neitzel, 2011; Hudesman et al., 2014; Turner, 2014). Through teachers' use of higher-level questioning versus basic recall and lower-level questions, students engage in mathematics thinking and are prompted to provided more meaningful reasoning and explanations that can inform teachers' future instruction (Chen et al., 2012). Interviews and observations conducted by Davis and Neitzel (2011) in a study of middle school assessment practices; found a need for a greater focus on self-regulated learning (SRL) in which students are involved in their personal assessment of learning.

Quality formative assessment and high-quality feedback cannot be separated from classroom instruction (Clinchot et al., 2017; Davis & Deitzel, 2011). Teachers recognize and support the need and use of formative assessment in the classroom within a culture and school climate that supports the use of formative assessments (Sach, 2015). The use of responsive formative assessment practices versus prescriptive formative assessment involves and prompts students to analyze and justify their thinking as opposed to simply focusing on if their answers are correct or incorrect (Clinchot et al., 2017).

An additional form of formative assessment was studied by Chen et al. (2012), in an examination of eighth-grade teachers' in Taiwan. The findings of this study supported the use of instructionally embedded formative assessments and revealed a difference in the quality of assessment in classrooms with high socioeconomic status (SES) compared to classrooms with lower SES. Low-level questioning plagued classrooms with low SES while well-planned higher-level questioning formative assessments were found to be present in high SES classes (Chen et al., 2012). Supporting the positive results of formative assessment use, Herman, Osmndson, Dai, Ringstaff, and Timms (2015) compared classrooms with high levels of formative assessment to classrooms with low-levels of formative assessment, concluding,

> Students whose teachers spend more time and who are more frequently engaged in analyzing and providing feedback on student work, as gauged by an overall log factor scores, achieve higher learning than do students whose teachers spend less time and who less frequently do so (p. 363).

Differences in the formative assessment practices lead to research about the variety of practices that exist along the assessment continuum from formal and planned activities to informal and impromptu short assessments (Cowie & Moreland, 2015; Hudesman et al., 2014; Jonsson et al., 2015).

Formal Formative Assessment

Formal planned formative assessment examples are detailed in several studies, providing concrete instances of classroom use. Formal formative assessments are well thought out in advance and planned prior to instruction. In separate, but complementary studies, Schoenfeld (2015) and Wilder (2015) discussed the Mathematics Assessment Project (MAP), formally known as Formative Assessment Lessons (Wilder, 2015). The MAP would fall into the category of a thoroughly planned and well-thought-out formative assessment (Cowie & Moreland, 2015). Mathematics specific assessments through MAP provided classroom mathematical challenges that engaged students in their own assessment process and are aligned to Common Core State Standards (CCSS) (Schoenfeld, 2015). The MAP tasks are described as engaging students in "conceptually rich mathematics" (Schoenfeld, 2015, p. 191), and Wilder reported student growth in all areas of a study dealing with a mathematics equation MAP challenge when pre and post-assessment scores were compared. An additional formal style of formative assessment in a discussion of the PILOT program was presented by Turner (2014), which provided an analysis of teachers' detailed use of multiple assessment opportunities and differentiation based on assessment results. The positive impact on both teaching and learning through student involvement, motivation, as well as teachers' differentiation of instruction were apparent in the formal styles of formative assessment. Informal formative assessments were also explained as benefiting classrooms.

Informal Formative Assessment

On the formative assessment continuum described by Cowie and Moreland (2015) the examples detailed by Turner (2014) and Akpan et al., (2012) would fall into the formal formative assessment category. However, the informal formative practices can be viewed as equally important in the process of involving students in embedded assessment practices for learning (Chan et al., 2014; Chen et al., 2012; Davis & Neitzel, 2011; Turner, 2014). Informal formative assessment strategies may not necessarily be planned in advance but administered based on a teachers need to gauge students understanding of a lesson and plan for the next instructional steps. Classroom formative assessment strategies such as think/pair/share, student-made quizzes and rubrics, exit and entrance tickets, student self-assessment, oral reports, observations, and a variety of game-like approaches to formative assessment can both impact learning and instruction (Akpan et al., 2012; Turner, 2014). These student-centered formative assessments focus on involving and engaging students in the assessment process while providing valuable information regarding a student's thinking resulting in data to inform future instruction (Turner, 2014; Wylie & Lyon, 2015). After a review of a variety of formative assessment strategies, Akpan et al., (2012) pointed out that "the more formative assessments are utilized in the classroom the better the results on a summative evaluation" (p.95), connecting again the synergy between formative and summative assessments (Delisle, 2015). However, implementing these formative assessment strategies requires time, effort, and training on the part of teachers (Wylie & Lyon, 2012). Research revealed shortcomings in teacher preparation programs specific to lesson planning to incorporate and prepare formative assessment strategies that connected to Common Core State Standards and provided support for student subskills toward mastery and application assessment strategies in the classroom (Ateh & Wyngowski, 2015; Matthews & Noyes, 2016).

Conclusion

This review of the literature has produced several major themes supporting the need to study formative assessment through the particular strategy of multiple assessment attempts. First, the positive impact of formative assessment was a reoccurring theme throughout the current and historical literature with specific attention given to the involvement of students in the process of formative assessment as a means for improving their understanding in a variety of subject areas and grade levels. Secondly, the use of formative assessments in an era of increased accountability and pressure to perform on summative or standardized testing demonstrated positive impacts on student learning. The third theme of digital literacy in the area of formative assessment was made clear through several studies supporting the use of technology-enhanced assessment practices to support timely feedback and involvement on the part of students in the learning process. Finally, moving beyond the support for using formative assessment to the need for an examination of specific formative assessment strategies is a theme of recommended research aligning with the current study to possibly provide information and address a gap in research for specific formative assessment strategies.

Implications

Involving students in quality and effective formative assessment strategies has great potential for educational gains and improved student learning. By examining the specific strategy of multiple assessment attempts, this study may provide information and tools to possibly inform professional development and pre-service teacher assessment training. Upon examination of study results, the information collected and analyzed in this study may be used to guide classroom assessment policies and practice. Finally, this study may serve as a catalyst for future research into specific formative assessment strategies.

The direction of possible projects will be based on the finding of this research that guides the final project development. With the goal of gaining information regarding the specific formative assessment strategy of multiple assessment attempts, publishing findings in a white paper written for an audience of educators and administrators is one possible project. Furthermore, based on the findings the development of a local level professional development for mathematics teachers may be an appropriate and advantageous project to inform teachers of specific formative assessment strategies. The data collection and analysis will direct the final project decision and development.

Summary

The public data related to student achievement lacking in the area of mathematics both at the local and national level indicates a need for examination of assessment practices as related to student growth and achievement. Building upon the historical and seminal work of Black and Wiliam (1998), a review of related formative assessment literature has revealed support for formative assessment practices with a need for examination of specific classroom strategies to implement quality formative assessment and feedback while involving students in the process of learning. Taking into account student and teacher perspective in the process of assessment in a 21-century classroom, the importance of feedback for learning is clear. Thus, the current study intends to address the gap in practice by providing information about the effectiveness, or lack thereof, of the use of multiple assessment attempts for student growth and achievement in the subject area of mathematics.

Section 2 of the study presents the quantitative research design, justification, and evaluation methods used to examine the possible impact of multiple formative assessment attempts in the area of mathematics. The detailed information regarding the sampling and data collection techniques are outlined with the use of archived data regarding multiple assessment attempts. Additionally, the analysis and statistical procedures used in this study are fully described. Finally, the assumptions, limitations, and details regarding how research protocols were followed and findings were analyzed and presented.

Section 2: The Methodology

Introduction

In Section 2, information regarding formative assessment variables in this study is presented. This section will present the overall research design, methodology, population, and sampling, as well as instrumentation and data collection. The research question in this study indicates the need for a quantitative approach for the analysis of data. This study investigates how the use of multiple assessment attempts with formative feedback compares to not using multiple assessment attempts in terms of students' mathematics achievement, growth, and course percentage grades. A quantitative, ex post facto quasi-experimental design was chosen to answer the research question into a comparison of numerical standardized test scores, growth scores, and course percentage grades based on classroom assessment practices. This section will conclude with a discussion of limitations of the formative assessment study and the protection of participants' rights.

Research Design and Approach

To address the local problem of assessment inconsistencies and answer the research question in this study, a quantitative method is needed. Careful thought and consideration was given to the appropriate selection of the research method. While a qualitative research method was originally considered, to provide insight into teachers' thoughts regarding formative assessment practices, it did not best fit the purpose or research questions of this study. A qualitative method would provide rich descriptions and details of how teachers use multiple assessment attempts in their mathematics classroom. However, knowledge of how teachers are using multiple assessment attempts is already known in the district through job-embedded collaboration discussions. Teachers use multiple assessment attempts to direct their teaching and student learning. Teachers provide both whole-group and small-group feedback on specific questions that were problematic for students and give students opportunities to work with peer groups and discuss strategies. A statistical analysis comparing achievement, growth, and course percentage grades for classrooms using multiple assessment attempts versus classrooms not using multiple assessment attempts is needed. Therefore, this specific assessment study is concerned with a statistical comparison between the types of classrooms assessments, with or without multiple assessment opportunities. With the research question centered on a comparison of two previously assigned groups and based on numerical data, the relevant literature indicates a quantitative, ex post facto quasi-experimental approach is justified (Lodico, Spaulding, & Voegtle, 2010). The ex post facto quasi design was used because the independent variable (with or without reassessment) was already determined before the onset of the study and students were already assigned to their classes prior to the study.

Additionally, while informed by a wealth of previous studies, the investigation of this formative assessment strategy is narrow and specific in focus, aligning with a quantitative method. Since the purpose of this study is to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts, a quantitative design was justified. With the individual classes already assigned prior to this study, and the research question seeking to determine if there is a difference between two types of assessment strategies, an ex post facto quasi-experimental design will be used. This research examined and compared possible differences between classes that were already established yet exposed to different assessment treatments (Lodico, Spaulding & Voegtle, 2010).

Setting and Sample

Population

A school district in the northwestern United States is the setting for this quantitative study. The school district is located in a suburban city with a student population of 10,406 students in the 2015-2016 school year. Of these 10,406 students, 40.3% are on free or reduced lunch status, with 5.2% of students classified as students with special needs. An examination of ethnicity and race reveals a lack of diversity with 89.4% Caucasian, 4% Hispanic/Latino, 1.3% American Indian/Alaska Native, 1.7% Asian, 1.1% African American, 0.4% Native Hawaiian/Pacific Islander, and 0.1% Multiracial. This district is one of the largest districts in the state and home to 10 elementary schools, three middle schools, two high schools, and one alternative high school with all schools in the selected district accredited (*District Profile*, 2016).

Accessible Population and Sample

With the purpose of this study geared toward middle school assessment practices, the target population for this study consists of approximately 2,248 middle school students already assigned to a mathematics course at two of the three middle schools in the district. The data for this study was archived and available for research purposes. Data was accessed only after I was granted permission from IRB and the local district. Of the total 2,248 middle school students, the target population of this study was narrowed down to, 1,441 from two of the local districts middle schools, ensuring that I had no contact with any students whose data was collected and analyzed. Out of the target population, a small portion (approximately 130 students) were assigned to a classroom using traditional assessment methods, without the possibility of reassessment. The majority (approximately 2,118 students) were assigned to classrooms using multiple formative assessment attempts with formative feedback.

It is important to note that during the 2015-2016 school year, most math classes chose to pilot the new formative assessment practices, with only a few classes not using multiple attempts with formative feedback. From these possible classes, two classes that were not using multiple reassessments and two classes using multiple reassessment and formative feedback were selected. A total of four classes were selected for a total of 83 students. Of the 83 students, 41 students were from two classes with teachers identified as using traditional assessment, with 42 students from two other classes with teachers using new multiple assessment attempts with formative feedback.

A convenience sample was employed because a simple random sample was not possible for students already assigned to a given math course through the Skyward (2017, Version 05.16.10.00.09) scheduling program (middle school counselor, personal communication, May 19, 2016). To be included in the study/sample, students must have completed the 2015-2016 and 2014-2015 SSAT because both SSAT scores were needed to calculate a student’s growth score as part of this study’s dependent variables. Growth scores were calculated by finding the difference between the current SSAT scaled mean score from the previous year's scaled mean score to determine the amount of mathematics growth a student has achieved over the course of the school year.

A sample size was comprised of 83 participants from the four classes. A power analysis for a one-way MANOVA with two levels and three dependent variables was conducted in G*power to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and a medium effect size ($f = 0.25$) (Faul, Erdfelder, Buchner, & Lang, 2013). Based on the assumptions, the desired sample size of 44 is sufficient. Therefore, the sample of 83 participants will ensure that the needed sample requirements are met for a medium effect size. Furthermore, because the one-way MANOVA contains only nominal independent variables with two levels (with or without reassessment) a post hoc is possible for any independent variable with less than three categories. Therefore, an independent samples *t* test was performed to analyze each of the dependent variables with respect to the two independent samples created from the with or without reassessment groups.

To control for preexisting conditions, students in classes using multiple and non-multiple assessment attempts were selected for this study after scrutinized and matched on characteristics of gender, class size, race, ethnicity, the percentage of students with special needs, and socioeconomic status (measured by percentage of students on free and reduced lunch). These demographic characteristics are reported in the results and analysis section. No significant demographic differences between the sample group and population were discovered.

Instrumentation and Materials

The data collection involved two main assessment sources: data from the SSAT and the common middle school mathematics assessments. First, the mathematics SSAT testing data provided standardized mathematics assessment scores. The second main source of data consisted of middle school mathematics common assessments. These common assessment scores were recorded and reported through the Skyward software (2017, Version 05.16.10.00.09) as a course percentage grade. The Skyward software (2017, Version 05.16.10.00.09) is used throughout the local district to record and report student course percentage grades and was used during the collection of archived data. These course percentage grades are a compilation of the common assessments developed for each unit of study and each standard in Grades 6 to 8 mathematics. These common assessments are averaged to create 70 to 80% of a student's total course semester grade percentage, with the remaining 20 to 30% from small quizzes and homework assignments. Therefore, the common assessments were used as the second instrument and source of data. For this study, the second-semester mathematics course percentage grades was used in an analysis to see if there were differences with classes applying multiple assessment opportunities compared with those not given multiple assessment opportunities.

State Standardized Achievement Test (SSAT)

The first instrument in the data collection process was the SSAT. All students in the state, Grades 3 to10 participate in the SSAT during the spring semester 8-week testing window. Students complete the English/Language Arts and Mathematics portion of the assessment during the testing window over a period of several days. For this study, only the Mathematics SSAT score was taken into consideration. The mathematics portion of the SSAT is an assessment instrument developed to measure a student's depth of knowledge and skills in mathematics. The SSAT was developed from the Smarter Balanced Assessment Consortium (SBAC) to measure specific State Standards and move beyond the simplicity of a multiple-choice assessment. The SSAT utilizes different question formats such as selected response, in which multiple answers apply to a given mathematics problem (District Student Results Brochure, 2015). Students are required to explain their thinking and reasoning on several questions of the SSAT test through the application of real-world questions (Smarter Balanced Assessment Consortium: Initial Achievement Level Descriptors and College Content-Readiness Policy, 2013).

The SSAT measures a greater depth of knowledge with fewer and more critical areas of focus compared to older versions of state mathematics assessments (District Student Results Brochure, 2015). Each question on the SSAT developed from the SBAC underwent rigorous testing for validity and reliability before administering a statewide pilot test in the spring of 2014 and the new testing system in the spring of 2015 (Smarter Balanced Assessment Consortium: 2013-2014 Technical Report, 2016). Reliability of the SSAT refers to the instrument maintaining consistent results with the validity of the instrument demonstrating evidence interpretation and use of scores.

The test reliability scores from a test-retest design, or pilot and field test from the SBAC for the SSAT are segregated by grade level. This study focused on middle school Grades 6-8 in the content area of mathematics. As reported in the Smarter Balanced

Assessment Consortium: 2013-2014 Technical Report (2016), the coefficient alpha was greater than 0.70 for each grade level and therefore considered acceptable for testing purposes of the SSAT computer adaptive test (CAT). The sixth-grade alpha coefficient ranged from 0.65 to 0.88 with a median score of 0.79. The seventh-grade alpha coefficient ranged from 0.62 to 0.84 with a median score of 0.79. Finally, the eight-grade alpha coefficient ranged from 0.59 to 0.84 with a median score of 0.75. A classical item analysis was conducted during the SSAT Pilot Test with content experts reviewing any items that were flagged for inconsistencies (Smarter Balanced Assessment Consortium: 2013-2014 Technical Report, 2016, p.154).

Test validity from a pilot and field test, as described in the reliability information above examined five sources of validity. The sources of validity include: content, internal structure, relations with external variables, response processes, and test consequences. The *Smarter Balanced Assessment Consortium: 2013-2014 Technical Report* details the importance of ongoing validity testing because of the relative newness of the assessment. The test validity is presented in several tables detailing the framework of evidence and sources of validity. The tables presented detail that the test has met at least 2 out of the 5 aforementioned sources of validity for each purpose of the test (Smarter Balanced Assessment Consortium: 2013-2014 Technical Report, 2016, pp. 52-53). Additionally, the summary of validity presents eleven different purposes associated with the SSAT with all five sources of validity accounted for in areas of achievement and growth toward mastery (Smarter Balanced Assessment Consortium: 2013-2014 Technical Report, 2016, pp. 33-60).

Scoring for the SSAT test ranges from 2000 to 3000 with a reported mean score and standard deviation, falling into one of four achievement levels. The achievement levels are indicated with a score of 1 for a below basic performance, 2 for a basic performance classification, 3 for a proficient score, and 4 indicating an advanced score on the SSAT. Additionally, a claim performance level is reported for each student based on data gathered from individual responses to SSAT questions. The claim performance is reported as one of three options for mathematics: below standard, at/near standard, and above standard. These claims are intended to serve as a broad statement of a student's overall performance based on their individual answers and the reasoning they provided throughout the assessment process (local district assessments student results brochure, 2015). Finally, a growth score for each student is calculated to determine how the individual student improved or failed to improve their SSAT score compared to the previous year's reported scaled score (local district State Department of Education, 2016). The SSAT and SSAT growth scores make up two of the three dependent variables for this study.

Common Mathematics Assessments and Course Percentage Grades

The third and final dependent variable for this study comes from common middle school assessments. Using a statistical analysis, one-way MANOVA, followed by an independent-samples *t* test, possible differences between students' second-semester course percentage grades were compared for students enrolled in a math class using multiple assessment attempts (see Appendix C for an example common assessments) compared to students not allowed multiple formative assessment attempts. Therefore, course semester grades, which are a compilation of common assessment scores, were needed for data analysis and gathered from the Skyward (2017, Version 05.16.10.00.09) grading system used by the local district. Teachers use the Skyward software (2017, Version 05.16.10.00.09) as an electronic grade book to record and report students' percentages for each common assessment in mathematics.

Common assessments were designed and written through a collaborative effort of teachers and district math coaches working together to develop common unit assessments for grades 6-8 with each unit of study. Each common assessment has three versions for teachers to use in the implementation of multiple assessment attempts with formative feedback. These common assessments are directly connected with the district curriculum and state standards, with the learning targets listed at the top of each assessment (see Appendix C for example versions of common assessments). Additionally, teachers used time during job-embedded collaboration to discuss common assessments and student results as they focus their pedagogical practices. These common classroom assessments are practical and applicable for the intended educational audience, yet, as later discussed in the limitation section of this study, the common assessments have no formal validity or reliability testing. Results from these common assessments are reported as a percentage, through Skyward (2017, Version 05.16.10.00.09), the electronic grade book software. The raw data is stored on a password-protected computer, in password-protected files for 5 years after the conclusion of the study. Raw data will be permanently removed from the computer at the end of the 5-year period.

Data Collection

After gaining approval from the Walden University Institutional Review Board (IRB approval # 11-20-17-0490804) and the local school district, SSAT, and mathematics second-semester course percentages grades were collected for analysis from the identified sample. The local district required researchers to obtain written permission from the local district superintendent through completion of a research form (Appendix B). Additionally, after gaining approval from the local district superintendent, I followed the local school Board policies 2140 (Student and Family Privacy Rights), 3570 (Student Records), and 3575 (Student Data Privacy and Security) outlining guidelines and the process for local research (District Board Policies, 2017). Working with the director of assessment at the local district office, I obtained data from the secured district electronic database for analysis of results. Next, with the assistance of the local district math coach, the sample of teachers using multiple assessment attempts with formative feedback was separated from those not using multiple assessment attempts with formative feedback. To ensure full protection of student and teacher identity, all names were removed from data results before the data was shared for the purpose of this study. The archived data was imported into SPSS version 24.0 for analysis.

Descriptive statistics provide the demographics of the sample for this formative assessment study and are presented in the data analysis section of this study. With the presence of three dependent variables measured on an interval scale and a nominal independent variable, a one-way MANOVA followed by an independent samples *t* test was used to determine if a difference exists between the assessment method and three dependent variables. The type of assessment in this study is the independent variable, traditional assessment without the option of reassessment or the new assessment option with formative reassessment for learning. The independent variable is nominal, with or without formative reassessment, creating two independent sample groups of student data. There are three dependent variables under investigation. These three variables include: The mathematics SSAT scaled score, which is reported as a mean score from 2000-3000. Next, the interval SSAT growth score is comprised of the difference between the 2015-2016 and 2014-2015 SSAT mathematics score. Finally, the interval mathematics second semester course percentage grades are the third and final dependent variable. The following hypotheses guided the data analysis of this study to answer the research question: How does the use of multiple assessment attempts with formative feedback compare to not using multiple assessment attempts in terms of students' mathematics achievement, growth, and course percentage grades?

H_o : Students enrolled in math classes using multiple assessment attempts with formative feedback will not have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

H_a : Students enrolled in math classes using multiple assessment attempts with formative feedback will have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

One-Way MANOVA and Independent-Samples *t* Test Methodology

The analysis for the research question above used a one-way MANOVA followed by an independent samples *t* test to investigate if the two assessment groups (with or without the use of multiple formative assessment attempts) differ statistically from one another in terms of the three dependent variables which include, students' standardized mathematics test score, growth on standardized mathematics test score, and course percentage grade in their mathematics course.

I examined assessment data for students who are already assigned to a given middle school math course through the Skyward (2017, Version 05.16.10.00.09) grading system. The classes selected for this study have similar demographics for comparison as identified through local district archived demographic data and growth scores will help provide control for pre-existing differences. Statistical tests were performed to check that all criteria and assumptions for the use of MANOVA are meet as detailed in the analysis section.

The independent variable in this study is nominal with two possible choices. A discrete value of 0 was assigned to the classes using a traditional form of grading, not utilizing a formative assessment as the first attempt on a test for feedback, rather students are given one attempt at an assessment. A discrete value of 1 was assigned to the second assessment option in which students receive a formative first attempt on an assessment with feedback from the teacher followed by a summative assessment that may be retaken as the student improves their individual understanding. The nominal independent variable created two independent groups of students (with or without reassessment options).

Therefore, an Independent-Samples *t*-Test was also preformed because a post hoc was not possible with only two groups in the independent variable, with or without reassessment options. The independent samples *t* test allowed for examination of each of the dependent variables individually to determine which, if any, were statistically significantly.

The dependent variables for the MANOVA and independent samples *t* test include the mathematics state standardized achievement test (SSAT), the growth score on the state standardized achievement test (SSAT), and the second-semester course percentage grades. The SSAT score is a scaled score from 2000-3000 and the growth and course percentage grade scores are interval dependent variables.

Data Analysis

The use of the quantitative approach provides answers to the research question asked in this study through a one-way multivariate analysis of variance (one-way MANOVA) and independent samples *t* test. A one-way MANOVA and independent samples *t* test quantitative analyses used in this study provides an answer to the research question above. I selected a one-way MANOVA and independent samples *t* test design to meet the intended purpose of this study and provide a means to answer the research question. The research question in this study is concentrated on a comparison between two assessment types with three dependent variables in questions. Therefore, a one-way MANOVA allowed for examination of a possible statistical difference. Additionally, an independent samples *t* test was used for analysis of each individual dependent variable to determine where the significant finding was. The data followed assumptions of normality, homogeneity of variance, and independence for the use of a one-way MANOVA as detailed in the analysis section (Terpening, Beqiri, & Schwering, 2013, p. 357). Additionally, the presence of two independent samples allowed for independent samples *t* test to determine exactly which variables provided the significant finding.

Analysis with One-Way MANOVA and Independent-Samples *t* Test

In an analysis of the research question, SPSS 24.0 was utilized for a one-way MANOVA and independent samples *t* test in an examination of classes with or without multiple attempts at formative assessment and a possible statistically significant difference between the two groups on SSAT mathematics scores, SSAT growth scores and course percentage grades. A discrete variable of 0 was assigned to classes not utilizing formative assessment attempts, and a discrete variable of 1 was assigned to classes in which students were allowed multiple formative assessment attempts. With the two possible assessment options, the independent variable is nominal, with or without formative reassessment. The dependent variables of SSAT growth scores and course percentage grades are interval with the SSAT score consisting of a scaled score between 2000-3000. A one-way MANOVA was performed for the previously described sample of students in an analysis of possible differences between the two assessment option groups. An F-test was used to determine if the null hypothesis should be rejected with a .05 level of significance. Additional tests such as Shapiro-Wilk test of normality or Levene's test of homogeneity of variance were completed using SPSS 24.0. All results are presented in tables and analysis in Section 2 of this study.

The one-way MANOVA is a powerful statistical test. However, with the nominal independent variable only containing two groups of with or without reassessment, a post hoc was not possible. Therefore, an independent samples *t* test allowed for the analysis of each independent variable with respect to each dependent variable using a *t* test to determine significance for each group if the null hypothesis should be rejected with a .05 level of significance.

Scope

This formative assessment study is specific to middle school mathematics; therefore, the scope of this study is limited to one content area only. Additionally, the scope of this study is concentrated on a student population from urban, northwest schools. All variables in the study are also concentrated on middle school mathematics. The SSAT mathematics scores are scaled scores ranging from 2000-3000 with the course percentage grades a continuous percentage from 0% to 100%. Finally, categorizing students in the sample as belonging to a course with or without formative multiple assessment attempts presents a nominal variable in this study. The formative assessment study is limited to the content area of mathematics and grade levels of 6-8 using archived data; future studies may examine different subject areas or grade levels concerning multiple formative assessment attempts.

Protection of Participants' Rights

Protection of Identity

In this research, the data collected is from secondary archived data stored in a secure electronic database. Before I had access to the data, the names of students and teachers linked to the achieved data was removed and randomly assigned a number. Once all data was deidentified, I analyzed the population demographics provided by the district and determined the sample of data had similar demographics to the from the student population. Therefore, the identity of teachers and students was protected throughout the analysis and examination of the assessment data. All information is confidential and protected through the removal and disassociation of names with SSAT test scores and mathematics course percentage grades. The identity of the local district was concealed to provide protection for the identity of the district upon publication of results. Additionally, all electronic information was stored on a password-protected computer with password-protected files. Finally, all data will be kept in a secure location for 5 years after the conclusion of the study. After the 5-year period, all hard copies will be shredded and electronic information deleted.

Permissions for the Study

Before the collection of any archived data, permission was granted from Walden University Institutional Review Board (IRB). Next, I completed all procedures to obtain approval from the local district, including the letter of cooperation before IRB approval, to conduct an examination of the archived testing and grade percentage data. Again, removing all names associated with the data set to ensure full confidentiality of teacher and student names. All procedures and guidelines were followed throughout the course of this study to ensure full protection of the identity teachers and students. The use of archived data allowed for an examination of assessment practices without intrusion or disruption of any teaching or learning in each school setting.

Analysis and Results

The purpose of this study was to compare mathematics achievement, growth, and course percentage grades for students who were given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. This study was designed to use a one-way multivariate analysis (MANOVA) to test if the two options for assessment, with or without reassessment differed significantly for the three dependent variables of this study. Additionally, an independent samples *t* test was also performed based to examine which of the independent and dependent variable combinations provided the significant finding found in the MANOVA. The following research question and hypothesis guided the one-way MANOVA and independent samples *t* test through the analysis portion:

RQ: How does the use of multiple assessment attempts with formative feedback compare to not using multiple assessment attempts in terms of students mathematics achievement, growth, and course percentage grades?

H_o : Students enrolled in math classes using multiple assessment attempts with formative feedback will not have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

H_a: Students enrolled in math classes using multiple assessment attempts with formative feedback will have statistically significant higher mathematics growth, achievement, and course percentage grades compared with students using traditional assessment methods without multiple assessment attempts and formative feedback.

This section provides the student demographics, with a complete summary of results, followed by an interpretation and discussion of the findings leading to The Project in Section 3.

Descriptive Statistics

The population of interest in this study was middle school mathematics students already assigned to a mathematics course with either an option for reassessment or not during the 2015-2016 school year. Upon IRB and district approval, a total of 105 student-archived scores were collected for the purposes of this study. I gathered these 105 student scores from two of the three middle schools in the district. The population of interest consisted of a total of 1,442 students from those two middle schools. Following IRB protocol, any students receiving special education services through an IEP or 504 were removed from the data because they are considered a vulnerable population. Students receiving special education services have a wide variety of accommodations, interventions, varied grade level curriculum, and additional progress monitoring based on their IEP or 504. Therefore, students with an IEP or 504 were removed from the data set to maintain consistency of instruction and assessment practices for students in sample. Additionally, I removed any students who did not have a SSAT score for the 2013-2014 school year because this score was needed to calculate student growth scores. The total sample of students for this study n = 83. Of the 83 students, 41 were from two classes allowing reassessment and 42 were from two classes not allowing reassessment. I then analyzed the sample for similar demographics compared to the district population.

The district population is homogenous with little diversity. The data collected for this study aligned with the overall district population. An examination of ethnicity and race reveal the closely aligned sample compared with the district population described in the setting and sample section of this study with 89% Caucasian, 1% Hispanic/Latino, 4% American Indian/Alaska Native, 1% Asian, 4% African America, 0% Native Hawaiian/Pacific Islander, and 0% of students Multiracial. Of the students in the sample, 35% were students on free or reduced lunch, with 10.8% of original 105 students in the sample qualifying for special education services. The students qualifying for special education services were removed before data analysis. The sample was comprised of an equal gender split with 50.6% female and 49.4% male students. SPSS was utilized analyze the descriptive statistics for the data collected. With the sample closely resembling the district population, the analysis of findings began with an examination of the means, and standard deviations to get an overall sense of the data. The means of the course percentage grades with or without reassessment are seen in Table 1 below.

Table 1

Descriptive Statistics

	Reassessment	*N*	*M*	*SD*	*SEM*
Second-Semester course percentage grades	Yes	42	76.74%	15.48%	2.39%
	No	41	70.73%	9.29%	1.45%
State Standardized Mathematics Test Score	Yes	42	2543.24	64.61	9.97
	No	41	2545.85	69.64	10.88
State Standardized Mathematics Growth Score	Yes	42	25.33	44.73	6.9
	No	41	37.46	48.24	7.53

I conducted a one-way multivariate analysis (MANOVA) to answer the research question in this study. The key elements of a MANOVA are detailed in the analysis section that follows along with the results.

One-Way MANOVA

I used a one-way MANOVA to investigate if the two assessment groups (with or without the use of multiple formative assessment attempts) differ statistically from one another in terms of the three dependent variables which include, students' standardized mathematics test score, growth on standardized mathematics test score, and course percentage grade in their mathematics course. As a powerful statistical test, the MANOVA allows for a multivariate analysis of variance between the independent variable split into two assessment options and the three dependent variables. Using SPSS 24.0, I confirmed that all of the nine assumptions of a one-way MANOVA were met. The first four assumptions include; two or more dependent variables, an independent variable with two or more categorical groups, independent observations with participants in separate groups, and an adequate sample size with $n = 83$, which is greater than the number of given dependent variables.

I used boxplots to examine the data for any outliers using SPSS 24.0. Another assumption of a one-way MANOVA is that there are no univariate of multivariate outliers. The boxplot of the second-semester course percentage grades revealed no outliers. However, the boxplots of the SSAT scores and growth scores appeared to have one outlier. Therefore, a Mahalanobis Distance test was used through SPSS 24.0 to analyze any unusual combinations of scores and identify any multivariate outliers. Through the use of the Mahalanobis Distance test, one possible outlier was revealed. However, the outlier was at a value of 9.79 with the stem-and-leaf plot produced by the Mahalanobis Distance test, indicating one outlier for any value of 9.8 or greater could violate one of the one-way MANOVA assumptions. Yet, with the outlier so close to the range of data and not within an extreme limit, I determined to allow the data because there was only one data point as an outlier and it was so close to the outlier limit.

A multivariate normality is another assumption of a one-way MANOVA. A Shapiro-Wilk test in SPSS 24.0 was used to test that the sample was normally distributed. The test showed a p value for all of the three dependent variables that was greater than the chosen alpha value of .05. Therefore, the data displays a normal distribution and upholds the one-way MANOVA assumption of multivariate normality. Table 2 displays the results of the Sharpiro-Wilk test of normality below.

Table 2

Sharpio-Wilk Test of Normality

	Statistic	*df*	*Sig.*
Second-Semester course percentage grades	0.98	83	0.21
State Standardized Mathematics Test Score	0.98	83	0.2
State Standardized Mathematics Growth Score	0.98	83	0.19

A linear relationship was examined using scatterplots through SPSS 24.0 to check the one-way MANOVA assumption of no multicollinearity. A scatterplot was created for each of the dependent variables paired with one another to provide a visual check that the dependent variables were moderately correlated. A scatterplot between the independent and dependent variable was not possible because the independent variable is categorical. The additional and final assumption of homogeneity of variance of a one-way MANOVA was tested for by using SPSS 24.0 and detailed in the following results section.

Results and Analysis

A one-way MANOVA was conducted indicating there was a statistically significant effect between the reassessment option and the combined dependent variables (F (3, 79) = 2.991, p = .04; Wilks's λ = .900, multivariate n^2 = .10). This was determined based on a p value =.04 which was less than the level of significance of .05. The multivariant n^2 indicates that approximately 10 % of the multivariate variance of the dependent variables is associated with the reassessment options. A Wilks's λ was an appropriate test to use based on Box's M test and Levene's Test of Homogeneity, to test for another one-way MANOVA assumption of homogeneity of variance (Laerd Statistics, 2018). Based on the multivariate test output, the *F* score of 2.911 is greater than the *F* critical associated with an alpha of .05 and *F* critical of 2.72 I reject H_o. The results indicated a statistically significant finding. Table 3 provides a detailed overview of the multivariate tests.

Table 3

Wilks's Lambda Multivariate Tests

Effect	*Value*	*F*	*Hypothesis df*	*Error df*	*Sig*
Reassessment	0.9	2.91	3	79	0.04

Computed using alpha = .05

Based on the statistically significant results of the one-way MANOVA, Box's Test of Equality of Covariance Matrices was performed showed a *p* (.011) > α (.001)- indicating that Wilks' Lambda is an appropriate test. *Box's M* test uses a significance of .001 to determine if the assumption is violated. The result of *Box's M*, seen below in Table 4, indicated that there was no significant difference between the covariance matrices, therefore, Wilk's Lambda was an appropriate test to use.

Table 4

Box's Test of Equality of Covariance Matrices

Box's M	*F*	*df1*	*df2*	*Sig.*
17.21	2.753	6	47458.76	0.011

The Levene's Test of Equality of Error and Variances was used to test an additional assumption of a one-way MANOVA that the variances of each variable are equal across all of the groups. Levene's Test as seen in Table 5 below displays the SSAT score and growth scores both had *p* >.05. However, the second-semester course percentage grade was $p <. 05$, indicating the assumption of equal variance was met for this dependent variable.

Table 5

Levene's Test of Equality of Variances

	F	*df1*	*df2*	*Sig.*
Second-Semester course percentage grades	11.05	1	81	0.001
State Standardized Mathematics Test Score	0.15	1	81	0.703
State Standardized Mathematics Growth Score	0.13	1	81	0.715

With a statistically significant result based on the one-way MANOVA, an analysis of Test of Between-Subject Effects was examined. The *F* score and later a independent samples *t* test for each of the dependent variables were analyzed independently due to the fact that a post hoc analysis is not possible with only two groups (with or without reassessment). The first dependent variable, second-semester course percentage grades had an *F* computed value of 4.570, which is greater than the *F* critical value of 3.95, based on *dfn* of 1 and *dfd* of 81. An *F* test is a one-tailed test and because the *F* computed value is greater than the *F* critical value I reject H_o - indicating there is a difference in the means. However, the other two dependent variables (SSAT score and growth score) have an *F* computed value less than the *F* critical value, indicating we do not reject the H_o and that there is not a difference between the means. The *F* score was determined by finding the mean square due to regression (MSR) and dividing it by the mean square due to error (MSE). By taking the sum of square regression (SSR) divided by the degrees of freedom numerator the mean square due to regression was calculated. Next, dividing the sum of squares error and degrees of freedom denominator, the mean square due to error was calculated. The *F* score is the MSR divided by the MSE. All data from the Test of Between Subject-Effects is below in

Table 6

Tests of Between Subject Effects

	df	*Mean Square*	*F*	*Sig.*	*df*
Second-Semester course percentage grades	1	748.74	4.57	0.04	81
State Standardized Mathematics Test Score	1	141.93	0.03	0.86	81
State Standardized Mathematics Growth Score	1	3052.69	1.412	0.24	81

While the results of a one-way MANOVA indicated statistically significant difference, an additional post hoc test was not possible because the independent variable contains only two groups (with or without reassessment). A post hoc test is not possible with less than three groups. Therefore, the Tests of Between-Subject Effects was analyzed. Of the three dependent variables, the second-semester course percentage grades revealed a significant *F* score of 4.570 with a significance level of less than .05, which is statistically significant. However, the remaining dependent variables did not indicate significance because their *p* values were larger than .05. The SSAT $p = .860$ and the growth score $p = .238$. The statistically significant finding was for the second-semester course percentage grades, indicating that students who were given reassessment options scores significantly lower than students who were not allowed reassessment options.

Independent-Samples t-Test

To provide additional strength to the statistical analysis and since as previously mentioned a post hoc was not possible for these data, An independent samples *t* test provided the clarification and scrutiny for each assessment option with each dependent variable. As seen in Table 1 and Table 7, results of the one-sample *t* test showed that the mean for the second-semester course percentage grades for students not allowed reassessment (M = 76.73%, SD = 15.48, n = 42) and students allowed reassessment options (M = 70.73%, SD = 9.39, n = 41) were statistically significant at the .05 level of significance with ($t(81) = 2.15$, $df = 81$, $p < .05$) with a level of significance of .05 was found only the course percentage grades dependent variable. Students who were allowed reassessment options had a lower average second-semester course grade by about 6% compared to students who were not allowed reassessments. Greater average second-semester course percentage grades for students not allowed the option of reassessment was the opposite of my original hypothesis.

For the course percentage grades $t(81)$= 2.15 with a *t* critical of 1.663 for the one-tailed *t* test, the null hypothesis is rejected which suggests there is a difference between the mean second-semester course percentage grades , state standardized mathematics test score, and growth score for the state standardized test because the *t* computed is greater than the *t* critical, indicating there is a statistically significant difference in the means for the course percentage grades . Upon examination of the remaining two dependent variables, the *p* value was greater than the level of significance of .05. To further support the analysis, confidence intervals were examined for each of the dependent variables with respect to the nominal independent variable. As seen in Table 7, the 95% confidence interval does not include the value of 0 for only the course percentage grades, which had significant findings. The SSAT and growth scores do include the value of 0 for the 95% confidence interval and are not statistically significant.

Table 7

Independent-Samples t *Tests*

		F	*Sig.*	*t*	*df*	*Sig.(2-tailed)*	*95% Confidence Interval of the Difference*	
							Lower	*Upper*
Second-Semester course percentage grades	Equal variances assumed	11.05	0.001	2.14	81	0.04	0.42%	11.60%
	Equal variances not assumed			2.15	67.45	0.04	0.43%	11.58%
State Standardized Mathematics Test Score	Equal variances assumed	0.15	0.7	0.18	81	0.86	-31.95	26.71
	Equal variances not assumed			0.18	80.21	0.86	-31.95	26.75
State Standardized Mathematics Growth Score	Equal variances assumed	0.13	0.72	1.19	81	0.24	-32.44	8.18
	Equal variances not assumed			1.19	80.2	0.24	-32.46	8.2

Summary of Analysis

The statistically powerful and complex one-way MANOVA indicated that the effect between the reassessment option and the combined dependent variables was statistically significant, which caused a rejection of H_o. Using a one-way MANOVA and an *f* test as well as an independent samples *t* test, confirmed a statistically significant difference for only the course percentage grades . The SSAT and growth scores were examined using both an *f* test and *t* test, but they did not indicate statistically significant differences between the independent variable groups, with or without reassessment. Finally, an examination of 95% confidence interval provides final confirmation of the statistically significant results described throughout this analysis. The discussion, assumptions, limitations, and delimitations sections that follow provide one final consideration of results, which lead to the project.

Discussion

The one-way MANOVA analysis revealed statistically significant results. Upon examination of the Tests of Between-Subjects Effects and the independent samples *t* test a difference was determined for course percentage grades only. These results indicate that between the two groups (with or without assessment retake options) only second-semester course percentage grades were impacted, while statistically significant differences were not indicated for the state standardized test or students' growth scores on the state standardized test.

The sample in this study mirrors the demographics of the district student population. Therefore, the sample can be considered representative of the population of interest. Additionally, no major departures from normality or homogeneity of variance were found during the analysis process that would influence the findings of this study. Upon analysis of the *f* test and *t* test, I found only the second-semester course percentage grades revealed a significant difference. Furthermore, students who were not allowed reassessment actually outperformed students who were allowed reassessment. This finding alone warrants a need for additional research because if reassessment is considered a formative assessment strategy, it goes against findings of Black and Wiliam (1998) and the argument that formative assessment improves student learning.

The purpose of this study was to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. This study met the intended purpose with significant findings. Students who were allowed test retake options had a lower mean second-semester course percentage grade (70.7%) compared to the second-semester course percentage grade (76.7%) for students who were not allowed retake options. While these findings indicate a statistically significant difference for the dependent variable of second-semester course percentage grades. It was hypothesized that the ability for students to use multiple reassessments as a formative assessment strategy would provide an increase in second-semester course percentage grade, SSAT scores, and growth scores. However, the findings of this study contradict that thought and warrant additional investigation regarding options for reassessment as a formative assessment strategy. As pointed out by Turner (2014) and Wylie and Lyon (2015), the power of formative assessment is in student involvement in the process and how teachers use the achievement information from assessments. An investigation and training specific to the area of how to involve students in formative assessment in the classroom and how teachers used assessment data may prove beneficial.

Although this study indicated significant findings, further research needs to be conducted to gain a better understanding of how assessment options impact course percentage grades state testing scores, and student growth scores. Specifically, as detailed in the following limitations section, research regarding students' knowledge that they were allowed reassessments and how that impacted their overall effort to prepare for assessments. Furthermore, and in agreement with previous formative assessment research (Ateh & Wyngowski, 2015; Matthews & Noyes, 2016), an investigation into how teachers and students used the information to guide instruction and learning based on the given classroom assessment would be of value in the area of reassessment as a formative assessment option.

Assumptions, Limitations, and Delimitations

Assumptions

To produce complete and reliable results for this formative assessment study, it is important to recognize and examine any inherent assumptions and limitations as well as their potential impact on the study results. With the mathematics department completing a new curriculum adoption in the spring prior to the 2014-2015 school year presented in this study, new curriculum materials were adopted. It is assumed that all teachers in the local district were using the curriculum materials as intended through the adoption specifications of the district. Additionally, to build consistency at the middle school level, with input from teachers, the mathematics coach developed common assessments for each unit of study and mathematics standard in grades 6-8. It is assumed that all middle school math teachers were using these common assessments and recording student percentages on the assessments through the Skyward (2017, Version 05.16.10.00.09) software system. It is also assumed that students were using feedback from teachers to improve their understanding and are making their best effort to complete all assessments, assignments, and state standardized tests. Finally, in calculating student course percentage grade scores, it is assumed that all teachers were entering scores into Skyward (2017, Version 05.16.10.00.09) that were linked to state mathematics standards. The assumptions of curriculum usage, common assessments, student effort, and standards are important to recognize moving forward in the research process with an awareness of how the assumptions may be linked to limitation or potential weaknesses in the presented study.

Limitations

Limitations that may affect results of this formative assessment study include concerns of inconsistent assessment practices. I will use the second-semester course percentage grade. The majority (70% to 80%) of the course percentage grade is composed of common assessments averaged over the course of a semester. Yet, this study is limited in that teachers are given flexibility in determining the remaining 20-30% of the grade a student’s grade. The remaining percentage of the grade is composed of small weekly quizzes and homework assignments to meet the needs of individual classes. However, district approved curriculum is used for quizzes and homework assignments throughout the middle school level. Yet, based on the needs of students in the class, teacher discretion is used on when to assign students homework and administer quizzes.

The district math coach designed common assessments with teacher input, making this data source practical and applicable to the intended educational audience to see how these common assessments with or without the option for reassessment as a formative strategy functions in a real-life school practice. However, even though the common assessments are all aligned with state standards and used in the classroom, they have not gone through formal testing for validity or reliability as in the case with the SSAT.

Additionally, students were already assigned to a teacher and mathematics course for the year. Therefore, an ex post facto quasi-experimental design was used since it is consistent with participants already assigned to preexisting groups. With the students assigned to the preexisting groups, students know ahead of time if their teacher will or will not allow reassessment of common assessments during the course of the school year. Therefore, an additional limitation is student awareness that they either can or cannot retake an assessment. This awareness may impact their effort and preparation for math course assessments, presenting a possible additional limitation. Finally, the preexisting groups may not be equal in terms of math ability or other demographics, therefore, limiting the ability to generalize findings of this study beyond the accessible population in this study.

Delimitations

With the local district piloting a new assessment program at the middle school level in the content area of mathematics, I limited the population of this study to include only middle school mathematics classes. Additional, delimitations include the sample size. To account for the large number of teachers opting to use the new multiple assessment attempts with formative feedback and only a small number of teachers not providing formative feedback, I specifically selected a total of four classes for the sample size in the correlation portion of this study. This will allow for an investigation into the two specific assessment options while keeping the study size manageable and meaningful for the local district and intended population. Data will only be examined under a theoretical framework focused on formative assessment and possible differences between two specific assessment practices. Finally, the overall quantitative design of this study presents a source of delimitation because I have examined numerical assessment data as linked to the aforementioned research question, as opposed to teacher or student perspectives and opinions on the use of multiple formative assessment attempts, which is aligned with a qualitative design. The delimitations presented impact the scope of this formative assessment study.

Summary

In Section 2, I discussed the quantitative method use for a statistical analysis and comparison of assessment methods in terms of achievement, growth, and course percentage grades. Furthermore, I presented the population, sampling procedures, instrumentation, and data analysis plan. This ex post facto quasi-experimental study of multiple formative assessment attempts uses secondary archived data. Data collection and analysis was carried out after receiving approval from the Walden University Institutional Review Board, as well as the local school district. Disassociation of names and data provided the necessary protection of all teacher and student identities.

The quantitative findings presented in Section 2, show a statistically significant difference between students who are allowed multiple formative assessment attempts versus students enrolled in a mathematics class not allowing multiple formative assessment attempts. Upon further investigation with the use of independent samples *t* tests, it was revealed that students who were not allowed reassessment had higher second-semester course average grades compared with students allowed reassessment. With a plethora of studies indicating a positive impact on student achievement with increased formative assessment, these findings are not consistent with the literature. However, as detailed in the limitations section of this study, only the opportunity for reassessment was compared, not how the reassessments were implemented or how students were involved in the formative assessment strategy. Formative assessment research calls for students' involvement (Ateh & Wyngowski, 2015; Matthews & Noyes, 2016), and research regarding student and teacher mindsets (Boaler, 2016). As a result, a 3-day professional development with ongoing follow-up support was designed to encourage middle school mathematics teachers to create a classroom culture and climate to involve students in the process of formative assessment for growth and achievement. A description of the project will be detailed in Section 3. In Section 4, I present a reflection detailing strengths, limitations, and implications for future research.

Section 3: The Project

Introduction

The purpose of this study was to compare mathematics achievement, growth, and course percentage grade for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. Based on the findings from this study, professional development in formative assessment is needed to support middle school mathematics teachers. The data from this quantitative study showed a statistical difference between students who were allowed reassessment compared with students in classes who were not allowed reassessment. However, there was a statistical difference only in second-semester course percentage grade, with no statistically significant difference for students' state standardized test score or growth score. Further, students enrolled in classes that did not allow reassessment had higher mean second-semester course percentage grade compared with students allowed reassessment. Therefore, the quantitative findings indicate a need for training and opportunity to reflect on how formative assessments are used in middle school mathematics classes and how to create a classroom culture to foster student involvement in the formative assessment process to foster growth and improved achievement.

I created a 3-day professional development program with ongoing support and collaboration to support teachers in the establishment and implementation of formative assessment practices that involve both the teacher and the student in the learning process. First, the program will allow for teachers to explore their current mindset about mathematics and how to create a classroom culture focused on growth and improvement.

Second, the professional development program will support teachers in implementing formative assessment strategies that involve students in the assessment process and allow teachers to use formative assessment data to drive instructional practices and decisions. Next, the program will examine technology uses and instructional strategies that allow teachers and students to have immediate feedback and inform both instructional and learning practices. Finally, ongoing support through job-embedded collaboration and technology will allow teachers to record and reflect on their formative assessment implementation in class for improvement. The purpose of this professional development program is to support teachers in creating a classroom culture and environment focused on growth and improvement in mathematics, increase teachers' knowledge of assessment practices and how to implement these practices in their classroom, and encourage the use of technology to provide immediate feedback and follow-up for improved formative assessment practices.

Rationale

The results for the study were only statistically significant in second-semester course grades, and the students not allowed reassessment actually outperformed students allowed reassessment as a formative assessment opportunity. Wylie and Lyon (2015) suggested targeted formative assessment professional development that accounts for the complex implementation process of formative assessment strategies surrounding clear learning expectations, feedback for learning, and developing a collaboration within a classroom setting. Black and Wiliam (1998) discussed positive improvements in student learning with improved formative assessment practices and served as a catalyst for this and many other formative assessment studies. Additionally, Sadler (1998) argued for student involvement in the process of formative assessment and the importance of this personal investment for increased learning and achievement. With the findings of this study revealing lack of improvement in second-semester course grades for students allowed reassessment and no difference in growth or state test scores between the two assessment options, an opportunity for professional development to improve formative assessment practices for middle school classes is evident. A need for increased professional development in assessment is necessary (Randel et al., 2016).

Based on the findings of this study, the current reassessment practice of allowing students to retake a test did not contribute to the learners' improvement or overall growth for their mathematics achievement. Therefore, training regarding effective implementation of formative assessment and the establishment of a classroom culture and climate for growth is warranted. Forming the theoretical foundation of this study, Black and Wiliam (1998) found improved student achievement and a positive impact on student learning with improved formative assessment practices. Additionally, Chan et al. (2014), and Dixson and Worrell (2016) pointed out the importance of adjusting instruction to the needs of the individual learner for positive growth. Building synergy between formative assessment practices and summative assessments was pointed out as an important element in improved learning by Delisle (2015). With the only statistical difference between the two assessment groups seen in the second-semester course grade and no statistically significant difference between the groups for the state mathematics test or growth score, the current use of reassessment and how to best implement formative assessment into mathematics classrooms needs training and support. In a qualitative study of math teachers' needs, it was made clear through teacher interview the need for "specialized professional development" (Fisher & Royster, 2016, p. 1005). The following review of the literature supports current implementation of formative assessment practices and creating a mathematics classroom and culture to support students' growth and learning. According to Andersson and Palm (2017a) "most teachers would benefit from substantial support in their endeavor to develop their use of formative assessment, and when such support is provided it might result in improved classroom practice that enhances students' achievement" (pp.119-120).

Review of the Literature

Using Walden University's resources and searching ERIC and Education Source databases as well as Internet searches with Google Scholar, I collected and analyzed articles from peer-reviewed journals. Additionally, I read and analyzed a variety of mathematics instruction books. Keywords for my search included *formative assessment, professional development and math professional development, in-service professional development, formative assessment technology, growth mindset, and teacher training*. After research and reaching saturation, the above-mentioned resources were used to create a formative assessment professional development to meet the needs as determined by the findings of this study.

Based on the findings of this study and current formative assessment and professional development literature, the project and therefore, this review of the literature, will be centered on three main areas of educational practice. First, using formative assessment strategies and techniques to drive mathematics instruction and improve student success is examined. Second, the literature review examined formative assessment in mathematics classroom for learning and growth with the creation of a classroom culture and climate that fosters a growth mindset. Finally, professional development and the use of classroom technology, specific to the curriculum area of mathematics, will provide efficient tools for assessment and timely feedback. The information and sources presented in this review of the literature, as well as results from this formative assessment study provide the foundation for the project, also presented in this section.

Formative Assessment

The use of formative assessment in the classroom can be carried out with a variety of strategies. Polly, Martin, and Pugalee (2017) described formative assessment as a process of collecting, analyzing, modifying, and addressing specific students needs. When used effectively, formative assessment was identified as one of the most powerful factors for student achievement (Polly, Martin, & Pugalee, 2017). In a recent study of a formative assessment professional development for mathematics teachers in Sweden, Andersson and Palm (2017a) found positive gains in student achievement. Formative assessment involves an interactive process between students, teachers, and peers to analyze areas of strength and focus on improvement and growth in areas of need for the learning. “Formative assessment demands a student-centered instructional approach in which students’ progress and performance coincide” (Meusen-Beekman, Brinke, & Boshuizen, 2016, p. 127) Key characteristics and strategies of formative assessment for the teacher, learner, and peers which include: clarifying learning goals, providing and using learning resources, using feedback to move learners forward, analysis of evidence of student learning (Andersson & Palm, 2017; Polly, Martin, & Pugalee, 2017). In essence, creating an active and team-like approach to learning is a critical component of formative assessment in the classroom.

In an extensive review of literature, Meusen-Beekman, Brinke, and Boshuizen (2015) examined self-regulated learning as it relates to formative assessment. Through their review, they found students' self-regulation could be developed through training and practice. This self-regulation practice involves formative assessment as students and teachers work together to plan, monitor, and reflect on their learning. Creating a classroom environment where active reflection and learning can occur is an important part of the formative assessment process. Through observations and teacher interviews, Andersson and Palm (2017a) pointed out the importance of creating a classroom culture where mistakes and questions were encourages and viewed as learning opportunities. Additionally, the researchers noted that students were involved in working together with peer groups and reflecting on what they already knew and next steps to move their learning forward (Andersson & Palm, 2017a). After the formative assessment professional development, teachers in the study noted they found improvements in setting clear goals, improved feedback for learning, and student involvement in the learning process.

In the formative assessment process, students take an active role in their learning. In a study of peer and self-assessment, Meusen-Beekman et al. (2016) found formative assessment was beneficial in supporting students to develop both peer and self-regulation skills. Both peer and self-assessment are complex skills that involve a reflective process of learning and thinking about next steps to move learning forward that should be focused on the task and process of learning. Students become less dependent on their teacher as the keeper of knowledge and more able to regulate their own learning. Additionally, students are able to engage in peer feedback and interactions when they are involved in the formative assessment process leading to positive impacts for student learning (Meusen-Beekman et al., 2016; Wylie & Lyon, 2015).

With formative assessment geared toward providing feedback for learning, timing of the feedback is important. Eddy, Harrell, and Heitz (2017) investigated short-cycle formative assessment and the observation protocol for middle and secondary math teachers called *AssessToday*. The findings of their study suggested that short-cycle formative assessment is beneficial in detecting student misunderstandings and providing feedback and areas for improvement. Additionally, the *AssessToday* protocol was found to be valid and reliable as a measure of teacher's formative assessment implementation (Eddy et al., 2017). In another formative assessment study, Polly et al. (2017) found a positive impact on student achievement with increased use of assessment tools to guide learning. Additionally, students in this study from a lower socioeconomic group grew more than their peers with increased formative assessment use. The timing and frequency of formative assessment is an important component of consideration and impactful for student achievement.

Formative assessment involves teachers, students, and peers working as a team toward improvement. Randel et al. (2016) described the importance of using clear learning targets that were made clear to students with ample feedback for learning as a critical component in the formative assessment process. Emphasis on feedback and details specific toward improvement are helpful for the learner, as opposed to a letter grade or check marks (Randel, et al., 2016).

An additional study from Pinger, Rakoczy, Besser, and Klieme (2018) found that not all types of feedback were equal in quality. After a quasi-experimental study of ninth-grade math classes, regarding implementation of formative assessment delivery, found positive effects when feedback was built into instruction. Additionally, the researchers recommended using process-oriented feedback to focus learners on the strengths and weaknesses they need to address in order achieve set learning goals (Pinger et al., 2018). Wylie and Lyon (2015) provided additional support to the importance of feedback in their formative assessment study and described the use of specific strategies that did not use letter grades or marks but written feedback and mastery grading to move learning forward.

While the formative assessment process and implementation into classroom practice are complex, major themes and commonalities can be seen in the review of current formative assessment literature. Wylie and Lyon (2015) presented a list of five clear and concise strategies for implementing formative assessment into daily classroom practices. These five strategies include:

1. clarifying and sharing learning expectations

2. engineering effective classroom discussions, questions and learning tasks that elicit evidence of learning
3. providing feedback that moves learning forward
4. activating students as the owners of their own learning
5. activating students as instructional resources for one another (pp. 140-141).

This comprehensive list of the five strategies is both practical in nature and meaningful to guide future formative assessment professional development programs. Student involvement in the assessment process and their ability to persevere leads to a discussion of how a growth mindset impacts learning.

Growth Mindset

Establishing a classroom culture and climate centered on improvement and growth creates prospects for improvement. Jo Boaler, a Professor of Mathematics Education at Stanford Graduate School of Education, pointed out the importance of a growth mindset for teaching mathematics and embracing mistakes as learning opportunities. “One of the most powerful moves a teacher or parent can make is in changing the messages they give about mistakes and wrong answers in mathematics” (Boaler, 2016, p. 15). As a Professor of Psychology and leading researcher of mindsets, Dweck’s (2015) discussion aligns with Boaler (2016) as they point out, students who have a growth mindset will embrace mistakes and improve versus students with a fixed mindset who will often shut down or give up when they have made a mistake. Establishing a mathematics classroom culture in which mistakes are embraced as opposed to rewarding correct answers creates chances for students to learn and grow (Boaler, 2016; Dweck, 2015).

A growth mindset encourages resilience and persistence as students learn from mistakes. With improved efforts and knowledge in educational brain research, Dweck (2015) described that belief in one's ability to grow and learn can have a direct impact on improved achievement over time. Our brains are created for growth and learning and demonstrate incredible plasticity for improvement (Boaler, 2016 & Dweck, 2015). In a qualitative study of Grades 4 through 9, Van der Nest, Long, and Engelbrecht (2018) examined the impact of formative assessment activities in mathematics. The researchers discussed the importance of growth mindset through creating a culture in which mathematics is attainable to everyone through decreased math anxiety and improved formative assessment efforts (Van der Nest, Long, & Engelbrecht, 2018). As pointed out by Dweck (2015), the current school system atmosphere is centered on evaluation, testing, and rewards. However, in a recent study comparing two different online math games found that students who were rewarded for growth demonstrated greater persistence compared to students who were rewarded for answering questions correctly and quickly. Additionally, students who were considered at-risk or struggling students showed the greatest amount of sustained effort because they were rewarded for growth, not answering questions quickly (Dweck, 2015).

In another study of a growth mindset, Chao, Visaria, Mukhopadhyay, and Dehejia, (2017) examined an incentive system to reward a growth mindset in which students were taught about how their brain grows and learns. It was explained to students that our brain was like other muscles in our body and grows when exercised. The findings of the growth mindset intervention improved student performance only when incentives provided students with autonomy (Chao et al., 2017). Creating a culture in mathematics classes that foster a growth mindset in an era of accountability is a challenging task and may begin with a teachers' growth mindset and establishing a culture and classroom climate geared toward embracing mistakes as part of a growth mindset. In another study, Anderson and Palm (2017) examined teachers' classroom practices during a 4-year study in Sweden. Through teacher interviews and observations, the researchers found improving formative assessment practices and growth mindset present a plethora of challenges and may require major changes to many classroom practices.

In an examination of teachers' growth mindset, Rutherford, Long, and Farkas (2017) pointed out teachers' beliefs in their abilities and their mindset about their effectiveness in the classroom may account for differences in student outcomes and motivation. Therefore, it is important to examine the mindset of the teacher as well as the student when discussing growth mindset and a culture of learning. In their study of teacher self-efficacy and mathematics, Rutherford et al, (2017) found that increased teacher value for professional training was associated with higher self-efficacy and a slight positive association with student achievement. A growth mindset is worthy of examination at both the teacher and student perspective. This study pointed out the positive impact professional development can play the role of student achievement.

In an examination of students' growth mindset, Yeager et al. (2016) examined teaching 9^{th}- grade students about growth versus fixed mindsets. The study provides insight on how to develop a program to inform students about the importance of a growth mindset and revealed improved GPA for students in the growth mindset intervention group. Developing a classroom culture and environment in which students feel safe, connected to peers and capability of working toward their full potential can improve student motivation and a growth mindset for success. However,

> "When students doubt their capacities in school- for example, when they see a failed math test as evidence that they are not a 'math person'- they behave in ways that can make this true, for example, by studying less rather than more or by avoiding future math challenges they might learn from" (Yeager et al., 2016).

In a study of 49 high school teachers in the United States, Copur-Gencturk and Papakonstantinou (2016) collected data from 2005-2009 and determined teachers who participated in sustained professional development showed improvement in mathematical discourse and instruction, but lacked in the areas of student interactions and use of multiple representations. The United States has room to grow in terms of establishing mathematics classrooms that foster engagement and meet the needs of all learners (Copur-Gencturk & Papakonstantinou, 2016). The establishment of a classroom culture and environment in which formative assessment and a growth mindset are key components is critical for the mathematics formative assessment project.

Mathematics Professional Development and Technology

Improved efforts in professional development for teachers in the content area of mathematics are a needed and worthwhile pursuit. In a comprehensive literature review, Gersten, Taylor, Keys, Rolfhus, and Newman-Gonchar (2014) determined that out of the

643 studies of math professional development interventions only two met standards for professional development set by the What Works Clearinghouse and showed positive improvements in students' math proficiency. In another study of 231 teachers, Randel, et al. (2016) examined the impact of Classroom Assessment for Student Learning, a formative professional development program. The study found significant improvements on teacher knowledge and student involvement. Yet, this improvement did not transfer to teachers' assessment practice. The need for improved mathematics professional development is evident and in-service teachers specify the need and importance of more professional development specific to assessment (Randel et al., 2016). Similar identified needs and recommendations resulted from a three-year study by Jacob, Hill, and Corey (2017) of the Math Solutions Program a mathematics professional development. In their experimental study in which teachers were randomly assigned to the professional development training or the control group without training, limited positive effects were found on teachers but no effects on student outcomes. The researchers reported that the findings were disappointing and stated, "substantial change ma only come when teachers have the mind-set, but also the materials and ongoing support, to implement what they have learned" (Jacob et al., 2017, p. 403). Taton (2015) suggested new forms of mathematics professional development in which teachers act as mathematicians and engage in solving meaningful tasks as they analyze pedagogical practices. As teachers themselves engage in solving new problems and mathematical discussions, they will improve their knowledge of how students may tackle a new mathematical idea and solve a problem.

A cultural shift in thinking about mathematics professional development would require thinking about doing math as being creative and flexible in thinking (Taton, 2015). Allowing teachers to fully engage in mathematical processes and standards for practice while learning about how to assess students' thinking and process through formative assessment. In a qualitative case study examining voluntary middle school workshops, Stewart and Houchens (2014) described the need for an institutional and cultural change for a successful formative assessment initiative. Through the use of semi-structured interviews, Stewart and Houchens (2014) detailed the need for improved instructional practices and formative assessment that clearly communicated student progress toward a specified goal.

Meaningful and successful professional learning requires intensive planning and coordination that will not happen in one-time workshops (Stewart & Houchens, 2014; Taton, 2015) Instead, intensive training with follow-up workshops show promise for improved teacher knowledge and student achievement (Gersten et al., 2014; Stewart & Houchens, 2014; Taton, 2015). As suggested by Levi-Keren and Patkin (2014) beginning the planning process for professional development in mathematics should account for the currents needs and expectations of teachers so the training can be tailored to meet the individual needs of all teachers who are part of the professional development program. The planning process should also allow for a collaborative emphasis between teachers with the use of an ongoing support in the form of follow-up workshops to provide ongoing support and feedback as teachers try new strategies with their students.

Collaboration and reflection is an important component of professional development for teachers. In a study by Andersson and Palm (2017b), 22 teachers participated in a professional development program focusing on formative assessment. Through a comparison of pretest and posttest scores and the use of ANCOVA, it was determined that classes of teachers who attended the training out performed classes in which their teacher did not attend the professional development training. Andersson and Palm (2017b) described the importance of collaboration time during the study and supporting teachers in trying new formative assessment strategies. Guise et al. (2017) provided additional support in a case study of coteaching and professional growth. The teachers in the case study pointed out the value of daily collaboration and allowing time for reflection to support their individual needs and growth as educators.

The initial planning phase of a mathematics professional development should account for the needs of the teachers in the group (Levi-Keren & Patkin, 2014). In an evaluation of a two-year in-service training, Levi-Keren and Patkin (2014) used open-ended questionnaires to determine professional development programs should account for the needs of individual teachers and create realistic expectations to meet the varying needs of teachers with different levels of experience in the classroom. As seen in a study of in-services teacher professional development in rural Kentucky, Intensive training for teachers in the area of mathematics can lead to improvements in teaching abilities and student achievement (Barret, Cowen, Toma, & Troske, 2015). Moreover, providing teachers with opportunities to think critically as mathematicians and collaborate in a group focused on growth and improvement allows for the establishment of a supportive learning community and ongoing improvement (Sevis, Cross, & Hudson, 2017; Stewart & Houchens, 2014; Taton, 2015). Addressing the needs of teachers with quality, ongoing professional development that allows teachers to position themselves as learners in a supportive and collaborative environment shows great promise for quality professional development. In an era of technology-rich classrooms, technology may help support formative assessment and professional development endeavors.

The use of classroom technology can provide both teachers and students with timely feedback for learning. In a recent study of a professional development program with technology integration, Hill, Bicer, and Capraro (2016) found that as teachers increased the amount of classroom technology they used as part of the MathForward program, their students' mathematics scores improved. Integrating technology into mathematics classroom can provide students and teachers with immediate feedback for learning while students explore mathematical concepts (Gurevich, Stein, & Gorev, 2017). However, with the fast-paced changes of technology, teachers pointed out that it was difficult to find time to integrate new technology into their classroom instruction and assessment practices (Hill et. al., 2017). Therefore, building time for classroom technology use into professional development plans that would allow teachers to engage in common planning time with technology and analysis of student data could prove worthwhile and helpful for teachers (Hill et. al., 2017; Polly et al., 2017). In another study, Yildiz and Gokcek (2017) examined the use of the math technology program Geogebra in a geometry class. The researchers conducted semi-structured interviews, observations, and video taped classes to gather data. The researchers pointed out the positive feedback the classroom teacher received from her students while using Geogebra and improved teacher and learning opportunities from the Geogebra math technology. “This shows the importance of teachers’ experiences of using new technologies in their classes” (Yildiz & Gokcek, 2017, p. 25). Using a wide range of technology tools to enhance math instruction and assessment as part of the professional development training has the potential for great success.

Project Description

The purpose of this professional development program (Appendix A) is to support teachers in creating a classroom culture and environment focused on growth and improvement in mathematics, increase teachers’ knowledge of formative assessment practices and how to implement these practices in their classroom, and use technology to provide immediate feedback and follow-up for improved formative assessment practices. The three, full-day sessions will begin with the establishment of creating a growth mindset classroom culture (Boaler, 2016; Dweck, 2015). Formative assessment is an active process of working toward clear goals. Ample feedback and involvement are required from teachers and students alike. Thus moving beyond simple grade marks to a deeper look at learning targets and working toward correcting mistakes for learning warrants discussion regarding growth mindset. The second day of the training includes a variety of mathematical tasks and formative assessment strategies. These tasks will allow teachers the opportunity to engage in meaningful mathematical discourse and exploration through the perspective of the student. Additionally, teachers will learn to implement formative assessment strategies such as clear learning targets, meaningful discussion, feedback, and involving students in their own learning and assessment (Randel et al., 2016; Wylie & Lyon, 2015). Teachers will be given time to practice, collaborate with colleagues, and refine lessons they will be using in their classrooms for the upcoming school year to include formative assessment practices. Finally, teachers will engage with a variety of instructional and assessment technology specific to mathematics. "Technology benefits mathematics learning" (Hill et.al., 2017). Therefore, the third day of training will be dedicated to teaching instructors how to use technology for mathematics as they learn to implement formative assessment strategies in their classroom. The combination of growth mindset, formative assessment strategy implementation, and mathematics classroom technology for formative assessment has great promise for improved student achievement.

The final component of the formative assessment professional development plan is ongoing support. The ongoing support will provide collaborative opportunities for teachers to meet 4 times throughout the course of the school year as a middle school math department. With assistance and leadership from instructional coaches, the 4 sessions will allow teachers to reflect on their implementation and use of classroom formative assessment strategies. Finally, peer observations and instructional coaching opportunities will be available for an additional layer of support.

Support

The major resources and needed support system already exists in the local school district and three middle schools. As the lead trainer in the formative assessment professional development, I already work closely with instructional coaches at the local level. We have collaborated and facilitated instructional trainings together over the last three years. The instructional coaches in the local district have expressed willingness to provide ongoing support for facilitation of the initial training and during the job-embedded collaboration follow-up sessions (instructional coach, personal communication, June 4, 2018). The instructional coaches are in the three middle schools on a weekly basis and work closely with all middle school math teachers. This regular presence makes the instructional coaches easily accessible as they have developed a working relationship with math middle school math teachers and have expressed willingness to assist in anyway possible. Furthermore, there are three middle school facilities to host the 3 full-day formative assessment professional development and follow-up sessions. Each site has Internet access, projectors, copiers, and supplies needed for the training. Additionally, all teachers have their own laptop supplied by the local district. The needed site, supplies, and leaders are already in place to support the implementation of the formative assessment professional development.

Barriers

Two potential barriers for the formative assessment professional development are a small amount of needed funding and scheduling. Follow-up sessions during the school year could occur during already scheduled job-embedded collaboration time for the middle school math department. These sessions have already been scheduled for the upcoming school year. However, the agenda for the sessions are not yet planned. Professional development days are already scheduled before the beginning of the school year. Therefore, a potential barrier is that this would add three additional days of professional development for teachers. A possible solution is to write a grant to fund teacher pay for participation in the training and provide teachers with in-service credit hours that can be used for state-level recertification. This would provide an added incentive for teachers who participate in the formative assessment professional development, as they would be adding three additional workdays to their schedule. The only resource that will need to be purchased is a copy of *Mathematical Mindsets* by Boaler (2016) for each participant. Funding from the math department money from each building, district math department money, or grant funding could be used for the purchase.

Implementation Plan and Timetable

This professional development program begins with a 3-day training will occur in late August, before the beginning of the school year. Additionally, teachers will receive ongoing opportunities for support through job-embedded collaboration 4 times throughout the school year to assist in reflection and implementation of formative assessment strategies. Ongoing support in the form of peer observations, instructional coaching, and 4 job-embedded collaboration sessions throughout the course of the school year will allow teachers time to collaborate and work toward improving formative assessment implementation.

The 3-day program will begin with creating a culture and climate that supports student growth. On day two of the program, teachers will learn to implement formative assessment strategies that engage both teachers and students in working as a team to improve learning. The third day will focus on the use of technology to aid the implementation of formative assessment strategies and providing meaningful feedback for both students and teachers to move learning forward. The use of classroom technology and resources will streamline both the feedback component of formative assessment as well as reflection and learning opportunities as teachers implement formative assessment practices. Implementing major themes and successful formative assessment strategies from the previous review of literature will occur throughout the three-day training and during the four follow-up sessions.

Roles and Responsibilities

In order for the formative assessment professional development plan to be successfully implemented, several responsibilities and roles need to be considered. First, the program would need full approval from the local district through collaboration with instructional coaches, the director of secondary education, and middle school building principals. Collaboration and meetings would take place to facilitate coordination between myself, as a trainer, instructional coaches, middle school principals, and the director of secondary education. The director of secondary education instructional coaches, and I would collaborate and oversee the implementation and professional development training. Upon selection of a site to host the 3 full-day sessions and follow-up job-embedded sessions, the instructional coaches and I would need to coordinate and ensure all logistics were prepared in advance and planned. Next, with the assistance of instructional coached, I would lead the sessions and be fully prepared with a vast understanding of the formative assessment professional development program. Finally, instructional coaches and trainers would need to coordinate future sessions based on the needs of the teachers and next steps for improvement.

Project Evaluation Plan

During the 3-day formative professional development program, teachers will complete a brief formative survey at the end of each day. The survey will allow teachers to reflect on their learning as well as inform the instructor of any needed adjustments to the next planned session. At the conclusion of the 3-day formative assessment professional development, teachers will reflect on their learning and set goals for the upcoming school year and implementation of formative assessment practices. Progress toward these set goals will be revisited and self-monitored at each of the 4 follow-up sessions throughout the job-embedded collaboration time. The surveys administered at the end of the 3-day training and the conclusion of the follow-up sessions will follow recommendations for evaluation of professional development workshops as detailed by Lakin and Chaudhuri (2016). The evaluation survey will be administered using a Google Survey (Appendix F) with a 5-point scale consisting of the following: 1-below expectations, 2- average, 3-truly above average, 4- outstanding, 5- top 5%. Lakin and Chaudhuri (2016) advised changing the typical 5-point Likert scale by moving an average rating to a 2, thus avoiding a ceiling effect in which participants actually rated professional development more favorable than intended. In their study of educational workshop rating scales, Lakin and Chaudhuri (2016) modified advised using this modified Likert-scale with a rating of 2 for average because it was found to reduce a ceiling effect and upward bias for a more accurate representation and evaluation.

Prior to the follow-up sessions, teachers will be asked to try new formative assessment strategies and assessment practices. These practices my included involving students in the process of reflection on their first formative assessment (Try 1) or the use of one of the technology resources presented during the professional development program. Teachers will be asked to reflect, discuss, and share their thinking and experience with the implementation of formative assessment strategies. Teachers will be encouraged to complete peer observations focusing on the use of formative assessment strategies. At the end of the school year, teachers will complete a final survey to evaluate the formative assessment professional development program to judge the impact and overall effectiveness of the program as well as anticipated positive social changes. Key stakeholders involved in this formative assessment professional development program include middle school mathematics teachers, middle school administrators, parents, community members, and the students involved in each teacher's classroom as they implement formative assessment strategies.

Project Implications

This professional development may lead to positive social changes through the focus on improved formative assessment strategies and implementation of those strategies in middle school mathematics classrooms, which may lead to positive social change. Developing a classroom culture and climate with an emphasis on growth mindset, formative assessment strategies, and enhanced use of technology for mathematics instruction may better prepare students and lead to improved math achievement. Teaching students that anyone can be good at math through growth and hard work is a powerful message to inspire achievement at the local level and beyond. "Every second of the day our brain synapses are firing, and students raised in stimulating environments with growth mindset messages are capable of anything" (Boaler, 2016, p. 5). This formative assessment professional development arms teachers with the latest research and strategies for growth mindsets, formative assessment strategies, and mathematical technology tools. This project has the potential to not only improve mathematics achievement for students at middle school level but as they continue into high school as well. Additionally, with improved achievement in mathematics and involvement in their own achievement through formative assessment, students may be inspired and better prepared for more advanced math courses at the high school and college level as well. This improvement in the field of mathematics may result in increased interest in STEM education and careers in the STEM field. Moving beyond the local level, this formative assessment professional development can be modified and used for different grade levels and location around the country or world. Mathematics is a universal language for cultures throughout the world. Improving students attitudes toward mathematics through a growth mindset, training teachers to use formative assessment strategies to help students work toward mastery, and using technology to streamline and aid the feedback process is a powerful tool for positive social change at all levels in mathematics and around the world.

Conclusion

The purpose of this study was to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. The quantitative data and a one-way MANOVA analysis revealed statistically significant results. Upon examination of the independent samples *t* test, a difference was determined for course percentage grades only. These results indicate that between the two groups (with or without assessment retake options) only second-semester course percentage grades were impacted, while statistically significant differences were not indicated for the state standardized test or students' growth scores on the state standardized test. Therefore, from these findings a formative assessment professional development was developed with goals to support teachers in creating a classroom culture and environment focused on growth and improvement in mathematics, increase teachers' knowledge of formative assessment practices and how to implement these practices in their classroom, and use technology to provide immediate feedback and follow-up for improved formative assessment practices.

Section 4: Reflections and Conclusions

Introduction

Formative assessment is a powerful tool for improving students' success and achievement in mathematics (Black & Wiliam, 1998; Wylie & Lyon, 2015). With the local district piloting a new formative assessment model by using multiple assessment attempts, an investigation into the effectiveness of the formative assessment strategy was warranted. The purpose of this study was to compare mathematics achievement, growth, and course percentage grades for students who are given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. Upon data collection and analysis, a formative assessment professional development program was developed with goals to support a classroom culture and environment focused on growth mindsets, increase teachers' knowledge of formative assessment practices and how to implement these practices in their classroom, and use technology specific to mathematics instruction and feedback for formative assessment.

This section includes the project's strengths and limitations as well as recommendations for alternative approaches. This section also includes discussion on scholarship, project development, and leadership. Finally, I included personal reflections as well as implications and applications for future research.

Project Strengths and Limitations

The formative assessment professional development project strengths are that it provides teachers with an opportunity to increase their knowledge and ability to formative assessment strategies specific to mathematics. This project begins with an intensive 3-day workshop with ongoing support throughout the course of the school year. Teachers will meet formally four times a year during district-wide middle school math job-embedded collaboration. Opportunities for reflection and collaboration are built into the 3-day workshop, with ongoing support during the school year. Self reflections and reflections with instructional coaches and peer observations are encouraged to help teachers' implementation of formative assessment strategies to push learning forward. The 3-day workshop, ongoing support, and reflection prospects are the main strengths of this formative assessment professional development project.

Limitations of this project include the project timing and volunteer participation. The 3-day intensive workshop would need to be completed before the beginning of the school year and before the official beginning of teacher contract hours. Completing the 3-day workshop before the start of the school year would save the district funding because they would not have to pay for substitute teachers. However, hosting a workshop prior to the start of teacher contract hours may limit some middle school math teachers from participating because of summer vacation plans or other district training. Additionally, with a voluntary participation in the formative assessment professional development, it is possible that only a limited number of teachers would participate and further limit job-embedded collaboration between members of the middle school math team. If only part of the middle school math team participates in the professional development, it could divide the team during collaboration opportunities and present problems with continuity of the department and common goals.

Recommendations for Alternative Approaches

The timing and volunteer participation present some limitations to the formative assessment project. However, creating an online option for the training may provide an alternative approach that would eliminate some of the previously mentioned limitations. With the 3-day training before the beginning of school and teacher contract hours, some teachers may find this timing limiting to their participation. However, use of Google Hangouts, Skype, Instant Messaging, or creating an online format based on the technology comfort level of the participants may allow more teachers to participate in this online alternative approach. Teachers could collaborate in small groups virtually or meet as grade-level groups throughout the summer when their coordinating schedules would allow.

An additional alternative approach is to use district or grant funding to pay for substitute teachers during the first quarter of the school year and allow all middle school math teachers to participate in the formative assessment professional development. Full participation from the middle school department would create unity toward moving learning forward using formative assessment. Working toward developing a growth mindset classroom culture, implementing formative assessment strategies, and using mathematics technology to enhance assessment strategies could be a common focus and goals for ongoing development and support with the entire department participating. Also, with full participation, future ongoing support through job-embedded collaboration would apply to all middle school math teachers an avoid dividing the department. Peer observations and instructional coaching could provide teachers with unique ways to advance their formative assessment practice. The use of an online or flexibility with the timing of the 3-day workshop could provide an alternative approach to the formative assessment professional development training and increase participation and overall effectiveness.

Scholarship, Project Development and Evaluation, and Leadership and Change

This study will provide educational stakeholders with information about the use of multiple reassessment opportunities as a formative assessment strategy. Development and implementation of the formative assessment professional development for mathematics teachers will allow teachers opportunities to improve their formative assessment knowledge, and craft of moving learning forward using formative assessment. Providing opportunities for collaboration, growth, and reflection with ongoing support may lead to increased mathematics achievement and growth.

Self-Analysis of Scholarship

The process of completing this study increased my depth of assessment knowledge and ambition to improve mathematics education. As a full-time middle school mathematics teacher, I found my passion for helping students succeed to be a driving force as I completed my doctoral journey. Pushing myself to keep a growth mindset and continue to learn enabled me to preserve through a rigorous doctoral program. During this process, I learned how to become a research practitioner as I crafted literature reviews and supported my study with peer-reviewed scholarly sources. Additionally, I learned the value of asking for support and help throughout this journey. Using Walden University resources and guidance from my committee members pushed me to grow as a student. Through countless revisions and tackling some nervous feelings about the complex statistics presented in this study, I was able to gain valuable perspective that I transferred to my teaching career. In working with students who struggle in mathematics, I was humbled by my own struggles with the doctoral process and gained new perspective as I work with students needing extra support in mathematics. This process has pushed me professionally to advocate for the needs of my math students and given me the confidence to be a leader of change throughout my school, district, and state.

Self-Analysis of Project Development

Based on the finding of this study and the call to action for improved instructional practices in mathematics, I was inspired to create the formative assessment professional development for middle school mathematics teachers. Having sat through a variety of professional development program in my twelve years of teaching middle school math, I reflected on what characteristic made the most meaningful and useful professional development experiences. I was both shocked and inspired to create a project that would allow teachers to learn about useful and research-based practices that would apply directly to their classroom.

The finding of my study that showed a significant difference between the two assessment groups but only for the dependent variable of second-semester course percentage grades was surprising. Especially surprising was that students not allowed reassessment opportunities had a higher mean second-semester course percentage grades compare to students who were given reassessment options. Therefore, based on these findings, I began a reflection on what would make the greatest impact to improve formative assessment practices.

Developing a growth mindset culture and climate (Boaler, 2016; Dweck, 2015) coupled with meaningful formative assessment strategies to push learning forward was the basis of thought in developing the formative assessment professional development training for middle school mathematics teachers. I wanted teachers to be pushed professionally, in a safe and collaborative environment that would allow them time to develop and learn. Finally, I wanted teachers to be able to walk away with finished products, finalized lesson plans, and a wealth of technology-rich resources to use in their classroom. Ongoing support, future job-embedded collaboration opportunities, reflections, and evaluations would continue to inform formative assessment practice and push math education to the next level of success.

Self-Analysis of Leadership and Change

Earning my doctoral degree has been a lifelong goal and dream. The goal of obtaining my doctoral degree was made possible through a scholarship provided by the Teacher of the Year program. I was honored and humbled to receive a full scholarship to earn my doctoral degree at Walden University. Through my work as a full-time mathematics teacher and collaboration with teachers around the country, I am inspired and determined to improve mathematics education in our country. Continuing my work as a mathematics teacher and serving on both school and district leadership teams provides an opportunity for me to impact positive changes in mathematics education. During the 2017-2018 school year, I served as a mentor teacher and collaborated with fellow Teachers of the Year around the United States to lead and inspire new teachers in the field of STEM as we work toward positive change in education. Through the development of my project study, I will continue to lead change as we work toward improved mathematics classrooms. Finally, I was recently asked to begin serving as a STEM trainer on a global level through STEM Revolution. Completion of my Doctoral Degree at Walden University has provided a wealth of opportunities for leadership and change as I continue my career as a teacher.

Reflection on Importance of the Work

As I reflect on the importance of my study, I think about opportunities to make a meaningful and positive difference. As reported by PISA, the United States ranked 36th out of 65 countries (Boaler, 2016). I view this ranking as a call to action and opportunity for positive change and leadership in math education. I discovered the value of my study and importance of my work through the literature review process. Quality formative assessment that moves learning in a positive direction and arms teachers with needed information to support student learning and growth is valuable and important in the process of improving math education in the United States. Formative assessment has shown to have a positive impact on student achievement and close the achievement gap (Black, 2015; Black & Wiliam, 1998; Marsh et al., 2016). As I end my doctoral journey, I am hopeful that my study and research regarding the specific formative assessment strategy of multiple assessment attempts add to the body of formative assessment research. Furthermore, I am optimistic that the project developed as a result of this study will provide positive improvements and social changes in mathematics education and may serve as a catalyst for future formative assessment studies.

Positive Social Changes

The research presented in the review of literature and knowledge gained from this study was the driving force in development of the formative assessment mathematics professional development. In an age of accountability and assessment driven data, this study examined the specific formative assessment strategy of reassessment and its impact on students' achievement, growth, and course percentage grades. Based on the statistically significant findings of this study and the development of the formative assessment professional development, this study may impact positive social changes to mathematics education.

Through findings of this study, teachers may increase their awareness and overall knowledge of how allowing reassessment in their mathematics classes will impact student achievement, growth, and course percentage grades. Additionally, The Project will provide teachers with ongoing support and training to create a classroom culture and climate supporting a growth mindset in mathematics. The formative assessment professional development will also arm teachers with practical and research supported strategies for quality formative assessment that will move students' learning forward. The specific formative assessment technology training will provide teachers with meaningful and efficient tools for feedback and support as they implement formative assessment strategies. Mathematics assessment and improving success in mathematics is a global topic of interest. Therefore, the findings of this study and formative assessment professional development training have great potential for positive social changes to improve student success in mathematics at the local level and beyond.

Implications, Applications, and Directions for Future Research

The information and findings that resulted from this study were used to create a unique professional development experience for middle school mathematics educators. In an era of accountability and testing pressure, this study is practical and relevant to today's mathematics teacher because of the focus on formative assessment to close the achievement gap. The professional development program that was created as a result of this study provided teachers with opportunities to engage in collaborative experiences as they grapple with applying formative assessments strategies to move learning forward in their classroom. This study has implications for positive student growth through the improved use of formative assessment strategies in which students are involved in the assessment process. Additionally, the ongoing support, opportunities for instructional coaching, reflection, and peer observations create possibilities for teachers to refine their formative assessment skills as they develop high-quality plans with the latest technology tools for feedback. Implications for improved mathematics achievement and growth through formative assessment can move beyond the present middle school plan.

This study and the formative assessment professional development can move beyond the middle school level and be applied beyond the local district. As middle school students move into high school, applications for developing a high school formative assessment professional development would provide continuity for students and continued involvement in the assessment process. Also, supporting secondary mathematics through applications of beginning the formative assessment process and development at the elementary level could prove beneficial. Improving assessment knowledge and how to create meaningful formative assessment K-12 could be applied to pre-service teachers through education courses in the local area and beyond.

Based on the findings of this study, the presented review of the literature, and the developed project, I recommend further research into specific formative assessment strategies within the mathematics classroom. Assessment is a broad topic, but one of major concern and worth in the world of education today. Examining specific formative assessment strategies across additional grade levels and subject areas could provide needed information about practical and useful classroom assessment techniques. Furthermore, research that uses a qualitative approach may gain teacher or student insight about their individual thoughts and knowledge surrounding specific formative assessment strategies. Increasing awareness and knowledge regarding formative assessment strategies is recommended to move learning and achievement forward.

Conclusion

This study compared mathematics achievement, growth, and course percentage grades for students who were given multiple formative assessment attempts compared to students who are not provided multiple assessment attempts. Researchers have shown the power of formative assessment and potential for closing the achievement gap (Black, 2015; Black & Wiliam, 1998; Boaler, 2016, Dweck, 2015; Marsh et al., 2016). After analysis of reassessment options, the present study showed a statistically significant difference, but only for students' course percentage grade. Based on the findings of this study, a formative assessment professional development program was created to provide teachers with a unique opportunity for collaboration, learning, and development of formative assessment implementation. Through the professional development training, teachers learn to create a growth mindset culture and climate in their classroom, engage students in the formative assessment process, and develop technology-rich formative assessment strategies to move mathematics learning forward. Through the intensive 3-day training, ongoing support, job-embedded collaboration, and reflection opportunities, teachers will receive knowledge, skills, and support to move student learning forward and improve achievement for middle school math students. This project will influence positive social changes for math achievement at the local level and beyond.

References

Akpan, J. P., Notar, C. E., & Padgett, S. A. (2012). Formative assessment: A basic foundation for teaching and learning. *National Teacher Education Journal*, *5*(1), 83-97.

Andersson, C., & Palm, T. (2017a). Characteristics of improved formative assessment practice. *Education Inquiry (Co-Action Publishing)*, *8*(2), 104-122. doi:10.1080/20004508.2016.1275185

Andersson, C., & Palm, T. (2017b). The impact of formative assessment on student achievement: A study of the effects of changes to classroom practice after a comprehensive professional development programme. *Learning & Instruction*, *49*92-102. doi:10.1016/j.learninstruc.2016.12.006

Ateh, C. M., & Wyngowski, A. J. (2015). The common core state standards: An opportunity to enhance formative assessment in history/social studies classrooms. *Clearing House*, *88*(3), 85-90. doi:10.1080/00098655.2015.1023245

Bal, A. P. (2012). Assessment preferences of pre-service teachers about mathematics course. *Journal of Turkish Educational Sciences*, *10*(3), 477-479.

Black, P. (2015). Formative assessment--An optimistic but incomplete vision. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 161-177.

Black, P., & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, *80*(2), 139-44

Black, P., & Wiliam, D. (2010). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, *92*(1), 81-90. doi:

10.1177/003172171009200119.

Bloom, B. (1968). Learning for Mastery. *Evaluation Comment, 1*(2), 1-11.

Boaler, J. (2016). Mathematical Mindsets. San Francisco, CA: Jossey-Bass.

Box, C., Skoog, G., & Dabbs, J. M. (2015). A case study of teacher personal practice assessment theories and complexities of implementing formative assessment. *American Educational Research Journal*, *52*(5), 956-983.

Chan, P.E., Graham-Day, K.J., Ressa V.A., Peters M.T., Konrad M. (2014). Beyond involvement: Promoting student ownership of learning in classrooms. *Intervention in School and Clinic, 50*(2), 105-113. doi: 10.1177/1053451214536039

Chao, M. M., Visaria, S., Mukhopadhyay, A., & Dehejia, R. (2017). Do Rewards reinforce the growth mindset?: Joint effects of the growth mindset and incentive schemes in a field intervention. *Journal of Experimental Psychology-General*, *146*(10), 1402-1419.

Chen, C. c., Crockett, M. m., Namikawa, T., Zilimu, J., & Lee, S. (2012). Eight grade mathematics teachers'formative assessment practice in SES-different classrooms: A Taiwan study. *International Journal of Science & Mathematics Education*, *10*(3), 553-579. doi:10.1007/s10763-011-9299-7

Chiang, Y., & Lin, S. J. (2014). The measurement structure, stability and mediating effects of achievement goals in math with middle-school student data. *Scandinavian Journal of Educational Research*, *58*(5), 513-527. doi:10.1080/00313831.2012.732607

Clinchot, M. m., Ngai, C. c., Huie, R. r., Talanquer, V. v., Lambertz, J. j., Banks, G. g., & Sevian, H. H. (2017). Better formative assessment. *The Science Teacher*, *84*(3), 69-75.

Conderman, G., & Hedin, L. (2012). Classroom assessments that inform instruction. *Kapp Delta Pi Record*, *48*(4), 162-168.

Cotton, D. d. (2017). Teachers' use of formative assessment. *Delta Kappa Gamma Bulletin*, *83*(3), 39-51.

Copur-Gencturk, Y., & Papakonstantinou, A. (2016). Sustainable changes in teacher practices: A longitudinal analysis of the classroom practices of high school mathematics teachers. *Journal of Mathematics Teacher Education*, *19*(6), 575-594.

Cowen, J., Barrett, N., Toma, E., & Troske, S. (2015). Working with what they have: Professional development as a reform strategy in rural schools. *Journal of Research in Rural Education*, *30*(10), 1-18.

Cowie, B., & Moreland, J. (2015). Leveraging Disciplinary Practices to Support Students' Active Participation in Formative Assessment. *Assessment In Education: Principles, Policy & Practice*, *22*(2), 247-264.

Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (Laureate custom ed.). Boston, MA: Pearson Education.

Davis, A. W., & Kappler-Hewitt, K. (2013). Australia's campfires, caves, and watering holes. *Learning & Leading with Technology*, *40*(8), 24-26.

Davis, D. S., & Neitzel, C. (2011). A self-regulated learning perspective on middle grades classroom assessment. *Journal of Educational Research*, *104*(3), 202-215. doi:10.1080/00220671003690148

De Lisle, J. (2015). The promise and reality of formative assessment practice in a continuous assessment scheme: The case of Trinidad and Tobago. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 79-103.

Desmos, Inc. (2018). Desmos. Retrieved from https://www.desmos.com/

Dixson, D. D., & Worrell, F. C. (2016). Formative and summative assessment in the classroom. *Theory Into Practice*, *55*(2), 153-159. doi:10.1080/00405841.2016.1148989

Doubet, K. J. (2012). Formative assessment jump-starts a middle grades differentiation initiative. *Middle School Journal (J3)*, *43*(3), 32-38.

Dweck, C.S., (2014, Oct.9). Developing a Growth Mindset. [video file]. Retrieved from https://www.youtube.com/watch?v=hiiEeMN7vbQ

Dweck, C.S., (2015). Growth. British Journal of Educational Psychology, 85, 242-245.

Eddy, C. M., Harrell, P., & Heitz, L. (2017). An observation protocol of short-cycle formative assessment in the mathematics classroom. *Investigations in Mathematics Learning*, *9*(3), 130-147. doi:10.1080/19477503.2017.1308699

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2013). G*Power Version 3.1.7 [computer software]. Uiversität Kiel, Germany. Retrieved from http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/download-and-register

Fisher, M. H., & Royster, D. (2016). Mathematics teachers' support and retention: Using maslow's hierarchy to understand teachers' needs. *International Journal of Mathematical Education in Science and Technology*, *47*(7), 993-1008.

Flórez Petour, M. T. (2015). Systems, ideologies and history: A three-dimensional absence in the study of assessment reform processes. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 3-26.

GeoGebra (2018). GeoGebra. Retrieved from https://www.geogebra.org/

Gersten, R., Taylor, M. J., Keys, T. D., Rolfhus, E., Newman-Gonchar, R., Regional Educational Laboratory Southeast, & National Center for Education Evaluation and Regional Assistance (2014). Summary of research on the effectiveness of math professional development approaches. REL 2014-010.

Guise, M., Habib, M., Robbins, A., Hegg, S., Hoellwarth, C., & Stauch, N. (2016). Preconditions for success and barriers to implementation: The importance of collaborative and reflective dispositions to foster professional growth during a coteaching clinical experience. *Teacher Education Quarterly*, *43*(4), 55-75.

Gurevich, I., Stein, H., & Gorev, D. (2017). Tracking professional development of novice teachers when integrating technology in teaching mathematics. *Computers in the Schools*, *34*(4), 267-283. doi:10.1080/07380569.2017.1387470

Grosas, A. B., Raju, S. R., Schuett, B. S., Chuck, J., & Millar, T. J. (2016). Determining if active learning through a formative assessment process translates to better performance in summative assessment. *Studies in Higher Education*, *41*(9), 1595-1611. doi:10.1080/03075079.2014.988704

Hannah, J., James, A., & Williams, P. (2014). Does computer-aided formative assessment improve learning outcomes?. *International Journal of Mathematical Education in Science and Technology*, *45*(2), 269-281.

Harks, B., Rakoczy, K., Hattie, J., Besser, M., & Klieme, E. (2014). The effects of feedback on achievement, interest and self-evaluation: the role of feedback's perceived usefulness. *Educational Psychology*, *34*(3), 269-290. doi:10.1080/01443410.2013.785384

Herman, J., Osmundson, E., Dai, Y., Ringstaff, C., & Timms, M. (2015). Investigating the dynamics of formative assessment: Relationships between teacher knowledge, assessment practice and learning. *Assessment in Education: Principles, Policy & Practice*, *22*(3), 344-367.

Hill, K. K., Bicer, A., & Capraro, R. M. (2017). Effect of teachers' professional development from mathforward™ on students' math achievement. *International Journal of Research in Education and Science*, *3*(1), 67-74.

Hopfenbeck, T. N., Flórez Petour, M. T., & Tolo, A. (2015). Balancing tensions in educational policy reforms: Large-scale implementation of assessment for learning in norway. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 44-60.

Hudesman, J., Crosby, S., Ziehmke, N., Everson, H., Issac, S., Flugman, B., & Moylan, A. (2014). Using formative assessment and self-regulated learning to help developmental mathematics students achieve: A multi-campus program. *Journal on Excellence in College Teaching*, *25*(2), 107-130.

IXL Learning. (2018). IXL. Retrieved from https://www.ixl.com/

Jacob, R., Hill, H., & Corey, D. (2017). The impact of a professional development program on teachers' mathematical knowledge for teaching, instruction, and student achievement. *Journal of Research on Educational Effectiveness*, *10*(2), 379-407. doi:10.1080/19345747.2016.1273411

Jonsson, A., Lundahl, C., & Holmgren, A. (2015). Evaluating a large-scale implementation of assessment for learning in Sweden. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 104-121.

Kahoot! (2018). Kahoot! Retrieved from https://kahoot.com/welcomeback/

Kalthoff, H. (2013). Practices of grading: An ethnographic study of educational assessment. *Ethnography & Education*, *8*(1), 89-104. doi:10.1080/17457823.2013.766436

Kellman, K. (2014). *Ready common core: Mathematics 8 teacher resource book*. North Billerica, MA: Curriculum Associates, LLC.

Laerd Statistics (2018). Retrieved from https://statistics.laerd.com/spss-tutorials/one-way-mancova-using-spss-statistics.php

Lakin, J. M., & Chaudhuri, S. (2016). Getting more out of educational workshop evaluations: Positively packing the rating scale. *Educational Research Quarterly*, *40*(1), 51-69.

Lau, A. S. (2016). ‘Formative good, summative bad?’ – A review of the dichotomy in assessment literature. *Journal of Further & Higher Education*, *40*(4), 509-525. doi:10.1080/0309877X.2014.984600

Levi-Keren, M. k., & Patkin, D. p. (2016). Mathematics teachers' professional development program - needs and expectations. *International Journal for Mathematics Teaching & Learning*, 1-33.

Lodico, M., Spaulding, D., & Voegtle, K. (2010). Methods in Educational Research. San Francico: John Wiley & Sons.

Lysaght, Z. (2015). Assessment "for" learning and "for" self-regulation. *International Journal of Emotional Education*, *7*(1), 20-34.

Lysaght, Z. Z., & O'Leary, M. (2013). An instrument to audit teachers' use of assessment for learning. *Irish Educational Studies*, *32*(2), 217-232. doi:10.1080/03323315.2013.784636

Marsh, J.A., Farrell, C.C., & Bertrand, M. (2016). Trickle-down accountability: How middle school teachers engage students in data use. *Educational Policy*, *30*(2), 243-280. doi: 10.1177/0895904814531653

Martin, C. S., Polly, D. D., Chuang, W., Lambert, R. G., & Pugalee, D. K. (2016). Perspectives and practices of elementary teachers using an internet-based formative assessment tool: The case of assessing mathematics concepts. *International Journal for Technology in Mathematics Education*, *23*(1), 3-12. doi:10.1564/tme_v23.1.01

Matthews, R., & Noyes, A. (2016). To grade or not to grade: Balancing formative and summative assessment in post-16 teacher trainee observations. *Journal of Further and Higher Education*, *40*(2), 247-261.

Meusen-Beekman, K. D., Joosten-ten Brinke, D., & Boshuizen, H. A. (2015). Developing young adolescents' self-regulation by means of formative assessment: A theoretical perspective. *Cogent Education*, *2*(1)

Meusen-Beekman, K. K., Joosten-ten Brinke, D., & Boshuizen, H. P. (2016). Effects of formative assessments to develop self-regulation among sixth grade students: Results from a randomized controlled intervention. *Studies in Educational Evaluation*, *51* 126-136. doi:10.1016/j.stueduc.2016.10.008

Mitton-Kukner, J., Munroe, E., & Graham, D. (2015). The challenge of differing perspectives surrounding grades in the assessment education of pre-service teachers. *Canadian Journal of Higher Education*, *45*(4), 322-342

Núñez-Peña, M. I., Bono, R., & Suárez-Pellicioni, M. (2015). Feedback on students' performance: A possible way of reducing the negative effect of math anxiety in higher education. *International Journal of Educational Research*, *70*80-87. doi:10.1016/j.ijer.2015.02.005

O'Connor, K. (2009). *How to Grade for Learning K-12*. (3rd ed.). Thousand Oaks, CA: Corwin.

Osterbur, M. m., Hammer, E. e., & Hammer, E. e. (2015). Does mechanism matter? Student recall of electronic versus handwritten feedback. *International Journal for the Scholarship of Teaching & Learning*, *9*(1), 1-13.

Owen, L. (2016). The impact of feedback as formative assessment on student performance. *International Journal of Teaching & Learning in Higher Education*, *28*(2), 168-175.

Petcovic, H., Fynewever, H., Henderson, C., Mutambuki, J., & Barney, J. (2013). Faculty grading of quantitative problems: A mismatch between values and practice. *Research in Science Education*, *43*(2), 437-455. doi:10.1007/s11165-011-9268-8

Phelan, J. C., Choi, K., Niemi, D., Vendlinski, T. P., Baker, E. L., & Herman, J. (2012). The effects of POWERSOURCE[C] assessments on middle-school students' math performance. *Assessment in Education: Principles, Policy & Practice*, *19*(2), 211-230.

Pinger, P. p., Rakoczy, K., Besser, M., & Klieme, E. (2018). Implementation of formative assessment - effects of quality of programme delivery on students' mathematics achievement and interest. *Assessment in Education: Principles, Policy & Practice*, *25*(2), 160-182. doi:10.1080/0969594X.2016.1170665

Pittaway, S., & Dowden, T. (2014). Providing students with written feedback on their assessment: A collaborative self-study exploring the nexus of research and practice. *Studying Teacher Education*, *10*(3), 197-209.

Polly, D., Wang, C., Martin, C., Lambert, R. G., Pugalee, D. K., & Middleton, C. W. (2017). The influence of an internet-based formative assessment tool on primary grades students' number sense achievement. *School Science and Mathematics*, *117*(3), 127-136.

Quizlet Inc. (2018). Quizlet Learning Tools & Flashcards, for Free. Retrieved from https://quizlet.com/

Quizizz Inc. (2018). Quizizz: Free quizzes for every student. Retrieved from https://quizizz.com/

Randel, B., Apthorp, H., Beesley, A. D., Clark, T. F., & Wang, X. (2016). Impacts of professional development in classroom assessment on teacher and student outcomes. *Journal of Educational Research*, *109*(5), 491-502.

Reeves, J. J., Gunter, G. G., & Lacey, C. C. (2017). Mobile learning in pre-kindergarten: Using student feedback to inform practice. *Journal of Educational Technology & Society*, *20*(1), 37-44.

Roscoe, K. (2013). Enhancing assessment in teacher education courses. *Canadian Journal For The Scholarship Of Teaching And Learning*, *4*(1), 1-15.

Rutherford, T., Long, J. J., & Farkas, G. (2017). Teacher value for professional development, self-efficacy, and student outcomes within a digital mathematics intervention. *Contemporary Educational Psychology*, *51*22-36. doi:10.1016/j.cedpsych.2017.05.005

Sach, E. (2015). An exploration of teachers' narratives: What are the facilitators and constraints which promote or inhibit 'good' formative assessment practices in schools? *Education 3-13*, *43*(3), 322-335.

Sadler, R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, (18)*, 119-144.

Sadler, R. (1998). Formative assessment: revisiting the territory. *Assessment in Education: Principles, Policy & Practice, (5)*1, 77-84. DOI: 10.1080/0969595980050104

Schoenfeld, A. H. (2015). Summative and Formative Assessments in Mathematics Supporting the Goals of the Common Core Standards. *Theory Into Practice*, *54*(3), 183-194. doi:10.1080/00405841.2015.1044346

Scriven, M., Tyler, R., Gagne, M. (1967). The Methodology of evaluation: Perspectives on curriculum evaluation. Chicago: Rand McNally & Co.

Seaton, K. A. (2013). Efficacy and efficiency in formative assessment: An informed reflection on the value of partial marking. *International Journal of Mathematical Education in Science and Technology*, *44*(7), 963-971.

Sevis, S., Cross, D., & Hudson, R. (2017). Mathematics teachers' take-aways from morning math problems in a long-term professional development droject. *North American Chapter of the International Group for the Psychology of Mathematics Education*, 39.

Shippy, N., Washer, B. A., & Perrin, B. (2013). Teaching with the end in mind: The role of standards-based grading. *Journal of Family & Consumer Sciences*, *105*(2), 14-16.

Shirley, M. L., & Irving, K. E. (2015). Connected classroom technology facilitates multiple components of formative assessment practice. *Journal of Science EducationaAnd Technology*, *24*(1), 56-68.

Smarter Balanced Assessment Consortium: 2013-2014 Technical Report. (2016). Retrieved June 1, 2016 from http://www.smarterbalanced.org/wp-content/uploads/2015/08/2013-14_Technical_Report.pdf

Smithson, M. (2012). The positive impact of personal goal setting on assessment. *Canadian Journal of Action Research*, *13*(3), 57-73.

Spector, J. m., Ifenthaler, D. d., Sampson, D. s., Yang, L. y., Mukama, E. e., Warusavitarana, A. a., & ... Gibson, D. d. (2016). Technology enhanced formative assessment for 21st century learning. *Journal of Educational Technology & Society*, *19*(3), 58-71.

Stewart, T. s., & Houchens, G. W. (2014). Deep impact: How a job-embedded formative assessment professional development model affected teacher practice. *Qualitative Research in Education (2014-6418)*, *3*(1), 51-82. doi:10.4471/qre.2014.36

Stiggins, R., & Chappuis, J. (2005). Using student-involved classroom assessment to close achievement gaps. *Theory Into Practice*, *44*(1), 11-18. doi:10.1207/s15430421tip4401_3

Stitt, J. L., & Pula, J. J. (2014). Voting for Subjectivity: Adding some gray areas to black-and-white, objective grading practices. *Delta Kappa Gamma Bulletin*, *80*(3), 24-27.

Taras, M., & Davies, M. S. (2013). Perceptions and Realities in the Functions and Processes of Assessment. *Active Learning In Higher Education*, *14*(1), 51-61.

Taton, J. a. (2015). Much more than it's cooked-up to be: Reflections on doing math and teachers' professional learning. *Perspectives on Urban Education*, *12*(1), 48-61.

Terpening, W.D., Beqiri, M., & Schwering, S. (2013). *Statistical analysis for business and economics: Concepts and Practice*. Napersville, Il: Hercher Publishing Inc.

Triola, M. F. (2012). *Elementary statistics technology update.* (11th ed.). Boston, MA: Pearson Education, Inc.

Tucker, S., Shumway, J. F., Moyer-Packenham, P. S., & Jordan, K. E. (2016). Zooming in on children's thinking. *Australian Primary Mathematics Classroom*, *21*(1), 22-28.

Turner, S. L. (2014). Creating an assessment-centered classroom: Five essential assessment strategies to support middle grades student learning and achievement. *Middle School Journal (J3)*, *45*(5), 3-16.

Van der Nest, A., Long, C., & Engelbrecht, J. j. (2018). The impact of formative assessment activities on the development of teacher agency in mathematics teachers. *South African Journal of Education*, *38*(1), 1-10. doi:10.15700/saje.v38n1a1382

Warlick, D. (2103, Feb.21). The Game of School.[video file]. Retrieved from https://www.youtube.com/watch?v=-rRni0ATGSA

Wilder, S. (2015). Classroom challenge: A 3D snapshot of student learning in mathematics. *Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *88*(3), 77-84.

Wormeli, R. (2011). Redos and retakes done right. *Educational Leadership*, *69*(3), 22-26.

Wylie, E. C., & Lyon, C. J. (2015). The fidelity of formative assessment implementation: issues of breadth and quality. *Assessment in Education: Principles, Policy & Practice*, *22*(1), 140-160. doi:10.1080/0969594X.2014.990416

Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., & ... Dweck, C. S. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology*, *108*(3), 374-391.

Yildiz, H., & Gokcek, T. (2018). The development process of a mathematic teacher's technological pedagogical content knowledge. *European Journal of Educational*

Research, *7*(1), 9-29.

Appendix A: The Project

The project is a 3-day professional development training with ongoing support and reflection time during job-embedded collaboration. Teachers are provided time to meet during every Monday morning during school hours through job-embedded collaboration. Thus, creating an opportunity for collaboration and ongoing support for formative assessment professional development. The purpose of this professional development program is to support teachers in creating a classroom culture and environment focused on growth and improvement in mathematics, increase teachers' knowledge of formative assessment practices and how to implement these practices in their classroom, and use technology to provide immediate feedback and follow-up for improved formative assessment practices. Middle school mathematics teachers are the target audience for the professional development project. The formative assessment professional development will consist of 21 hours of training spread over the course of 3 consecutive days of training before the start of the school year. Followed by at least 4 additional hours of ongoing reflection and support during job-embedded collaboration time that will be spread out over the course of the school year. This additional support will consist of observation opportunities and reflections from each participating teacher. Teachers will have opportunities to use formative assessment strategies as well as observation and reflection time for instructional growth purposes. The goal of this professional development program is to increase teachers' awareness and use of formative assessment practices with middle school mathematics students, create a classroom culture and environment conducive of a growth mindset, and improve teachers' use of classroom technology to aid in formative assessment practices. The learning outcomes for this formative assessment professional development are that teachers will:

1. Develop an understanding of how to create a growth mindset in their mathematics classroom.
2. Improve their use of formative assessments to improve student performance and growth in mathematics through the use of Formative Assessment Feedback (Appendix D) and Coding for Learning (Appendix E) forms.
3. Implement technology tools for instruction and assessment in their mathematics classroom.
4. Reflect and collaborate on their individual use of formative assessment strategies in their classroom.

The goals and learning outcomes in this formative assessment professional development will allow teachers to support student growth and improvement in their mathematics classroom. Additionally, teachers will be encouraged to reflect and collaborate with colleagues as they grow and improve their pedagogical practices regarding formative assessment and the use of classroom technology.

Table A1

Professional Development Timeline

Time	Day 1	Time	Day 2	Time	Day 3
8:00- 8:30	Introduction/Icebreaker	8:00-8:30	Assessment of vs. for learning discussion	8:00-8:30	Desmos
8:30-8:45	Quick Sketch	8:30-9:00	Formative Assessment Strategy Work- Part 1	8:30-8:45	Debrief Desmos and discussion
8:45-9:00	Game of School/Growth Mindset	9:00-9:45	Grading vs. Feedback	8:45-9:00	IXL Introduction and mini lesson
9:00-9:45	Classroom Culture Collaboration	9:45-10:00	Break	9:00-9:45	Development time with Desmos and IXL
9:45-10:00	Break	10:00-11:15	Formative Assessment Strategy Work- Part 2	9:45-10:00	Break
10:00-11:15	Growth Mindset/Brain Lesson	11:15-12:00	Lesson Planning with Formative Assessment	10:00-11:15	Kahoot, Quizizz, Quizlet and Geogebra
11:15-12:00	Growth vs. Fixed Mindset Brainstorming/ Collaboration	12:00-1:00	Lunch	11:15-12:00	Creating, Planning and Exploring Technology Formative Tools
12:00-1:00	Lunch	1:00-2:30	Formative Assessment Lesson Planning and Development Collaboration Time	12:00-1:00	Lunch

1:00-2:30	Growth Mindset Lesson Development	2:30-3:00	Conclusion and Lesson Plan Presentations	1:00-2:00	Lesson Development with Formative Technology
2:30-3:00	Evaluation/Conclusion			2:00-2:30	Lesson Sharing and Collaboration
				2:30-3:00	Conclusion and Follow up support

Formative Assessment Professional Development Day 1: Growth Mindset

Materials:

Laptop for each participant and Internet connection

Each participant will need a copy of Boaler (2016)

Whiteboards, markers, erasers, poster paper, pencils

Projector and document camera

Portable speaker and phone with music for transitions

Prework: Each participant provided with a copy of Boaler (2016) to read the first two chapters *The Brain and Mathematics of Learning and The Power of Mistakes and Struggle*. In addition, participants will view two video clips to build their schema regarding growth mindset and the game of school

https://www.youtube.com/watch?v=-rRni0ATGSA (Game of School)

https://www.youtube.com/watch?v=hiiEeMN7vbQ (fixed vs. growth mindset video from Carol Dweck)

8:00-8:30 Introduction and icebreaker that will be used as a needs assessment

Facilitator Notes: Welcome participants to the formative assessment professional development and discuss and overview of the 3-day training. Go over the learning outcomes and agenda for the day. Participants will meet and greet each other as music plays and describe their individual needs and goals of the formative assessment professional development training. Table groups with then create a list of the top five needs for the group. The facilitator will collect the list from each group to use as formative assessment for the professional development training.

8:30-8:45 Mathematics Classroom Quick Sketch

Facilitator Notes: Lead participants in a visualization thinking strategy in which they will assume the perspective of a student. Participants will complete a quick sketch of their ideal classroom for learning mathematics. Next, lead participants in an art walk in which they will view each other's quick sketch and note similarities. Lead a small discussion about what participants noticed or wondered.

8:45-9:00 Game of School and Growth Mindset

Facilitator Notes: Lead a discussion asking participants to reflect on if students are playing the game of school in their classroom or engaged in deep learning and growth. Ask participants to reflect on their reading and two videos assigned in their prework. Use a think-pair-share strategy for discussion purposes and have teachers change partners at least twice to gain different perspectives. Relate the discussion back to the quick sketch of the classroom and discussion. Transition the group to move beyond playing the game of school and focus on a growth mindset and improvement.

9:00-9:45 Creating a Classroom Culture and Environment for a Growth Mindset

Facilitator Notes: Working in groups of three with each grade level 6-8 represented per group, participants will collaborate to create and establish group norms for their classroom to create a classroom culture and environment for a growth mindset. Teachers will work in their teams to create a poster that will display classroom growth mindset group norms and share their posters with the professional development group before a short break.

9:45-10:00 Break

10:00-11:15 Growth Mindset and Brain Lesson

Facilitator Notes: Ask participants to again reflect on their learning from the assigned prework and their schema regarding growth vs. fixed mindset. Ask, “What do you think about the power of ‘yet’?” Use a think-pair-share strategy to allow teachers to share and discuss their thinking. Next, lead a lecture on how the brain learns new information. Introduce participants to brain vocabulary and the process of learning and retaining new information.

11:15-12:00 Growth vs. Fixed Mindset Lesson Brainstorming

Facilitator Notes: Participants will work individually to search for videos and design an introduction to growth vs. fixed mindset for their classes. Participants will be encouraged to save resources they find and be prepared to share with colleagues they will be working with after lunch.

12:00-1:00 Lunch

1:00-2:30 Growth Mindset Lesson Development and Reflection

Facilitator Notes: Ask, “Do we as teachers demonstrate a growth mindset?” and “Does our classroom environment facilitate learning and growth or playing the game of school?” Allow participants individual think time and reflection then lead small group discussions that will transition to collaboration and development of growth mindset lessons for students. Teachers will use their knowledge from the prework resources and learning of the day to develop lessons to teach their middle school students about growth mindset and how their brain work and learns new information. Teachers will work with one partner to collaboratively develop a lesson to use during the first week of school that will help establish a culture and climate of growth mindset. Teachers will share resources they found during their independent work before lunch with each other as they develop their growth mindset and brain lessons for their students.

2:30-3:00 Concluding Article and Evaluation

Facilitator Notes: Lead a brief reflection back to students original quick sketch of their classroom and discuss what changes they would make to their sketch based on their learning today. Participants will complete the day 1 evaluation survey to provide feedback and formative assessment information of the first session. Assign Chapter 8 Assessment for a Growth Mindset from (Boaler, 2016) for reading before the next session. Finally, teachers will be asked to bring one assessment that they use during the first quarter of school for use during the second day. The facilitator will revisit the list of needs each group provided at the beginning of the session. Adjustments to the plan may be made according to the needs of the groups.

Formative Assessment Professional Development Day 2: Formative Assessment Strategies

Materials:

Laptop for each participant and Internet connection

Each participant will need a copy of Boaler (2016)

Whiteboards, markers, erasers, poster paper, pencils

Projector and document camera

Portable speaker and phone with music for transitions

Examples of assessments from teachers' classrooms

Prework: Each participant will read Chapter 8 of Boaler (2016) to prepare for engagement in formative assessment and mathematical tasks. Each participant will also bring one example assessment that they will be using the first quarter of school or one from the previous school year that a student has completed.

8:00-8:30 Teachers will discuss the concept of assessment for learning versus assessment of learning based on their prework reading, prior knowledge, and classroom experience.

Facilitator Notes: Lead teachers in a reflection and discussion of the reading from the previous night regarding assessment for learning as compared to assessment of learning. Push groups to reflect on their thinking by asking, "what made you say that" as participants share their thinking and ideas with groups.

8:30-9:00 Formative Assessment in Action Part 1- Strategy Work

Facilitator Notes: Participants will engage in a choice of mathematical tasks and then select a formative assessment to show their assessment of learning. They may select a reflection, exit ticket, or two wishes and a star (Boaler, 2016, pp.155-164) or find and fix for mastery (Wylie & Lyon, 2015). Participants will then engage in peer assessments and writing productive comments for learning.

9:00-9:45 Grading vs Feedback

Facilitator Notes: Participants will discuss grading versus feedback and make clear connections between grading for learning and grading of learning. Suggestions for grading practices will be reviewed from (Boaler, 2016, pp. 167-169).

9:45-10:00 Break

10:00-11:15 Formative Assessment in Action Part 2- Feedback for Learning

Facilitator Notes: Participants will select a student example assessment or an assessment they will be giving during the first quarter of the school year (this was part of their prework). The facilitator will introduce the Formative Assessment Feedback (Appendix D) and Coding for Learning (Appendix E) forms and guide participants through use of the form to elicit positive peer and self-reflection practices to move learning and instruction forward. These forms will be introduced for use on the first attempt of an assessment to engage learners in the formative assessment and reflection process. The Formative Assessment Feedback and Coding for Learning forms can be used for grades 6-8 and for any of the mathematical standards. The forms will be shared with teachers through a Google Doc and available for their use to customize and meet the needs of their learners. Teachers will work in partners as they role-play how the

Formative Assessment Feedback and Coding for Learning forms will be used in the classroom with students.

11:15-12:00 Lesson Planning with Formative Assessment

Facilitator Notes: Participants will now assume the role of teachers and again use the assessment they brought to the session to guide their lesson planning and formative assessment. Teachers will work individually at first, then collaborate with their grade level teams to create and embed formative assessment strategies to support the given assessment they brought and the lesson plans for that particular assessment. Teachers will work as grade level teams to implement and modify the Formative Assessment Feedback and Coding for Learning forms to meet the needs of their individual classes and grade level standards. Teachers will focus on key components of formative assessment presented by Wylie and Lyon (2015) which include: clarifying and sharing learning expectations, effective classroom discussions and evidence of learning, feedback to move learning forward, activating students as owners in their learning and the peer feedback.

12:00-1:00 Lunch

1:00-2:30 Formative Assessment Lesson Planning Time and Development

Facilitator Notes: Participants will select one grade level partner and grade level mathematical standard to develop and improve a lesson plan and assessments. Teachers will use Formative Assessment Feedback and Coding for Learning forms for each of the formative try 1 assessments they are planning to use throughout a unit of instruction. The facilitator will monitor groups as they work, taking notes of group questions, successes, and areas of need to adjust instruction and provide support.

2:30-3:00 Concluding Formative Assessment Plan and Sharing

Facilitator Notes: Participants will share their assessment plans and improvements they have made throughout the day. Finally, participants will complete a reflection of their learning today in the form of a two stars and a wish reflection (Boaler, 2016, p. 156). They will record two highlights of the day and one area they would like to know more about or wish that the training would address.

Formative Assessment Professional Development Day 3: Technology Tools

Materials:

Laptop for each participant and Internet connection

Each participant will need a copy of Boaler (2016)

Whiteboards, markers, erasers, poster paper, pencils

Projector and document camera

Portable speaker and phone with music for transitions

Prework: Participants will be asked to create teacher accounts for each of the following mathematics websites: www.Desmos.com, www.IXL.com, www.Kahoot.com, www.Quizizz.com, www.Quizlet.com, www.Geogebra.com

The above-mentioned math websites will be used throughout the third day of the training as teachers work to develop technology enhanced lessons and formative assessment plans. The facilitator will provide demonstrations for each of the formative assessment websites and specific uses for classroom instruction. Additionally, the facilitator will provide small group assistance and one-on-one training for teaches as needed throughout the technology formative assessment training session. Details for each website and lesson planning time are provided in the facilitator notes below.

8:00-8:30- Desmos.com classroom www.Desmos.com

Facilitator Notes: Provide each participant with the classroom code for Desmos.com. The teachers will engage in collaborative exploration and working as mathematicians as they work through the Desmos.com Polygraph challenge with linear functions. As participants work, demonstrate the feedback component and instant formative assessment tool to gather information. The facilitator will highlight the feature of Desmos.com in which student conversations are viewed and present opportunities for discussion and mathematical discourse as well as vocabulary development. The facilitator will teach participants how to create class codes, pause student activities, and resume student work after brief discussions in the classroom. Finally, the facilitator will present the wide variety of assessment options and formative tools on the teacher activities page of Desmos.com.

8:30-8:45- Debrief of the Desmos.com

Facilitator Notes: Participants will engage in a brief discussion about classroom use and assessment possibilities of Desmos.com and similar technology tools.

8:45-9:00 – IXL Introduction https://www.ixl.com

Facilitator Notes: Participants will again assume the role of a student as they explore IXL.com and the formative assessment possibilities with IXL for both students and teachers. The facilitator will highlight the key features of IXL through the analytic capabilities for formative assessment data. The facilitator will provide detailed instruction and demonstrations to the entire group with the IXL analytic tools including how to show student common mistakes, retrieve and interpret diagnostic data, show a class real time view to provide instant help for students, provide instruction on how to interpret IXL student smart scores, track student growth, and progress as they work through math standards. Teachers will develop a basic comfort level with the IXL tools that they will implement and practice during the following development time.

9:00-9:45- Development time with Desmos.com and IXL.com

Facilitator Notes: Teachers collaborate with their grade level colleagues as they explore resources, plan lessons with formative assessments using IXL and Desmos that are aligned with their grade level standards. The facilitator will support grade level groups and provide small group and individual support as needed with Desmos.com and IXL.com. The facilitator will check for understanding and implementation of the IXL analytic tools and Desmos.com classroom activities in the lesson plans created in grade level groups.

9:45-10:00 Break

10:00-11:15 Kahoot (www.kahoot.com) Quizizz (https://quizizz.com) Quizlet (https://quizlet.com) and Geogebra www.Geogebra.com

Facilitator Notes: The facilitator will lead participants in an exploration of Kahoot, Quizizz, Geogebra, and Quizlet as formative assessment technology tools. As they explore a variety of mathematical standards and resources, participants will gain resource knowledge and experience using the technology tools. The facilitator will teach participants how to create, edit, and present Kahoot, Quizizz, and Quizlet technology tools in a live format with students. The facilitator will also demonstrate how to gather formative data from each of the technology tools that can be used to inform next instructional steps for students. The facilitator will provided guided instruction on the use of graphing tools with Geogebra and demonstrate graphing linear functions and transformations on the website to show how this technology tool bridges algebraic and geometric concepts for classroom exploration.

11:15-12:00 Creating, Planning, and Exploring

Facilitator Notes: After the brief overview of Kahoot, Quizizz, Geogebra, and Quizlet, participants will collaborate with grade level partners and small groups to create activities for each of the technology formative assessment resources as they pertain to their given grade level standards in math. The facilitator will continually monitor and adjust to meet the needs of all collaborative groups by providing guidance and support in the development of formative assessment technology lessons. Guidance and support will be provided in the form of small group assistance and one-on-one interventions based on the needs of each participant and their comfort level with classroom technology.

12:00-1:00 Lunch

1:00-2:00 Lesson Development with Technology

Facilitator Notes: Teachers will combine their formative assessment strategies, the use of the feedback guide from day 2 of the training, and the formative assessment technology resources they have learned about and developed to collaborate and create engaging mathematical lessons with formative assessments to move learning forward and inform instruction. Through collaborative time with grade level colleagues, teachers will have at least one complete mathematics lesson with formative assessment structures in place and ready for use with students.

2:00-2:30 Lesson Sharing and Collaboration

Facilitator Notes: Teachers will present their lesson design and formative assessments with the professional development participants for feedback and any suggestions for improvement. Final lessons will be uploaded to a shared drive for other grade level team members to use throughout the course of the school year.

2:30-3:00 Follow-up Introduction and Ongoing Support

Facilitator Notes: Teachers will be invited to observe each other with their implementation of formative assessment strategies and lessons they developed during the training as they use new strategies in their classroom. Teachers will be invited to continue working with their colleagues through job-embedded collaboration time and through the 4 scheduled meetings during the middle school math all district meetings. District coaches will be available to assist middle school math teachers in their implementation of formative assessment strategies and during reflection of strategies. Additionally, teachers will be encouraged to complete peer observation of each other for peer feedback throughout the year. Teachers will complete a Google Survey (Appendix F) to provide the facilitator with feedback for improvement and to provide teachers with ongoing support that will be helpful for their individual needs.

Appendix B: Local District Research Permission

The urban northwest school district provided me with a letter of cooperation granting permission for this study. However, to protect the identity of the district it was requested all identifying information be removed before publication of this study. The letter of cooperation is on file with Walden University.

Appendix C: Example of Multiple Formative Assessments- Attempt #1

Unit #1: Expressions, Equations, and the Number System Name: ____________________

Topic #1: Integer Exponents – VERSION #1

Learning Targets
• I can generate equivalent numerical expressions by applying the properties of integer exponents.

1. Select ALL expressions that are equivalent to $(2)^3 \cdot (2)^4$.

   a. $(2+2+2)\cdot(2+2+2+2)$ b. $(2\cdot2\cdot2)\cdot(2\cdot2\cdot2\cdot2)$ c. 2^{12}

   d. 2^7 e. $(2^5)\cdot(2^5)$

2. Select ALL expressions that are equivalent to $(4^2 \times 4^5)^3$.

   a. $(4^{10})^3$ b. $(4^7)^3$ c. $4^6 \times 4^{15}$ d. $4^5 \times 4^8$ e. 4^{21}

3. Select ALL expressions that are equivalent to $\frac{12^{-4}}{12^4}$.

   a. 12^8 b. $\frac{1}{12^8}$ c. 12^0 d. 12^{-1} e. 12^{-8}

Assessments adapted from Ready curriculum material purchased by the local district

Kellman, K. (2014). *Ready common core: Mathematics 8 teacher resource book*. North Billerica, MA: Curriculum Associates, LLC.

Appendix C: Example of Multiple Formative Assessments- Attempt #2

Unit #1: Expressions, Equations, and the Number System   Name: ____________________

Topic #1: Integer Exponents – VERSION #2

Learning Targets
• I can generate equivalent numerical expressions by applying the properties of integer exponents.

1. Select ALL expressions that are equivalent to $(3)^4 \cdot (3)^2$.

   a. $(3 \cdot 3 \cdot 3 \cdot 3) \cdot (3 \cdot 3)$
   b. $(3 + 3 + 3 + 3) \cdot (3 + 3)$
   c. 3^6
   d. 3^8
   e. $(3^3) \cdot (3^3)$

2. Select ALL expressions that are equivalent to $(2^3 \times 2^4)^2$.

   a. $(2^7)^3$
   b. $(2^{12})^2$
   c. $2^6 \times 2^8$
   d. $2^5 \times 2^6$
   e. 2^{14}

3. Select ALL expressions that are equivalent to $\frac{7^3}{7^{-3}}$.

   a. $\frac{1}{7^6}$
   b. 7^{-6}
   c. 7^0
   d. 7^6
   e. $\frac{1}{7^{-6}}$

Assessments adapted from Ready curriculum material purchased by the local district

Kellman, K. (2014). *Ready common core: Mathematics 8 teacher resource book.* North Billerica, MA: Curriculum Associates, LLC.

Appendix D: Formative Assessment Feedback Form

The standard I am working toward mastering
Evidence of Learning
I need some help with the following: I will seek help from my teacher, peers, or need more practice on my own. ________________________________
Where is my brain growth and understanding with the above standard? (Circle one of the following) I have met this standard. I am close to meeting this standard. I have not met this standard, yet.

Here are my next steps for learning:

1.

2.

3.

Appendix E: Coding for Learning Form (Example)

Square and Cube Roots Try #1 Coding For Learning

Please work through each question on Try #1 and look for areas to improve before Try #2 next week. Use this time to reflect on your learning and what you need to do before your Try #2.

Codes for Common Mistakes and Growth

A= I need to work on the relationship between area and the side length of a square. Blue i-Ready lesson + Building squares and cubes task

V= I need to work on the relationship between volume and the side lengths/surface area of a cube. Blue i-Ready lesson+ Building squares and cubes task

S= I need to work on finding square roots (both answers) IXL F.14 & 15

C= I need to work on finding cube roots IXL F.19

E= I need to work on equations with square and cube roots and the idea of inverse operation IXL F.17, 18, 20

Try #1 Percentage	Try #2 Goal	Steps to reach my goal

Formative Assessment Professional Development Feedback Survey

Please complete the following survey to provide formative feedback and details about your experience during the formative assessment professional development training.

* Required

1. **Please select one of the following to rate your overall experience.** *

   Mark only one oval.

   - 1- Below Average
   - 2- Average
   - 3- Truly Above Average
   - 4- Outstanding
   - 5- Top 5%

2. **Please select one of the following to rate your experience for day 1- growth mindset** *

   Mark only one oval.

   - 1- Below Average
   - 2- Average
   - 3- Truly Above Average
   - 4- Outstanding
   - 5- Top 5%

3. **Please provide a suggestion for improving the growth mindset training and a highlight from day 1.**

   ____
   ____
   ____
   ____
   ____

4. **Please select one of the following to rate your experience for day 2- Formative Assessment Strategies** *

   Mark only one oval.

   - 1- Below Average
   - 2- Average
   - 3- Truly Above Average
   - 4- Outstanding
   - 5- Top 5%

Formative Assessment Professional Development Feedback Survey

5. **Please provide a suggestion for improving the formative assessment strategies training and a highlight from day 2.**

6. **Please select one of the following to rate your experience for day 3- Formative Assessment Technology Tools** *

Mark only one oval.

- 1- Below Average
- 2- Average
- 3- Truly Above Average
- 4- Outstanding
- 5- Top 5%

7. **Please provide a suggestion for improving the formative assessment technology training and a highlight from day 3.**

8. **Do you have any additional suggestions or comments?**