IMPACT OF CONCEPT-BASED MATHEMATICS INSTRUCTIONAL STRATEGIES ON SEVENTH GRADE STUDENT ACHIEVEMENT

by

Katherine Annette Lawley Ellsworth

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2020

IMPACT OF CONCEPT-BASED MATHEMATICS INSTRUCTIONAL STRATEGIES ON SEVENTH GRADE STUDENT ACHIEVEMENT

by

Katherine Annette Lawley Ellsworth

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

2020

APPROVED BY:

Lisa Hall Foster, Ph.D., Committee Chair

Michelle Jones Barthlow, Ed.D., Committee Member

ABSTRACT

In a nation with declining enrollment in college math courses, it is important to examine how mathematics is being taught in the K-12 education system and to identify best practices. The purpose of this study was to examine the impact concept-based instructional strategies has on middle school student achievement in mathematics when integrated into the traditional mathematics curriculum. Participants included 424 seventh grade students from two middle schools. Students Measures of Academic Progress (MAP) Fall-to-Winter data 2018 prior to implementation was used a covariate and Fall-to-Winter data 2019 data during the implementation of concept-based instructional strategies integrated into the traditional math curriculum was used for the dependent variable. Student achievement was analyzed using an analysis of covariance (ANCOVA) and determine that there was a significant difference in math achievement when instruction is provided to student by teachers who have received professional development on concept-based instructional strategies. These findings have implications on teacher preparation, daily curricular instruction, and competitiveness for students in the global economy. Future research is suggested to determine impacts of concept-based instruction on students functioning above and below grade level, as well as teacher efficacy on implementing concept-based instruction for middle grades.

Keywords: mathematics, middle grades, concept-based, instructional strategies, professional development

Copyright Page

Dedication

This dissertation is dedicated to mathematics teachers everywhere; in their relentless pursuit to increase mathematical skills for all that walk through their doors. To those that strive for students to understand mathematics in more deep and meaningful way, thus providing students with access to the key to the gate of “powerful knowledge”.

Acknowledgments

I am eternally grateful to a Heavenly Father that has been my constant companion throughout this journey. He has lifted and supported me in this effort and shown me a glimpse of what He sees in me.

I would like to acknowledge the love and support of my husband, Cecil. He served as proofreader and editor. He ensured I had a quiet space to work and relinquished countless hours of my time.

To my parents, I wish to express my deepest gratitude for instilling in me a love of learning and the confidence to reach for the stars. Their constant encouragement and belief in me throughout this doctoral journey, as well as my entire life, has had a positive and significant impact in who I have become.

To my dissertation chair, Dr. Lisa Foster, thank you for stretching me in my thinking and writing. Your encouragement and feedback allowed me to reach new heights. Thank you for believing in me and my study! In addition, I would like to thank Dr. Michelle Barthlow for her commitment to ensuring my success! I feel confident in saying Dr. Foster and Dr. Barthlow are the finest Liberty University has to offer and I am blessed in having worked with them.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Alaska School District 1 (ASD1)

Alaska School District 2 (ASD2)

Analysis of Covariant (ANCOVA)

Dynamic Strategic Math (DSM)

Measures of Academic Progress (MAP)

Massive Open Online Course (MOOC)

Northwest Evaluation Association (NWEA)

Organization of Economic Cooperation and Development (OECD)

Trends in International Mathematics and Science Study (TIMSS)

Program for International Student Achievement (PISA)

Rasch unIT (RIT)

Word Problem Strategy (WPS)

CHAPTER ONE: INTRODUCTION

Overview

Mathematics is a universal truth that is constant and reliable in its outcomes (Mazur, 2016). It is a subject that is strict and clear in its laws and rules; yet can be so difficult for many to understand and utilize (Mazur, 2016). The dilemma lies in the concept that knowing the laws and rules are different than understanding them. Understanding requires one to recognize the interconnectedness of math to the world around them. Thus, creating a competitive global edge in research and development as well as economically. This study sought to understand the influence concept-based instruction may have on mathematics achievement in the middle grades. This chapter will provide the necessary background for the study, a statement of the problem and purpose, discuss the significance of the study, and pose a research question.

Background

Across the United States, there are concerns regarding math performance for students in the public education system. In order to establish a clear understanding of how students in the United States perform in mathematics, analyzing the data that compares them to their counterparts in other educational systems is essential. According to the National Center for Education Statistics (2019), students on average in the United States score above the center point (500) in grades 4 and 8 on the Trends in International Mathematics and Science Study (TIMSS) (International Comparisons, 2019). TIMSS data was collected from 54 educational systems for Grade 4 and four educational systems for Grade 8. An education system is defined by the TIMSS as "countries and other benchmarking educational systems" (International Comparisons, 2019). The data revealed that 10 educational systems had higher scores on average in mathematics in Grade 4. Eight educational systems had higher mathematic scores than other countries on average in Grade 8 (International Comparisons, 2019). In 2015, the Organization of Economic Cooperation and Development (OECD) utilized the Program for International Student Achievement (PISA) to measure student achievement for 73 countries/educational systems throughout the world in reading, mathematics, and science literacy (*International Comparisons of Achievement*, n.d.). They not only found that the United States scored below the OECD average, but in addition 36 countries/educational systems on average scored higher than students in the United States (*International Comparisons of Achievement*, n.d.).

In the United States, prior to World War II, rigorous high school math classes were reserved for college-bound students. Classes such as algebra, geometry, and trigonometry were viewed as “intellectual luxuries” (Vigdor, 2013). Thus, the content was restricted to a select group as it was deemed unimportant and irrelevant too much of the work force (Vigdor, 2013). After World War II, there was an influx of students entering college through the Government Issue (GI) Bill (Vigdor, 2013). This increased enrollment brought a decrease in students pursuing math-intense degrees. It would be reasonable to assume an increased enrollment with a less prepared cohort explains this decline (Vigdor, 2013). The “Race to Space” in the middle of the century, ignited a focus on math instruction (Vigdor, 2013). This focus was intended to provide rigorous math instruction for all students. However, this did not result in an increase in students seeking a math-intense degree. Instead, the nation demonstrated a decline in students seeking a degree that was math intense (Vigdor, 2013).

The *Nation at Risk* report of 1983 brought with it a renewed concern for math achievement in the United States (Vigdor, 2013). Resources were directed to the average and low-performing students and away from the high performing students. In addition, there was an increase of courses with a higher level of difficulty being offered in high school, such as calculus

(Vigdor, 2013). Despite this movement of offering higher level mathematics classes in high school, students entered post-secondary education less prepared (Douglas & Salzman, 2020). In addition, the number of students seeking math-intense degrees continued to decline (Vigdor, 2013). Mathematics has been termed as "powerful knowledge" and has become the gatekeeper to access high-income related professions (Hudson, 2018). The dilemma remains in properly preparing students for post-secondary coursework that will make high-income professions accessible for all.

Most recently, common core standards have been a focus in mathematics education. The common core standards specify standards for mathematical learning (*Standards for Mathematical Practice*, 2020). The common core standards in mathematics for the middle grades include ratios and proportional relationships, the number system, expressions and equations, geometry, and statistics and probability (*Standards for Mathematical Practice*, 2020). Max and Welder (2020) found providing opportunities for students to justify and explain their reasoning resulted in a deeper conceptual understanding of mathematical content opposed to only providing a solution. Rotter's Theory served as a guided for this study as it posits that teachers' perceptions of efficacy influence student achievement (Rotter, 1966). In a study conducted on teachers' perceptions of common core mathematics Davis et al. (2017), found 40% of the teachers held the perception that their district-adopted materials did not align with common core. The researchers also determined that teachers perceived their instructional practices shifting to one with more conceptual understanding for mathematics (Davis et al., 2017).

Hattie (2018) asserts there are three levels of understanding. They include surface, deep, and conceptual understanding (Hattie, 2018). He further posits that it is a combination of surface and deep understanding that produces a conceptual understanding (Hattie, 2018). The development of conceptual understanding is reliant upon Constructivism Theory. Thus, it was utilized as a theoretical framework for this study. Constructivism Theory is rooted in the work of Dewey (1916), Piaget (1972), Vygotsky (1978) and Bruner (1990). Collectively, they describe constructivism as new knowledge that is actively constructed base on the learner's prior experiences. This requires the learner to construct and reconstruct their knowledge throughout the learning process (Woolfolk Hoy & Hoy, 2003). More specifically, Bruner (1964) posits a theory of cognitive growth in which students represent knowledge in a variety of forms. It is further asserted that the ability to represent knowledge in a variety of forms allows for knowledge to be transferred to other environments (Bruner, 1964).

Recognizing the decline in post-secondary students entering math-intense degrees, it is important to understand how to better prepare students for success at the university level in math-intense areas of study. Identifying instructional strategies that may improve student achievement in mathematics is of interest to educators at all levels. While much has been examined at the elementary and high school level. There is little literature examining the influencers of success in mathematics in the middle grades.

Problem Statement

The purpose of the study was to determine the success of concept-based instructional strategies when combined with the traditional curriculum for seventh grade mathematic students. Developing a conceptual understanding for universal application of math skills increases students' engagement in math classes (Young et al., 2017). Increased engagement is important to assist students who struggle with mathematics (Young et al., 2017). According to Murata et al. (2017), exposure to a wide variety of strategies, strategies that are at a developmentally appropriate level, and transitional strategies between the developmental phases of mathematical learning can assist in addressing this struggle.

Separate studies (Kong & Orosco, 2016; Paul, 2018) sought to determine the impact of instructional strategies on student achievement. Both found, that when prescriptive instructional strategies where employed in conjunction with the adopted materials student achievement increased (Kong & Orosco, 2016; Paul, 2018). The problem is student achievement and interest in post-secondary coursework in mathematics has demonstrated a continuous decline over the last several decades (Douglas & Salzman, 2020; Vigdor, 2013). Not all students learn the same (Tyagi, 2017). It is necessary to identify instructional strategies that have the greatest impact on the largest number of students regardless of student learning style, subject preference, socioeconomic status, or previous acquired background knowledge. Therefore, an exploration of the impact of targeted instructional strategies was warranted. Specifically, the impact of concept-based mathematics instructional strategies for seventh grade students and to better understand the impact of student constructed knowledge.

Purpose Statement

The purpose of this quantitative, causal-comparative study was to determine the impact of concept-based instructional strategies when combined with the traditional curriculum for seventh grade mathematics students. A causal-comparative relationship study was conducted with teacher participation in concept-based instructional strategies professional development as the independent variable (Gall et al., 2007). The study examined the impact of concept-based instructional strategies on student achievement in mathematics. Instructional strategies have been defined as instructional methods that are specialized and target a specific learning behavior (Silver et al., 1996). As posited by Murata et al. (2017) instructional strategies have a positive influence on student achievement. Student achievement served as the dependent variable as it would demonstrate the effect (Gall et al., 2007). Student achievement data is a measurement that can be utilized to measure a student's progress toward an identified learning goal (*MAP Growth*, 2020). Student data has been utilized in many studies to determine effectiveness (Benders & Craft 2016; Casey et al., 2017; Kong & Orosco 2016; Lim 2019; McGee et al., 2017; Paul 2018; Tee et al., 2019). The population for this study was seventh grade students from two middle schools located in neighboring school districts. The students in Alaska School District 1 received mathematics instruction from teachers trained in concept-based instructional strategies. The students in Alaska School District 2 did not receive mathematics instruction from teachers trained in concept-based instructional strategies.

Context of Present Study

The concern for math achievement throughout the nation, is also present in Alaska School District 1 (ASD1). ASD1's longitudinal data demonstrates a regression in mathematics for middle grade students (Spargo & Ellsworth, 2019). Although, the data also indicates that by 12th grade students recover and score above the national average in mathematics; the goal for ASD1 is to eliminate the regression in the middle grades (Spargo & Ellsworth, 2019).

In response, district administration implemented a process to analyze and provide meaningful solutions to the problem. The first step taken was to review the curriculum. It was thoroughly reviewed by ASD1's curriculum council. After it was determined the curriculum was adequate, an examination of the fidelity of implementation (FOI) took place. Middle grade mathematic teachers throughout the school district were monitored for fidelity to the program. It was established that teachers were implementing with fidelity. Next, a math consultant was employed to study ASD1's math instruction, curriculum, and Measurement of Academic Process

(MAP) data. The consultant observed in a variety of classrooms from low-performing teachers to high-performing teachers. The results of the study indicated a lack of concept-based instruction regardless of the level of teacher performance.

ASD1 responded by a creating a one-year intensive professional development plan focused on concept-based instructional strategies for all secondary mathematics teachers, with an emphasis on middle grade teachers. The professional development plan consisted of three components. The first component was a one-day professional development training conducted by a consultant. Second, the consultant conducted onsite observations and modeled mathematics instruction followed by consultation with the mathematics teacher. Last, a college credit course was offered on teaching for conceptual understanding. Participation was not required but strongly encouraged by district and site administrators. The participation in observations, modeling and debriefing with the consultant is considered the most critical part of the plan. The purpose of the study was to determine the success of concept-based instructional strategies when combined with the traditional curriculum for seventh grade mathematic students considering the professional development received. The study adds to the empirical data that examines the impact of targeted instructional strategies. More specifically it provides additional evidence of the influence of concept-based instructional strategies on student achievement in mathematics.

Significance of the Study

Through concept-based mathematics instructional strategies, students are required to construct conceptual and apply perspective of mathematic. Constructivism requires students to construct and reconstruct their knowledge throughout the learning process (Woolfolk Hoy & Hoy, 2003). In addition, it requires deep and conceptual understanding (Hattie, 2018). Therefore, the results of this study add to the body of literature regarding constructivism theory.

There have been several studies that examined mathematics achievement for a defined population. For example, Young et al. (2017) sought to understand the impact of socializing agents on mathematics achievement for black girls. Douglas and Salzman (2020) examined college mathematics coursework based on major and gender. They found that a student's major played a greater role than gender. Torres (2017) examined the subgroup of American Indian and Alaska Native student achievement. This study found that cultural discontinuity between home and school did not have a significant impact on student mathematics achievement in grades four and eight. Hudson (2018) took a broader approach and examined the epistemic quality in mathematics instruction in the primary classroom. He posits that curriculum should be addressed to clarify what students are entitled to learn in mathematics.

The proposed study provides meaningful data for ASD1 and is beneficial to other districts throughout the nation that are experiencing a regression in middle grade mathematics. In addition, the examination of the impact of combining conceptual-based teaching strategies with the traditional curriculum could influence how higher education prepares mathematics teachers for the primary and secondary classroom.

The study examined students who received instruction from teachers trained in concept-based instructional strategies in math class when compared to their peers who did receive instruction from teachers trained in concept-based instructional strategies. Therefore, it has the potential to identify the influence concept-based instructional strategies has on students' mathematics achievement. Specifically, the impact it has on algebraic thinking. Improved mathematics achievement may influence the number of students entering a course of study in post-secondary that requires strong math skills. As previously noted, mathematics is considered "powerful knowledge" as a gatekeeper to high-income professions (Hudson, 2018). Therefore, providing students access to "powerful knowledge" will create a more competitive workforce.

Research Questions

RQ1: Is there a statistically significant difference in mathematics achievement between seventh grade students who are instructed by teachers who were trained in concept-based instructional strategies and teachers who were not trained in concept-based instructional strategies for mathematics controlling for prior achievement?

Definitions

1. *Concept-based instruction* - instruction that develops ways of thinking and practicing (Barradell & Kennedy-Jones, 2015).
2. *Constructivism* - A psychological and philosophical perspective contending that individuals construct or form much of what they learn and understand (Schunk, 2016).
3. *Educational Systems* - Entities participating in Program for International Student Assessment, including countries and subnational entities ("International Comparisions," 2019)
4. *Implementation Fidelity* - The degree to which programs are implemented as intended by the developers (Brigandi, 2019).
5. *Measures of Academic Progress (MAP)* - A computer-adaptive interim assessment for grades K-11, in the subject areas of reading, language usage, math and science (Brown, 2001).
6. *Professional Development* - A process of improving educator skills and competencies needed to produce outstanding education results for students (Hassel, 1999).

7. *Program Evaluation* - an assessment of the merit, worth and significance of a program (Gargani & Miller, 2016).
8. *Trends in International Mathematics and Science Study (TIMSS)* - An international comparative assessment that evaluates mathematics and science knowledge in grades four and eight (International Comparison, 2019).
9. *Participation rate* - The percentage of recruited people who participate in specified activities (Arfken & Balon, 2011).

CHAPTER TWO: LITERATURE REVIEW

Overview

Across the United States, there are concerns about math performance for students in the public education system. In response to this concern, a comprehensive literature review was conducted to examine what has been studied regarding the effect of concept-based math instruction on student achievement for middle school students when supplementing traditional curriculum. This chapter will provide an overview of current literature pertaining to this topic. The theoretical frameworks that align with this study will be discussed. In addition, the literature as it relates to program/instructional strategies selection and implementation, professional development, and program evaluation of effectiveness will be reviewed, synthesized, and analyzed to demonstrate emerging trends. Upon the completion of the review, a gap in the literature will be identified for future investigation.

Theoretical Framework

Rotter's Theory and Constructivism provided the theoretical framework for this study. Rotter's Theory was tested as it relates to a teacher's ability to influence student achievement through the development of efficacy. Constructivism was tested as it relates to the student's ability to construct mathematics conceptual to improve achievement and demonstrate growth. In this study, the two theories work together, Rotter's is focused on the teachers and constructivism is focused on the students. The end goal for both is increased student mathematics achievement.

Rotter's Theory

Rotter's (1966) theory asserts that a relationship exists between the efficacy of the teacher and student achievement. Efficacy is defined as a teacher's belief that they have the ability to influence student's behavior and academic achievement even when a lack of students' academic motivation is present (Tschannen-Moran & Woolfolk Hoy, 2007). Hattie (2018) posits that collective teacher efficacy has the greatest effect size and influence over all other indicators on student achievement. Collective teacher efficacy occurs when a group of teachers perceives its' collective efforts will result in a positive effect on students (Goodard et al., 2000). Therefore, collective teacher efficacy should be cultivated and nourished to improve student academic achievement (Hattie, 2018). It has been demonstrated that impactful leaders make a concerted effort to develop teacher efficacy to increase student achievement (Hattie, 2018). Collective teacher efficacy is a factor to consider when implementing concept-based instructional strategies within a school or across a school district.

Constructivism

Constructivism offers a model of instruction that is student-centered (Bruner, 1964). It is a model by which students are expected to become actively involved with the content through explicit structures designed by the teacher (Bruner, 1964). Constructivism is comprised of three key perspectives. This includes exogenous, endogenous, and dialectical (Bruning et al., 2011). An exogenous perspective contends that knowledge can be developed through external experiences, modeling, and teaching. An endogenous perspective proposes that knowledge derives from knowledge previously acquired. In addition, it is not directly acquired from environmental interactions. The dialectical perspective posits, knowledge is obtained from human and environmental interactions. Thus, knowledge is a result of confronting mental contradictions that are presented in a person's interaction with the environment (Bruning et al., 2011). The constructivism theory is important to this study as it provides a theoretical framework focused on modeling, teaching, drawing on prior knowledge and interacting with others and the learning environment. The purpose of conceptual-based mathematic instructional strategies is to create deep understanding through modeling and constructing knowledge (Hannula, 2018).

Both Rotter's Theory and Constructivism was used to frame this study to determine the influence of concept-based mathematics instructional strategies. Rotter's Theory was applicable to the classroom teacher in an examination of the impact of professional development on concept-based mathematics instructional strategies and its' effect on student achievement. Rotter's Theory operates in conjunction with constructivism in this study. Constructivism provided the framework for student's receiving concept-based instructional strategies and its' impact on student achievement.

Related Literature

Due to the nature of the study, it is important to review literature related to instructional strategies selection, professional development, and program evaluation. Instructional strategies identification and implementation will examine targeted instructional strategies, mathematics instructional strategies, concept-based instructional strategies, and mathematics concept-based instructional strategies, and classroom setting.

Upon the identification of an appropriate instructional strategy and before implementation begins, professional development must be conducted. Therefore, a review of literature surrounding professional development is necessary. The four categories represented in the literature review are effectiveness of professional development, observation, feedback, and modeling quality instruction, professional learning communities, and efficacy.

Last, a review of the literature regarding program evaluation was conducted. This portion of the literature review addresses analyzing for effectiveness, trajectory trends, and other factors that may impact the study. The purpose of this study is to determine if concept-based mathematics instructional strategies impact student mathematic achievement.

Instructional Strategies Identification

Identification of instructional strategies should be carefully selected to align with the identified need. After appropriate professional development has taken place and implementation has begun, monitoring should occur to increase reliability and validity in the results (Brigandi, 2019). Monitoring could be accomplished by means of classroom observations utilizing a program implementation checklist to provide feedback for the teacher.

Careful consideration should be given when implementing a program to improve instruction. The data collected may be utilized to make decisions regarding continued instruction. Therefore, it is essential to collect reliable and valid data. A contributing factor to obtaining reliable data is proper program implementation. Teacher modification of the curriculum frequently occurs when implementing a program (Moon & Park, 2016). Hence, ensuring implementation fidelity is vital.

Targeted instructional strategies

Targeted instructional strategies have proven to increase student achievement. Johns & Moyer (2018) examined how the utilization of a framework to select instructional strategies assists in identifying the critical learning objectives that are rigorous and measurable. The use of a framework proved to be beneficial (Johns & Moyer, 2018). It provided a means of selecting best practice recommendations for student-centered learning, as well as for assessment (Johns & Moyer, 2018).

Often, the first decision in selecting an instructional strategy is whether instruction should be implicit or explicit. During explicit instruction, the teacher provides extensive structures, procedures, and routines. In addition, a clear learning objective is defined for the student. On the other hand, implicit instruction does not offer a clear learning objective. The teacher provides information or poses a problem to solve and allows students to develop their own solutions and create their own conceptual structures (Clements-Stephens et al., 2012).

Mathematics instructional strategies

Mathematics instruction can be explicit or implicit. Students receiving instruction in an explicit learning environment more frequently utilize advanced strategies (Heinze et al., 2018). However, students receiving instruction in an implicit learning environment utilize newly acquired strategies that were more sustainable than the students in an explicit learning environment (Heinze et al., 2018). In addition, students that received implicit instruction were able to self-develop and adapt a variety of strategies to solve mathematics problems (Heinze et al., 2018).

It is beneficial to understand how researchers have examined specific instructional strategies for effectiveness on student achievement. For example, Paul (2018) sought to determine the instructional strategies teachers employ when teaching close reading strategies in a variety of content areas, including mathematics (Paul, 2018). This collective case study examined the current practices through a Massive Open Online Course (MOOC). The study demonstrated that teachers were more likely to use instructional strategies that were presented in professional development opposed to best practices for their content area (Paul, 2018).

In another study, Kong and Orosco (2016) examined the effect of word problem solving strategies for minority students who were identified as at-risk in mathematics. In this study, it was determined Word Problem Strategy (WPS) and Dynamic Strategic Math (DSM) when implemented in conjunction with the adopted math curriculum “demonstrated strong evidence of a causal relationship" (Kong & Orosco, 2016). In addition, the percentage of non-overlapping data was 100%. This indicated the intervention was effective.

Concept-based instructional strategies

Bell (2017) identified two key points in neuroscience that promote learning and instruction. One key point is neurons can be built and strengthen through repetition of skills (Bell, 2017). In opposition, McGee et al. (2017), found that automaticity did not improve student achievement. The second key point is the brain has a need for novelty (Bell, 2017). Due to the need for novelty, teachers should incorporate a variety of instructional strategies into lessons including project-based assignments, multimedia, and graphic organizers (Bell, 2017). Acknowledging that interesting and varying instructional strategies is appealing to the brain or thought process is essential when engaging students in conceptual learning (Bell, 2017; Clements-Stephens et al., 2012)).

Mathematics concept-based instructional strategies

Transitioning from a traditional mathematics curriculum to concept-based instruction can prove to be difficult (Erickson & Lanning, 2014). However, if done correctly students will be engaged in learning activities that encourage synergistic thinking, collaborative learning, and knowledge that is transferable (Erickson & Lanning, 2014). Transferability is constructed when students are engaged in both the knowledge and the process (Bruner, 1990; Erickson & Lanning, 2014). Thus, developing skills that are beneficial to understanding more complex concepts (Bruner, 1990; Erickson & Lanning, 2014).

Conceptual understanding is imperative to the understanding of mathematics (Egodawatte & Stoilescu, 2015). Researchers have concluded mathematic students typically resort to the use of procedures when solving word problems and utilize a lower level of conceptual understanding (Egodawatte & Stoilescu, 2015). It is suggested math problems are solved best when there is an interdependence of knowledge, skills, and strategies (Powell et al., 2018).

One instructional strategy to developing concepts is the use of language (Powell et al., 2018). This refers to how the teacher verbally interacts with the student to facilitate the development of a concept (Powell et al., 2018). It has been suggested that precision in language in the early grades allows students to focus on constructing mathematical knowledge opposed being consumed in the technical procedures (Shockey & Pindiprolu, 2015). It has been noted that teachers in the middle grades must be deliberate and precise in word selection when teaching mathematics (Powell et al., 2018). In addition, the language of math should be clear and concise (Powell et al., 2018).

Another innovative approach to teaching algebraic conceptual thinking is with magic. A study demonstrated that when students were presented with a magic activity and were taught to solve it, utilizing algebraic principles, they easily transferred that conceptual knowledge to solve other magic math problems (Lim, 2019). In addition to magic activities, student-developed math card games have been found effective in developing conceptual understanding (Roman, 2016). It is asserted that in the process of planning and developing the math card game for peers to play, students gain a deeper understanding of the concept than through traditional instruction (Roman, 2016). Again, it is noted the importance of clear and concise language, this time for the rules of the math game (Roman, 2016).

Classroom setting

The classroom setting is foundational to the implementation of instruction. The theoretical framework utilized defines the learning environment and instructional activities. This study was guided by the constructivist approach to instruction. In addition, an examination of the role of technology in concept-based learning is explored.

Constructivism. Traditionally, classrooms have been teacher centered. The teacher has acted as the “sage on the stage”. In a teacher-centered classroom, the teacher is the keeper and dispenser of all knowledge. Constructivism is an epistemology that provides a model that is student-centered (Schunk, 2016). It is in this setting that the teacher becomes the “guide on the side”. Constructivism places an emphasis on actively engaging learners in an integrated curriculum (Schunk, 2016). During engaged learning, students are constructing and reconstructing their deep understand of concepts (Woolfolk Hoy & Hoy, 2003).

In the classroom the constructivist approach to mathematics is considered an integral part of a daily activities, not merely a subject to be taught (Shrestha, 2019). Steffe (2016) suggests, a major goal of a constructivist teacher is to participate in interactions with students that provides the learner with an opportunity to create and sustain mathematical independent activities and interactivities that may go beyond the teacher’s suggestions or guidance. In addition, the constructivist teacher of mathematics builds experiential models of mathematical learning for students (Steffe, 2016). It is further noted that the teacher plays a variety of roles in the classroom as both a first-order observer and a second-order observer.

As a first-order observer, the teacher utilizes their own knowledge and experience to engage with the student in a responsive and intuitive interaction (Steffe, 2016). During responsive and intuitive interactions there are no intentional distinction between the knowledge of the teacher and the knowledge of the student (Steffe, 2016). As a second-order observer, the teacher utilizes awareness and reflection on past experiences to guide instruction (Steffe, 2016). During analytical interactions, the teacher observes a student’s language and actions to analyze the student's thinking and understanding of concepts (Steffe, 2016). This allows the teacher to understand how the student is constructing knowledge and thereby, the teacher becomes de-centralized to the learning process (Steffe, 2016). In addition, as a second-order observer, the teacher can focus on creating scenarios of learning that may be aligned to the student's way of processing knowledge (Steffe, 2016).

Another aspect of constructivism is self-regulation (Schunk, 2016). Some mechanisms of self-regulation include metacognitive strategies, time management, motivation, and structuring of the environment (Schunk, 2016). Preiss et al. (2018) conducted a factor analysis that suggests that students prefer activities that promote metacognition and motivational regulation. When looking specifically at mathematical learning, researchers found that both a student's mathematical mindset and self-efficacy were positive predictors of a student's effort regulation (Roney et al., 2019).

Technology Use. In this modern age of technology, the role it plays in primary, secondary, and higher education cannot be overlooked. The extent to which technology is utilized in the classroom is impacted by the level of comfort the teacher has using technology (Kikiakidis, & Johnson, 2015). Kikiakidis and Johnson (2015) sought to understand how teachers perceived the integration of math software into the regular math curriculum. The results from this qualitative study indicated that teachers perceived the math software to be beneficial for students in understanding math concepts and students enjoyed problem solving (Kikiakidis, & Johnson, 2015). In addition, the teachers perceived that math proficiency increased, as a result, of the interaction with math related text, animations, graphics, and videos (Kikiakidis, & Johnson, 2015). Last, the teachers expressed a need for additional professional development on use of the software (Kikiakidis, & Johnson, 2015). This is also supported by Liu and Liao (2019) who found that professional development regarding new technology was critical for teacher self-efficacy.

A recent study was conducted to examine the achievement of higher-order cognitive outcomes by utilizing tablet applications that connected with cross-curricular math instruction and different modes of representation (Volk et al., 2017). The researchers determined that students that were supported using technology applications had better outcomes than their counterparts that did not use technology applications. It is interesting to note that although the effect size for conceptual knowledge was small, procedural knowledge and problem solving both demonstrated a medium effect size (Volk et al., 2017). This study provides key information when examining the service delivery model for concept-based instructional strategies.

Professional Development

Professional development has been identified to improve teacher competences; thus, creating a positive effect on student achievement (Pharis et al., 2019). The purpose of professional development is to create opportunities that are deliberately focused on meaningful conversations that ask good questions and are resolution oriented (Cooper et al., 2018). Professional development can be provided through a variety of formats. These formats include, but are not limited to, training by consultants, train-the-trainer, and professional learning communities.

The importance of meaningful and purposeful professional development is found in the literature. Yurtseven and Altun (2016) examined the effect of a specific professional development designed to increase a teacher’s ability to improve student achievement when learning English as a foreign language. The study revealed there were significant gains for students that scored in the medium range of acquisition (Yurtseven & Altun, 2016). Hassel

(1990) identified professional development as a process that could produce excellent educational results in student achievement by improving teacher skills and competencies. Guskey (2000) stated, “One constant finding in the research literature is that notable improvements in education almost never take place in the absence of professional development”.

Effectiveness of professional development

It has been noted that significant improvement does not take place without purposeful and quality professional development (Pharis et al., 2019). Cooper et al. (2018) posits professional training provided by “experts” resulted in positive changes in teacher competency. Conversely, other researchers assert the most meaningful learning for educators happens through facilitated conversations with their peers (Baker et al., 2018). Effective professional learning takes place when the leader operates in a growth mindset and develops and nourishes it in others (Kouzes & Posner, 2017). Growth mindset is the belief that a person can cultivate their basic qualities through effort (Dweck, 2008). Continuous growth is diminished or extinguished when people operate in a fixed mindset. A fixed mindset is one that operates in the belief that qualities are fixed and cannot be changed (Dweck, 2008). Dweck (2008) also asserts it is a mindset, as opposed to a skill set, that makes the critical difference when tackling challenging situations.

In an effort to provide quality professional development programs, effective elements must be identified. Blank (2013) identified common elements that are present in effective professional development programs. These elements include the appropriate duration of professional development (contact hours), multiple professional learning activities offered utilizing active learning methods (delivery model), and group participation and collaboration (Blank, 2013). It is also noted, one-time and short-term events were ineffective methods of professional development (Blank, 2013).

Duration. Martin et al. (2019) found that when mathematic teachers selected to participate in professional development multiple times throughout a school year the topics fell into four distinct areas. Mathematic teachers distinctly selected professional development focused on deepening their own knowledge of mathematical content, strategies for engaging students in instruction, implementing specific standards and professional learning communities that provided support (Martin et al., 2019). Teachers identified participating in professional development that deepened their own knowledge of mathematical content as having the greatest impact on instruction delivered to students (Martin et al., 2019).

Deep learning. When discussing concept-based instructional strategies for students it is evident that its goal is deep learning (Erickson & Lanning, 2014). Bradley and Hernandez (2019) posit a structure for deep learning that includes personalized, relevant, and relational instruction. In their framework, students' work toward five learning goals (Learning Policy Institute et al., 2019). These goals include empirical reasoning, quantitative reasoning, social reasoning, personal qualities, and communication (Learning Policy Institute et al., 2019). Their data analysis suggests that students that focus their learning in these five areas develop deeper learning. In addition, students score higher on state assessments and graduate from high school at a higher rate than their counterparts in the same school district (Learning Policy Institute et al., 2019).

Deep learning is also related to teacher learning. Martin et al. (2019) aligns with Hattie's (2012) checklist for an effective professional development program. Martin et al. (2019) asserts that an effective professional development program consists of ensuring the professional development generates a teacher's deeper understanding of the content, supports learning through classroom observations, and assists teachers by providing effective feedback. In addition, Hattie (2012) states, effective professional development programs attend to students' affective attributes and enhances the teachers' ability to influence both surface and deep student learning.

Frequency. It would be negligent to discuss the impact of duration on deep learning without also discussing frequency. Effective frequency of professional development can be provided in a variety of formats (Darling-Hammond et al., 2017). This includes intensive workshops with follow-up days, semester or yearlong classes, and ongoing mentoring/coaching (Darling-Hammond et al., 2017). In addition, Derrington (2016) suggests that when teachers meet frequently and regularly for professional development teacher leadership increases.

Delivery model. Darling-Hammond et al. (2017) asserts that meaningful professional learning requires an implementation that has adequate time and quality. However, it is noted that there is no clear threshold for the length of duration (Darling-Hammond et al., 2017). Darling-Hammond et al. (2017) advocate for what they term sustained professional development. Sustained professional development is repeated over an extended period (Darling-Hammond et al., 2017). It allows a teacher to learn, apply in the classroom, and reflect with colleagues to make needed adjustments. They posit that sustained professional development has a stronger impact on both teacher and student learning than sporadic professional development (Darling-Hammond et al., 2017).

When providing professional development, it is important to have an effective delivery model. The most common delivery models include face-to-face meetings, virtual meetings, or a combination of face-to-face and virtual meetings. Carpenter and Munshower (2020) found that teachers perceived virtual meetings to be just as effective as traditional face-to-face meetings. In addition, Li and Karnsy (2020) posits both face-to-face and virtual learning activities have the capacity to build connections among teachers. This connection often led to teachers seeking out other participants for advice.

Collaboration. As a result of schools increasingly utilizing a collaborative community to structure teaching, collaboration has become an important aspect of well-designed professional development (Darling-Hammond et al., 2017). It has been noted that collaboration can serve as a “powerful tool for professional development” (Tallman, 2019). Increased collaboration results in an increase in reflective practices (Tallman, 2019). Collaboration can exist in a variety of configurations, such as one-on-one, small group or school-wide interactions (Darling-Hammond et al., 2017). A positive correlation exists between increased student achievement and professional development that utilizes collaborative structures that permit teachers to problem-solve and learn collectively (Darling-Hammond et al., 2017).

Eaker et al. (2002) asserts there is a need to establish a culture of collaboration. The authors posit it is critical for leaders to provide time, parameters, and support to create collaborative and effective teams (Eaker et al., 2002). In addition, it is suggested that collaborative meetings have developed protocols to ensure focus is maintained (Eaker et al., 2002). Rempe-Gillen (2018) asserts that participation in collaboration as a means of professional development is based on teacher preference. This 2018 study acknowledges that historically teachers have taught in isolation (Rempe-Gillen, 2018). The researcher concluded, for teachers to willingly participate in a collaboration model requires the teacher to possess self-awareness (Rempe-Gillen, 2018). This was found even more so when teachers were asked to collaborate across school settings, such as elementary with secondary (Rempe-Gillen, 2018).

Time. As previously noted, time is critical to creating collaborative and effective teams (Eaker et al., 2002). Sterrett et al. (2018) assert that it is the role of the principal to provide teachers time for professional development that is during non-instructional time with minimal interruptions and minimal paperwork. In addition, relieving teachers of other duties that would interfere with the designated time is a critical factor (Sterrett et al., 2018). These provisions allow for teachers to strengthen the learning community (Sterrett et al., 2018). Bradshaw (2015) posits that a yearlong professional development schedule should be developed that reflects the needs of the school. In addition, an evaluation should be completed and reviewed to create a cycle of improvement (Bradshaw, 2015).

Parameters. Darling-Hammond et al. (2017) define effective professional development as “structured professional learning” that changes the teacher’s knowledge and practices that result in improved student learning. Structured professional learning occurs when parameters and guidelines are utilized to facilitate the learning process. The parameters may include guidelines for social interactions and expectations, identified goals, procedures, evaluation, and reflection (Eaker et al., 2002). Defining appropriate social interactions and expectations is the first step to creating a climate and culture of learning (Flippen Group, 2014).

Support. One role of the school administrator is to support teachers in their learning (King, 2016). Support is provided through leadership, serving as a change agent and advocate, and providing structured professional learning communities (King, 2016). King (2016) asserts that these actions result in transformative, collaborative, and constructivist change in teacher practices (King, 2016). In addition, another form of support is providing professional development onsite and provide a teacher resource center with quality literature (da Silva & Oleveira, 2020). Another form of professional development is providing mentoring for identified teachers, specifically, new to the profession (Tanis & Barker, 2017). Teachers that work with a mentor report that the experience provided transformative learning opposed to learning simple skills (Tanis & Barker, 2017).

Observation, feedback, and modeling quality instruction

Observation, feedback, and the modeling of quality instruction influence the instructional practices of classroom teachers (Darling-Hammond et al., 2017; Maeng et al., 2020). All three may be conducted by peers, supervisors, or a consultant. Thus, each provides a unique perspective to the observed instruction.

Observation. Conducting observations and providing feedback have demonstrated an impact on teachers' instructional practices (Maeng et al., 2020). It provides an avenue for teachers to understand the concept of a "need" to be reflective in their practice (Darling-Hammond et al., 2017). Classroom observations provide information for supervisors, consultants, and colleagues enabling them to share specific feedback with the classroom teacher (Tallman, 2019). Three types of observation include observations conducted by peers, supervisors, and consultants (Tallman, 2019).

Peer observation. Peer observation has been defined as the process of a teacher observing a colleague's instruction in a non-judgmental manner and may or may not provide feedback (Bell & Thomson, 2018). Researchers found when promoting peer observation, administrators primarily utilized one of three way to encourage teacher participation (Bell & Thomson, 2018). Administrators encouraged participation through focusing on the benefits of observation, focusing on collegiality and collaborative conversations among staff or focusing on autonomy of choice for the instructional staff (Bell & Thomson, 2018). In addition, administrators' reasons for their selected approach was usually grounded in their own personal experience, disciplinary differences, or pressure from within the institution (Bell & Thomson, 2018). A more modern approach to peer observation was studied by Jones and Gallen (2016). They examined the effectiveness of online peer observation. Although they found some benefit for instruction, there was not overwhelming or clear evidence of its effectiveness (Jones & Gallen, 2016).

Supervisor observation. When a supervisor utilizes observation, it is inherently an evaluation tool. Therefore, an important role of the administrator is to provide professional development that includes understanding the purpose, process, and the tool to by utilized (Robertson-Kraft & Zhang, 2018). As with peer observations, it is noted that teacher ownership of the process was dependent upon the perception that the process was framed as an opportunity to grow and develop as an educator (Malloy, 2020). This shift of evaluation observations from being punitive to a means of support and develop is an immense task for an administrator (Malloy, 2020). Once the purpose and process have been established teachers must be well-acquainted with the tool and administrators well trained in its use (Roegman et al., 2016). The role the administrator plays in utilizing the tool properly can influence teacher motivation in a positive or negative manner (Cuevas et al., 2018).

Consultant observation. Consultant observation occurs when a consultant with an expertise observes a teacher's instruction (Murcia & Pepper, 2018). Murcia & Pepper (2018) assert that consultant observation has a positive effect on teacher motivation to improve instruction. In multiple studies, it has been noted that consultant observation and feedback have a stronger impact on teacher instruction than peer or supervisor observation (Murcia & Pepper, 2018; Stringfield et al., 2017). An important aspect of consultant observation as with peer and supervisor observation is appropriate and timely feedback.

Feedback. Feedback provides an educator with an opportunity to be reflective in instructional practices and seek improvement (Schwartz et al., 2018). Upon the completion of an observation the one being observed should be provided with timely and specific feedback (Candela & Brown, 2019). The feedback is best framed by an observation tool that is understood by the one receiving the feedback (Hofer, 2016). Feedback can be provided from a variety of sources, such as, peers, supervisors, and consultants (Tallman, 2019).

Peer feedback. Peer feedback has been found to be more effective when the peer observer has a valid and reliable observation tool/rubric (Candela & Brown, 2019). Teachers reported that the utilization of a tool allowed them to be reflective on the complexities of teaching, provide beneficial feedback to their colleagues, and increased their desire for direct feedback from supervisors and consultants (Candela & Brown, 2019). Collegial and collaborative conversations are a by-product of peer observation with focused feedback (Bell & Thomson, 2018).

Supervisor feedback. Supervisor feedback has been found to be inconsistent. Kraft & Gilmour (2017) found that administrators were more reluctant to assign new teachers a below proficient rating. Principals cited a teacher's potential and motivation as causes to assign and inflated rating (Kraft & Gilmour, 2017). Principals were fearful of decreasing motivation in a teacher that demonstrated a willingness to improve and felt it unfair to rate new teachers below proficient due to lack of experience (Kraft & Gilmour, 2017). Regarding experienced teachers, a study concluded that when an administrator facilitates the involvement of experienced teachers in an observation/feedback evaluation model there is a higher likelihood of positive change (Derrington, 2016).

Consultant feedback. It is asserted that consultants provide more robust and beneficial feedback to teachers (Stringfield et al., 2017). This is contributed to the consultant's deeper understanding of the complexities of instruction (Stringfield et al., 2017). In addition, consultants were more capable of conveying the complexities and facilitate teacher change (Stringfield et al., 2017). Last, a meaningful two-way dialogue between teachers and consultants empowered teachers to alter instruction for improvement (Murcia & Pepper, 2018). Feedback has been found to be a powerful tool it effective feedback (Darling-Hammond et al., 2017).

Reflection. Another powerful tool for effective feedback is reflective practices (Darling-Hammond et al., 2017). Quality professional development models that have resulted in an increase in student achievement have provided an intentional time for teachers to reflect on practices (Darling-Hammond et al., 2017). Reflective practices work in concert with feedback. Participating in reflective practices is an opportunity to receive positive and constructive feedback to an observation that can be utilized to improve instruction (Darling-Hammond et al., 2017). Effective professional development models utilize feedback and reflective practices to create a robust environment that promotes teacher learning (Darling-Hammond et al., 2017).

Vygotsky (1987) asserts that reflection is a higher psychological function. In addition, it is a social construct that is mediated through human activities. It is recognized as a social construct because it begins as a shared cognition amidst the community of learners and through internalization transforms into individual consciousness (Vygotsky, 1978). It is a metacognitive action by nature, as it requires one to think about their thinking (Lampert-Shepel & Murphy, 2018).

Reflection has been categorized into three levels. The levels include surface reflection, pedagogical reflection, and critical pedagogical reflection (Larrivee, 2008). Surface reflection is described as the utilization of data and adjusting instruction based on experience alone (Larrivee, 2008). Pedagogical reflection occurs when methods and practices are adjusted based on students' performance (Larrivee, 2008). Critical pedagogical reflection is described by a commitment to learn continually and improve instructional practices, be critical of one's own practice, and viewing teaching practice as something that is constantly evolving (Larrivee, 2008). Reflection can be accomplished by a variety of means. Two of these means are through written reflection and reflective discussions. Lampert-Shepel and Murphy (2018) found that the use of reflective discussions had a greater influence on changing instructional practices than written reflection.

Modeling quality instruction. In addition to teacher observation for feedback, the observation of quality instruction has been noted as an influencer of increasing a teacher's desire to learn and grow in the profession (Darling-Hammond et al., 2017). It was also found to increase student learning (Darling-Hammond et al., 2017). Modeling is a crucial component of social cognitive theory (Bandura, 1986). One function of modeling is observational learning (Bandura, 1986). Observational learning occurs when learning takes place through giving attention to a competent model (Schunk, 2016).

Darling-Hammond and colleagues (2017) identified a variety of methods in which modeling can occur. The list includes the observation of videos, demonstration lessons, and observation of peers. Furthermore, the researchers (Darling-Hammond et al., 2017) stress the importance of modeling instruction in conjunction with professional conversations following the observation. Professional conversations often take place in professional learning communities (Baker et al., 2018).

Professional learning communities

Professional learning communities are designed to "harness the power of collective intelligence" (Dufour et al., 2004, p. xiii). Effective professional learning communities develop mission, vision, values, and goals, establish collaborative teams, encourage collective inquiry, and are oriented toward orientation and experimentation. In addition, professional learning communities create a continuous improvement cycle, and are focused on results (Dufour et al., 2004).

Establishing a vision for an organization provides clarity, focus, and purpose (Kouzes & Posner, 2017). Brown (2018) states, “Clear is kind, unclear is unkind”. A clear vision provides an opportunity to collectively and collaboratively establish values and goals that are supported by professional development. Collaboration builds trust in an organization, thereby increasing open dialogue (Kouzes & Posner, 2017). Trust develops incrementally over time and is a key element to success in any organization (Brown 2018). When trust is present organization are comfortable discussing the “gritty facts” and collectively seek solutions (Brown 2018).

Research has demonstrated when a shared vision and commitment to improving instructional practices is present, the participants move from seeking and sharing information to eliciting shifts in instructional delivery (Baker et al., 2018). In addition, the professional learning community model provides the opportunity to construct knowledge collectively (Baker et al., 2018). Constructing knowledge collectively builds capacity for sustainability in school improvement and creates the possibility of building networks not only within a school, but also between multiple schools to share knowledge (Baker et al., 2018).

Eaker et al. (2002) states there are four priorities for effective professional learning communities. These priorities include a focus on learning, a focus on collaborative culture, a focus on results, and providing timely, relevant information (Eaker et al., 2002). Researchers found that teachers who have the highest participation rate in ongoing professional development, such as professional learning communities, top interest is in learning about the barriers students face in understanding mathematical concepts (Martin et al., 2019). The teachers’ focus is on student learning. In the same study, researchers noted that teachers perceived value in collaborating with others to learn how to improve instruction (Martin et al., 2019). In addition, it was also noted that assessing students for evidence of results was a high priority for teachers participating in professional learning communities (Martin et al., 2019). Darling-Hammond et al., (2017) notes that analyzing student data in a collaborative format provides opportunities for teachers to develop a common understanding of instructional strategies that effective or ineffective and for whom.

As previously stated, professional development can be delivered in a variety of formats. Thus, professional learning communities can as well. Li and Karnsy (2020) noted that teachers that engaged in online interactions as a supplement to face-to-face meetings created a more robust network and stronger connections within that network. It was also noted, connections were more likely to be created if participants posted less and commented more on others' posts (Li & Krasny, 2020). However, Prenger et al. (2019) found that the connections or networks weakened when extended beyond a school site. In addition, there is a positive correlation between online dialogue and decreased anxiety or fear of being judged by colleagues (Carpenter & Munshower, 2020). Teachers are more likely to openly discuss educational philosophy and discourse through an online format (Carpenter & Munshower, 2020).

Efficacy

Efficacy has been defined as the ability to produce a desired outcome (Bandura, 1993). In education, efficacy has been described as a teacher's confidence in their ability to influence student achievement and motivation through sound teaching practices resulting in improved student achievement (Skaalvik & Skaalvik, 2007). When examining efficacy there are two distinct categories. These categories are self-efficacy and collective efficacy (Bandura, 1993).

Self-efficacy. Generally speaking, self-efficacy refers to a personal belief of one's ability to learn or perform at designated levels (Bandura, 1986). This belief instills a desire to develop outcome expectations (Bandura, 1986). Establishing outcome expectations is shown to influence achievement (Schunk, 2016). In addition, research indicates that self-efficacy is primarily specific to content (Schunk, 2016).

Liu and Liao (2019) found a high correlation between teacher efficacy and the format, content, duration, and quality of professional development. The data collected for this study indicated that high participation rate in school visits and workshops/in-service trainings resulted in an increased self-efficacy in the areas of instruction and student engagement (Liu & Liao, 2019). However, they suggested a further examination of duration and quality of professional development on important end goals of professional development programs (Liu & Liao, 2019).

Kim and Seo (2018) sought to synthesize previous research regarding the "relationship between teacher efficacy and students' academic achievement and to identify factors that affect this relationship". In doing so, they discovered a positive relationship between student academic achievement and teacher efficacy. Kim and Seo (2018) concluded that student academic achievement could be positively affected when teachers believe they can have an influence on student outcomes.

Romanov et al. (2019) assert that mathematics teachers' self-efficacy can be developed through properly compiling and organizing math tasks. Math tasks when properly scaffolded increase student conceptual learning and understanding of mathematical principles. They go on to posit, that problem solving is most effective when students recognize various methods to reach a solution (Romanov et al., 2019). This signals a deeper understanding of the content and the process to problem solving (Romanov et al., 2019). Thus, it is necessary for teachers to possess a working knowledge of proper compiling and organizing of math tasks (Romanov et al., 2019).

Collective efficacy. Collective efficacy refers to the "beliefs of a group to enact an effective organization" (Bandura, 1997). It has been asserted that teachers not only construct self-efficacy; they also construct collective efficacy, often referred to as collective teacher efficacy (Goddard et al., 2004). Collective teacher efficacy is the belief that the staff's efforts will have a positive impact on student achievement (Goodard et al., 2000). Bandura (1993) posits that collective teacher efficacy has a stronger link to student achievement than socioeconomic status. It has been noted that when collective teacher efficacy increases so does student expectations (Donohoo, 2018). Researchers have found strong collective teacher efficacy is also linked to increased job satisfaction and reduced stress (Avanzia et al., 2015, Klassen et al., 2010)

Jahnke (2010) identifies several factors that contribute to collective teacher efficacy. Most are the same critical factors for professional development, such as, a supportive and positive environment, clear and well-articulated vision, and high expectations. However, Jhanke (2010) also suggests that shared leadership plays a significant role. This has been supported by other researchers who found facilitating shared leadership is a means to develop collective teacher efficacy (Derrington, 2016, Putney & Jones, 2019). Shared leadership occurs when an administrator provides opportunities for teachers to take a leadership role in professional development (Calik et al., 2012). This creates a "reciprocal causality" between teacher self-efficacy and collective teacher efficacy (Bandura, 1997).

Program Evaluation for Effectiveness

Program evaluations are beneficial in a variety of circumstances. A program evaluation may be used to determine the effectiveness of a program and its value or merit (Gargani &

Miller, 2016). In addition, program evaluations can determine the significance or impact on a group of people (Gargani & Miller, 2016). Program evaluation falls under the umbrella of evaluative inquiry (Gargani & Miller, 2016). To better understand program evaluation, it should be noted that impact evaluation, comparative effectiveness, and implementation science are all subsets of program evaluation (Gargani & Miller, 2016).

It has been asserted that impact evaluation can be conducted from three perspectives (Cromwell & Aghajanian, 2017). These perspectives include impact by design, impact by interaction, and impact by emergence (Cromwell & Aghajanian, 2017). An impact by design perspective evaluates the effectiveness of the program design and structure (Cromwell & Aghajanian, 2017). As it would imply, impact by interaction evaluates how the participants interact with the program and their colleagues as it relates to the program (Cromwell & Aghajanian, 2017). Impact by emergence refers to a data collection system that allows participants to recognize trends during the process (Cromwell & Aghajanian, 2017).

A program evaluation of comparative effectiveness contains a control group and a treatment group for comparison (Yang et al., 2020). Implementation science has been defined as framework to promote an integration of findings and evidence from research into practice and policy (Kramer & Howe, 2014). In the field of education where there are constant concerns about effectiveness, program evaluation is a tool to establish accountability and inform decision-making (Gargani & Miller, 2016).

Analyzing effectiveness

It has been said that we measure what we treasure, and we treasure what we measure. In order to establish worth and significance of any program, a reliable and valid evaluation must be conducted. Effectiveness of a program can be analyzed both qualitatively and quantitatively.

Using a quantitative approach student data can be utilized to measure the effect on student achievement. In a qualitative approach, interviews and surveys can be conducted to determine perceptions of improvement and collective efficacy efforts. When evaluating the effectiveness of a targeted intervention four dimensions should be measured. These dimensions are program model, quality of delivery, target audience, and participants' responsiveness (Greenberg et al., 2005).

Krupa (2017) focused research efforts on measuring the effectiveness of reform efforts and the impact on student achievement as it relates to teachers' implementation of math curricula. Krupa and Confrey (2017) conducted a study with 19,526 high school students to determine the effectiveness of an integrated reform-based curriculum compared to a subject-specific curriculum. The study demonstrated that students participating in integrated math curriculum outperformed students enrolled in a subject specific curriculum on an Algebra I final exam (Krupa, & Confrey, 2017). However, the same results were not realized on the Algebra II exam (Krupa, & Confrey, 2017). It is speculated that the lack of alignment in the Algebra II course was a factor to be considered (Krupa, & Confrey, 2017). This close analysis provided data to allow the school district to make informed decision on how to improve mathematics instruction at the high school level.

The Measures of Academic Progress (MAP) has been utilized as an assessment in a variety of studies to determine effectiveness (*MAP Growth*, 2020). Some of the studies have included topics such as, blended learning, flexible small groups, school-wide cluster grouping, and summer learning (Benders & Craft, 2016; Fazal & Bryant, 2019; Kuhfeld, 2019; Matthews et al., 2013). However, after great effort, the author was unable to locate studies that examined the effect of concept-based mathematic instruction strategies when combined with traditional curriculum as measured by MAP.

Trajectory trends

It is essential to understand the long-term effect of instructional strategies in the early grades on student performance in later grades. The best way to accomplish such a task is through conducting a longitudinal study. Longitudinal studies require a lengthy span of time; therefore, are not conducted with high frequency. In addition, trajectory trends are established throughout the study that can predict possible outcomes. Instructional trajectory trends are the learning paths that are created through teacher instruction (Casey et al., 2017). Casey et al., (2017) conducted such a study to examine the effect of spatial skills and mathematics strategies for first grade girls on analytical math reasons in fifth grade. The researchers used a path analysis to determine if longitudinal correlational pathways existed for girls as they traveled from first grade to fifth grade (Casey et al., 2017). It was concluded that first grade girls' spatial skills were the highest predictor of success in math reasoning in fifth grade girls (Casey et al., 2017).

Trajectory trends may also be identified in shorter studies. Trajectory trends are meaningful ways to determine where students are on the learning continuum. In a recent study, trajectory trends were utilized to track mathematical thinking and understanding of first grade students (Murata et al., 2017). The researchers examined the effect of math discourse among students and the teacher to improve concept learning (Murata et al., 2017). The study identified three key strategies that influenced a student's development of mathematical concepts. This included exposure to a wide variety of strategies, both strategies that are at a developmentally appropriate level, and transitional strategies between the developmental phases of mathematical learning (Murata et al., 2017).

Other factors

When conducting research, there is a focus on the specific factors to by studied. However, it is equally important to consider other factors that may influence a study. For this study, two factors to be considered are math anxiety and motivation.

Math anxiety. Unfortunately, the idea of "math class" strikes fear in many people. Somewhere along their educational career, math anxiety began to diminish their ability to obtain mathematic knowledge and impede learning. In the area of mathematics, math anxiety plays a role in student performance (Skaalvik, 2018). Skaalvik (2018) sought to understand the correlation between student math grades, math achievement goals, math anxiety, and the coping strategies employed by students in math classes. Among the various conclusions in this study, it was determined that performance-avoidance and self-protective strategies were high indicators of math anxiety (Skaalvik, 2018).

Motivation. Another factor that should be taken into consideration is motivation. Motivation has been defined as an internal construct that is heavily influenced by external factors (Dweck, 2008). Motivation has been categorized as being intrinsic or extrinsic. Intrinsic motivation refers to a desire to participate in an activity with no apparent or obvious reward other than the task itself (Deci et al., 2001). The four sources of intrinsic motivation have been identified as challenge, curiosity, control, and fantasy (Lepper & Hodell, 1989). On the other hand, extrinsic motivation refers to a desire to participate in an activity with a clear end reward in mind (Deci et al., 2001).

Student motivation. Yu and Singh (2018) sought to understand the relationship between student motivation and high school mathematics achievement. This study included three variables related to teaching: support received by teachers (professional development), the utilization of conceptual teaching, and the use of procedural teaching (Yu & Singh, 2018). Procedural teaching of mathematics refers to placing an emphasis on the facts and skill fluency (Yu & Singh, 2018). Conceptual teaching refers to understanding the mathematic principles to appropriately problem solve (Yu & Singh, 2018). The study indicated that a student's positive self-efficacy in mathematics led to an interest in mathematics that resulted in a higher rate of success (Yu & Singh, 2018). Likewise, a student's negative self-efficacy in mathematics led to a disinterest in mathematics that resulted in a lower rate of success (Yu & Singh, 2018). In other words, success led to increased motivation and interest, while struggling students developed decreased motivation and interest. Ojose (2015) asserts that when mathematics is related to real world application, students in the middle grades demonstrate intrinsic motivation.

Teacher motivation. Just as with students, teachers' motivation can be described as intrinsic or extrinsic. Researchers noted, a high level of intrinsic motivation will occur when it has personal value and is integrated into practice (Wan-shuai et al., 2019). Therefore, it is incumbent upon administrators and teacher leaders to assist in the development of a sense of value (Wan-shuai et al., 2019). In addition, when teachers' practices are validated by their peers and student engagement a positive emotion is created that leads to intrinsic motivation (Wan-shuai et al., 2019). Cuevas et al. (2018) asserts that teacher evaluation is an extrinsic motivation for teacher performance. In their 2018 study, teacher evaluation had a larger impact on extrinsic motivation than student achievement (Cuevas et al., 2018).

Summary

As stated earlier, conceptual understanding is imperative to the understanding of mathematics (Egodawatte & Stoilescu, 2015). Identifying the appropriate instructional strategies to improve student achievement in mathematics is essential (Johns & Moyer, 2018). Several studies have indicated instruction that utilizes targeted instructional strategies have increased student mathematic achievement (Clements-Stephens et al. 2012; Heinz et al., 2018; Kong & Orosco, 2016; Paul, 2018). It has been acknowledged that transitioning to concept-based instruction can be difficult (Erickson & Lanning, 2014). However, concept-based instruction has been linked to the ability to understand more complex concepts and as a result becomes transferable to other environments (Erickson & Lanning, 2014).

Effective instruction is imperative to increasing math performance for middle school students. There are several contributing factors to ensuring effective instruction. First, professional development providing clarity for staff in understanding the purpose and meaning of the identified instructional strategies is vital (Kouzes & Posner, 2017). The literature indicates that quality professional development is continuous and provided in a variety of formats (Pharis et al., 2019). In addition, it is collaborative, utilizes modeling of quality instruction, and provides opportunities for observation, feedback, and reflection (Darling-Hammond et al., 2017). Next, it is imperative to be explicit concerning the implementation process. Implementation fidelity plays a role in determining the reliability of trends or themes that may emerge as a result of an analysis (Brigandi, 2019). Proper program evaluation will demonstrate the effectiveness of concept-based math strategies (Gargani & Miller, 2016). A comprehensive program evaluation process should be established and maintained for proper assessment of instructional effectiveness (Gargani & Miller, 2016).

While the literature is robust on elementary and high school mathematics, the literature on middle school mathematic is leaner. The review of the literature indicated a gap regarding the effect of concept-based math instruction on middle school student achievement when supplemental to traditional curriculum. This study provides relevant data designed to determine effective concept-based math strategies and instruction that increase student achievement. The results of the study provided valuable information concerning middle school math instruction in the Alaska School District 1. In addition, the results provide insight to other school districts throughout the nation, when determining a course of action to improve mathematics performance for middle school students.

CHAPTER THREE: METHODS

Overview

This study sought to examine if there is a statistically significant difference in seventh grade students' mathematics achievement among teachers based on participation in professional development on concept-based instructional strategies. The purpose of this chapter is to introduce the methods by which the study was conducted. This will include the design, a statement of the research question and null hypothesis, a description of the participants and setting, a description of the instrument, procedures, and how data analysis will be conducted.

Design

A causal-comparative design was employed for this study. The purpose of this study was to identify the difference in seventh grade students' achievement data in mathematics when compared to teacher participation in professional development. Therefore, two groups were compared utilizing categorical data which is characteristic of a causal-comparative study (Gall et al., 2007). This approach is most appropriate to compare the rate of participation to students' achievement data. In addition, students were not be randomly assigned to groups and the researcher will not manipulate the variables. Both factors are indicative of a causal-comparative relationship study (Gall et al., 2007). The causal-comparative relationship study has been used in a variety of studies. For example, when studying the relationship of affective and metacognitive factors on student mathematics achievement the causal relationship was employed (Tee et al., 2019). Tyagi (2015, 2017), in two separate studies used the causal relationship approach. In the earlier study, he examined the relationship between mathematical creativity and mathematical problem-solving performance (Tyagi, 2015). The later study examined mathematical intelligence and mathematical creativity (Tyagi, 2017).

The independent variable for this study was participation in professional development by the mathematic teachers. This was categorized by teachers that participated in professional development on concept-based instructional strategies and teachers that did not participate in professional development on concept-based instructional strategies. The dependent variable was student achievement. Student achievement data was identified using the Algebraic Thinking Strand score on MAP. Previous baseline scores for the two groups will be the covariate. When a researcher seeks to identify cause and effect relationships of an educational phenomena a causal relationship study is most appropriate (Gall et al., 2007). The researcher utilized student achievement data and teacher professional development data. This quantitative approach will allow the researcher to collect numerical data to describe observable behaviors (Gall et al., 2007). Another important facet to this study is that the design allowed the researcher to measure the independent variable by category, such as teacher participates in professional development of concept-based instructional strategies for mathematics or the teacher does not participate in concept-based instructional strategies for mathematics (Gall et al., 2007). Therefore, the researcher sought to measure participation level of seventh grade mathematics teachers (independent variable) to student achievement (dependent variable).

Research Question

RQ1: Is there a statistically significant difference in mathematics achievement between seventh grade students who were instructed by teachers who were trained in concept-based instructional strategies and teachers who were not trained in concept-based instructional strategies for mathematics controlling for prior achievement?

Hypothesis

The null hypothesis for this study was:

$H_0$1: There is no statistically significant difference in mathematics achievement between seventh grade students who were instructed by teachers who were trained in concept-based instructional strategies and teachers who were not trained in concept-based instructional strategies for mathematics when controlling for achievement growth test scores in the previous year.

Participants and Setting

The target population for this study was seventh grade mathematics students from two middle schools in two suburban school districts in Alaska of similar student enrollment. Pseudonyms will be used for all schools. A convenience sample was utilized for this study. Convenience sampling is a method where a group of cases are selected due to their easy access and availability (Gall et al., 2007). A convenience sample was collected for seventh grade students enrolled in a seventh-grade mathematics course. Students enrolled in a remedial math class or an advanced math class were not be included in the study. This controlled for mathematics curriculum. In addition, the sample included students who did and did not receive instruction from teachers trained in concept-based mathematics instructional strategies. A convenience sample was collected for seventh grade mathematics teachers based on level of participation in professional development.

Identification of participants and eventual data collection began early September. Consent for the study was obtained from the superintendents prior to data collection. The demographics for the student target population in ASD1 was 65.28% Caucasian, 0.93% African American, 9.33% Hispanic, 15.28% Alaska Native/American Indian, 0% Pacific Islander, 5.09%

Asian, and 5.09% Two or more races. The target student population was 50.7% male and 49.3% female and consist of 34% students categorized as socio-economically disadvantaged.

The demographics for the student target population in ASD2 was 17.14% Caucasian, 9.83% African American, 8.55% Hispanic, 8.98% Alaska Native/American Indian, 10.7% Pacific Islander, 23.5% Asian, and 21.3% "Two or more races". In addition, the target student population was 50.7% male and 49.3% female and consist of 52% students categorized as socio-economically disadvantaged.

A convenience sample was utilized due to the proximity of the researcher to the identified school district. The sample consisted of 17 seventh grade classes with a total of 424 participants from two middle schools. This reflects a sample size of 192 students in the treatment group and 232 students in the control group. According to Gall et al. (2007), this sample size was adequate because it exceeded 126 participants per group, which is the required minimum for a medium effect size with a statistical power of 0.7 at the 0.05 alpha level. In this study, the level of participation in professional development was the independent variable.

In order to protect all participants involved, pseudonyms were assigned to each participant (students and teachers), and to each participating middle school. This ensured that any potential bias is prevented. Any educator that participated within the study were licensed through the state of Alaska within the required field, which in this study is mathematics. In addition, two teacher groups were formed. The ASD1 cohort consisted of teachers that received professional development on concept-based instructional strategies. The demographics for the teacher target population in ASD1 was 100% Caucasian. The target teacher population was 75% male and 25% female. The ASD2 cohort consisted of teachers that did not receive professional development on concept-based instructional strategies. The demographics for the teacher target population in ASD2 was 86% Caucasian and 14% Hispanic. The target teacher population was 43% male and 57% female.

Instrumentation

Northwest Evaluation Association (NWEA) Measurement of Academic Progress (MAP) mathematic scores was utilized for this study. In 1973, in an effort to create a precise manner to assess student achievement and growth, educators and researchers throughout school districts in Oregon and Washington formed an association (NWEA, 2019). This association is known today as the Northwest Evaluation Association (NWEA, 2019). The MAP assessment is an adaptive computer-based assessment for measuring students' achievement and growth annually that has been in use since 1985 (NWEA MAP Alaska, 2016). Students in the middle grades answer 40-43 mathematics questions that adapt based on the student's response to each question (MAP Growth, 2020). The MAP Growth assessment was created in 2000 to assess what students know and identify what they need to learn next (MAP Growth, 2020). A MAP score is calculated using the Rasch unIT (RIT) scale. The RIT scale "measures the value of a student's score in relation to his/her scores on previous tests" (NWEA Growth, 2020). It is national normed with over 10.2 million testing data points (MAP Growth, 2020). MAP assessment construct validity has been established through multiple studies that validate achievement and growth measures (Wang et al., 2013). Multiple sources are utilized, such as, "test content, internal structure, and relations to other content" (NWEA, 2019). The sixth-grade mathematics assessment n =163,305 and the seventh-grade n = 154,280 (NWEA, 2019). Both grade levels demonstrated a Pearson r of 0.84 and a p- value of 0.88 (NWEA, 2019).

Reliability for the MAP assessment was conducted using multiple reliability coefficients (NWEA, 2019). The reliability coefficients were test-retest reliability, marginal reliability, and precision score (NWEA, 2019). By utilizing multiple reliability coefficients, the researcher was able to describe the influence of sources of error (NWEA, 2019). The MAP assessment for mathematics for grades six and seven demonstrated an internal consistency reliability rate of 0.905 and 0.915 respectively (NWEA, 2019).

The MAP assessment has been utilized in previous studies. Corcoran (2018) employed the use of MAP assessment mathematics scores to examine how preparing teachers may raise students' mathematical learning. NWEA MAP mathematics scores have been utilized to examine the effects of blended learning (Fazal & Bryant, 2019). In addition, specific evaluation has been completed linking Alaska state assessment to MAP assessment (NWEA MAP Alaska, 2016). The MAP assessment provides scores for six mathematical strands. The mathematic strands assessed and the corresponding *Reliability*, *Mean* and *Standard Deviation* for Grade 7 are Algebraic Thinking (*R*= 0.893, *M*=223.4*, SD*=18.8), Numbers and Operations (*R*= 0.948, *M*=201.0*, SD*=27.1), Measurement and Data (*R*= 0.942, *M*=199.0*, SD*=27.5), Geometry (*R*= 0.897, *M*=222.7*, SD*=19.1), The Real and Complex Number System (*R*= 0.898, *M*=225.1*, SD*=19.3), and Statistics and Probability (*R*= 0.905, *M*=222.9*, SD*=19.9) (NWEA, 2019). A validity score is not available for individual strands. For the purpose of this study, the MAP score for the strand of Algebraic Thinking was utilized opposed to other strand scores or the composite score of all strands. The strand Algebraic Thinking specifically addresses conceptual thinking (NWEA, MAP Alaska, 2016).

Procedures

Data collection began after all appropriate consents and approvals had been gained. School districts' permission was obtained by meeting with the superintendents to discuss the importance and relevance of the study (see Appendix A). Next, approval was obtained by the

Liberty University Institutional Review Board (see Appendix B). As this data is archival, multiple data and information was requested from assessment analyst in ASD1 and ASD2. Student data included seventh grade students' MAP scores on the Algebraic Thinking strand as sixth graders for the winter of 2018 to establish prior knowledge. In addition, MAP scores on the Algebraic Thinking strand will be collected for the winter of 2019 as seventh graders to measure achievement. Middle School A located in Alaska School District 1 (ASD1) on average has an enrollment of 230 seventh grade students each year. Seventh grade mathematics teachers in this school participated in concept-based instructional strategies professional development. The researcher collected and analyzed MAP data as sixth graders from 2018-2019 to establish prior knowledge. This was then be compared to their MAP achievement data 2019-2020. In addition, data was collected from Middle School B in Alaska School District 2 (ASD2) where teachers did not participate in concept-based instructional strategies professional development.

In order to ensure students' and teachers' confidentiality, all data was received with a student/teacher identification number. The identification number was specific to the individual and their school location. No personal identification information was released to the researcher. All data sets were secured and stored in two locations. Data was stored on a computer that required two-factor authentication. In addition, all data was backed-up on an external hard drive that was housed in a locked cabinet.

Data Analysis

The researcher hypothesized there is no statistically significant difference in seventh grade students' mathematics achievement data among teachers who participated in concept-based instructional strategies for mathematics professional development and those that did not participate in concept-based instructional strategies for mathematics professional development.

The null hypothesis was tested by conducting an analysis of covariance (ANCOVA) test for significance in the differences between the groups. An ANCOVA was utilized to control for the initial differences between groups prior to comparing to groups with a variance (Gall et al., 2007). In this study, the covariate (initial difference in the two groups) was the students' achievement scores from the previous year.

Data was screened for inconsistencies and extreme outliers. Double entry and verification of scores were used to check for inconsistencies. Box and Whisker plots were used to determine extreme outliers. Outliers were identified as students that demonstrate more than two years of growth or those that demonstrate a loss of two years. NWEA cautions that students who demonstrate dramatic growth or loss (more than 2 years) in a short testing cycle, such as fall to winter, are more indicative of improper test-taking in one of the two testing opportunities (NWEA, 2019). The Kolmogorov-Smirnov test was used to test for assumptions of normality since the sample size will be greater than 50 *(N>50)* and the Levene's test was used to test the homogeneity of variance. The Assumption of Linearity was tested with scatter plots to analyze achievement scores for the two groups of students. Groups were formed by students whose teacher received professional development in concept-based instructional strategies and students whose teachers did not receive professional development in concept-based instructional strategies. In addition, an Assumption of Bivariate Normal Distribution was tested utilizing a series of scatter plots between the two groups to determine if the classic "cigar shape" exist to determine if the assumption is tenable. In order to look for interactions, an Assumption of Homogeneity of Regression Slopes was tested. The effect size was established by means of the eta-squared statistic (η^2) with interpretation based on Cohen's d with a threshold of 0.14 for a large effect, 0.06 for a medium effect, and 0.01 for a small effect (Gall et al., 2007).

CHAPTER FOUR: FINDINGS

Overview

As previously stated, the student examined the impact of professional development of teachers in concept-based instructional strategies on seventh grade mathematics student achievement. This chapter will restate the research question and null hypothesis. Additionally, it will provide descriptive statistics and the results of the study. The results include data screening, assumption testing, and the results as related to the null hypothesis.

Research Question

RQ1: Is there a statistically significant difference in mathematics achievement between seventh grade students who are instructed by teachers who were trained in concept-based instructional strategies and teachers who were not trained in concept-based instructional strategies for mathematics controlling for prior achievement.

Null Hypothesis

$H_0$1: There is no statistically significant difference in mathematics achievement between seventh grade students who were instructed by teachers who were trained in concept-based instructional strategies and teachers who were not trained in concept-based instructional strategies for mathematics when controlling for achievement growth test scores in the previous year.

Descriptive Statistics

Descriptive statistics were performed after a statistically significant outlier was removed. There were 209 (49.3%) female participants and 215 (50.7%) male participants (see Table 1). There were 196 (46.2%) white participants. There were 424 7th graders (100%). Scores from the winter test window were greater in the treatment group (*M*=225.43, *SD*= 10.88) compared to the control group (*M*=216.20, *SD*=15.70) (see Table 2).

Table 1

Frequency Table -2019-2020

	Overall		By Grouping	
	Frequency	Percent	Treatment	Control
Gender (Student)				
Female	209	49.3	96	114
Male	215	50.7	96	118
Ethnic Group				
Alaska Native/American Indian	20	4.7	0	20
Asian	56	13.2	0	56
Black	25	5.9	0	25
Hispanic or Latino	39	9.2	18	21
Multi-ethnic	62	14.6	15	47
Native Hawaiian or Pacific Islander	26	6.1	0	26
White	196	46.2	159	37
Grade				
7	424	100.0	192	232
Teacher Gender				
Female	5	50	1	4
Male	5	50	2	3
Teacher Ethnicity				
White	9	90	3	6
Hispanic	1	10	0	1

Table 2

Descriptive Statistics

Group	Mean	Std. Deviation
ASD1	225.43	10.88
ASD2	216.20	15.70

Notes. Dependent Variable: Winter scores in 2019-2020

Results

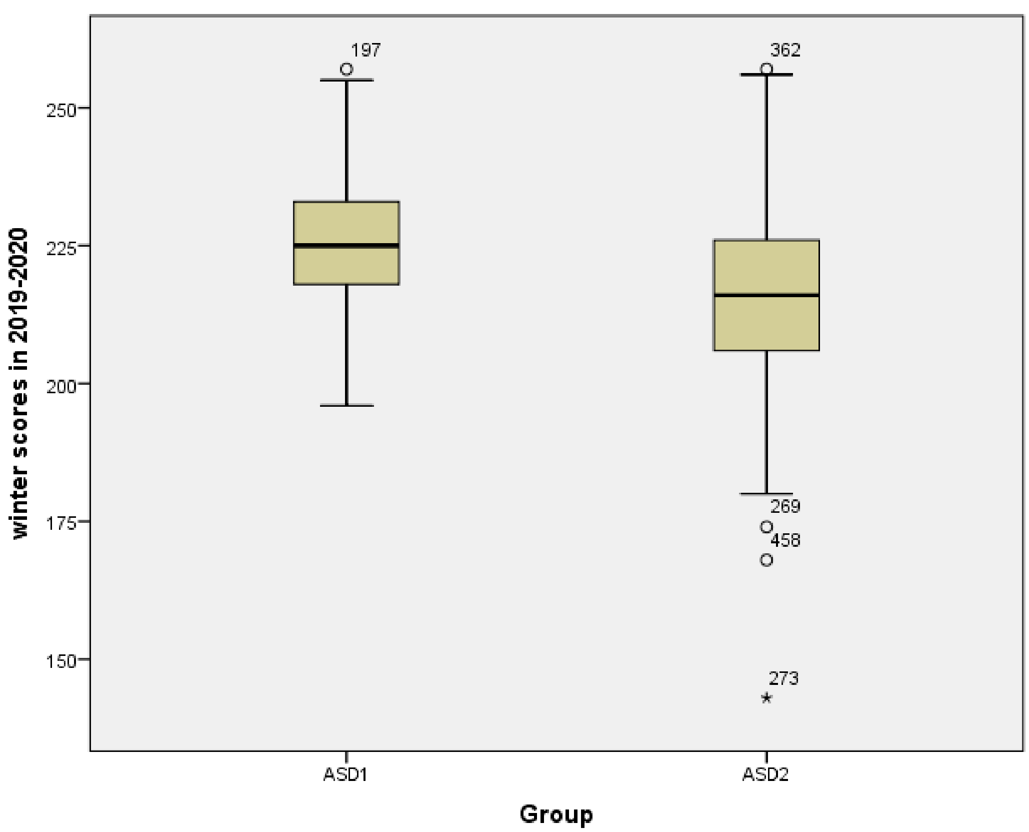
In this section, the data screening, as well as the results from the assumption testing and analysis are presented.

Data Screening

Data screening was conducted on each cohort regarding data inconsistences and outliers. The researcher sorted the data based on the dependent variable and scanned for inconsistencies. No data errors or inconsistences were detected. A Box and Whisker plots was utilized to detect outliers. One extreme outlier was detected and removed (see Figure 1).

Figure 1

Box and Whiskers for Winter Scores 2019-2020

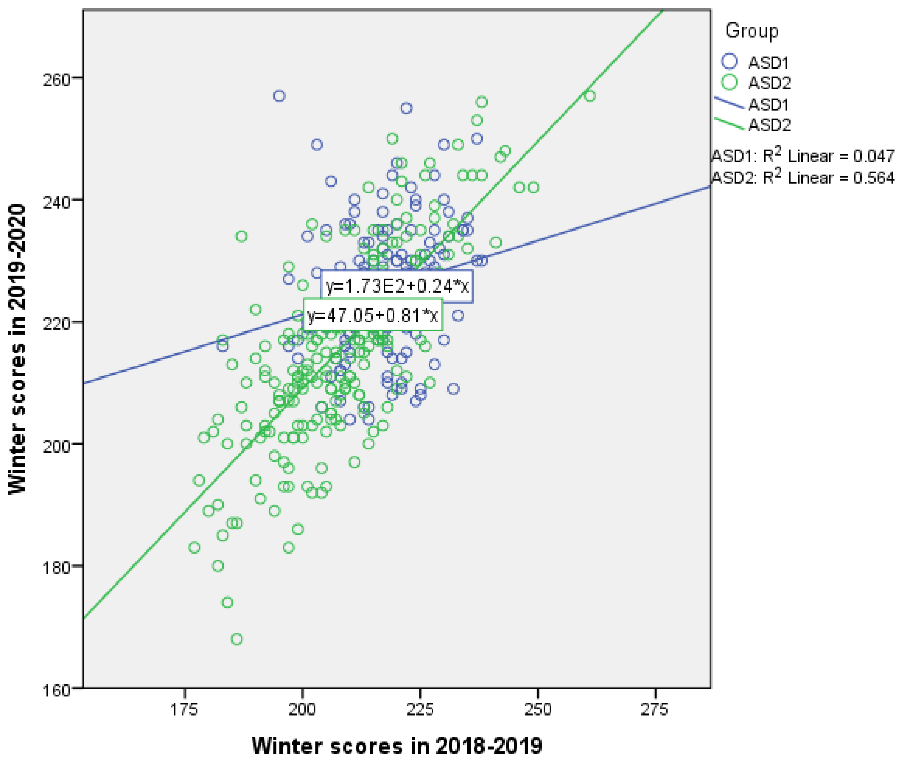


Assumption Testing

The assumption of linearity was tested by using scatter plots. There was a linear relationship between the covariate (winter scores in 2018-2019) and the dependent variable (winter scores in 2019-2020) (see Figure 2).

Figure 2

Linearity



Assumptions of normality were tested by using the Kolmogorov-Smirnov test. The data were normally distributed (p = .200) as indicated in see Table 3.

Table 3

Tests of Normality

	Kolmogorov-Smirnov[a]		
Group	Statistic	df	Sig.
ASD1	.053	143	.200*
ASD2	.032	232	.200*

Homogeneity of variance was found tenable using the Levene's test (*p* = 0.200) as seen in Table 4. The assumption of bivariate normal distribution was tested by using scatter plots between the two groups. The assumption of bivariate normal distribution was satisfied (see Figure 3). The assumption of homogeneity of slopes was tested (see Table 5). There was no homogeneity of regression slopes because the interaction term was significant, $F(1, 371) = 107.01$, $p < 0.001$. Since the assumption of homogeneity of regression slopes was not met, the data were transformed.

Table 4

Levene's Test

F	df1	df2	Sig.
.001	1	373	.977

Figure 3

Bivariate Normal Distribution.

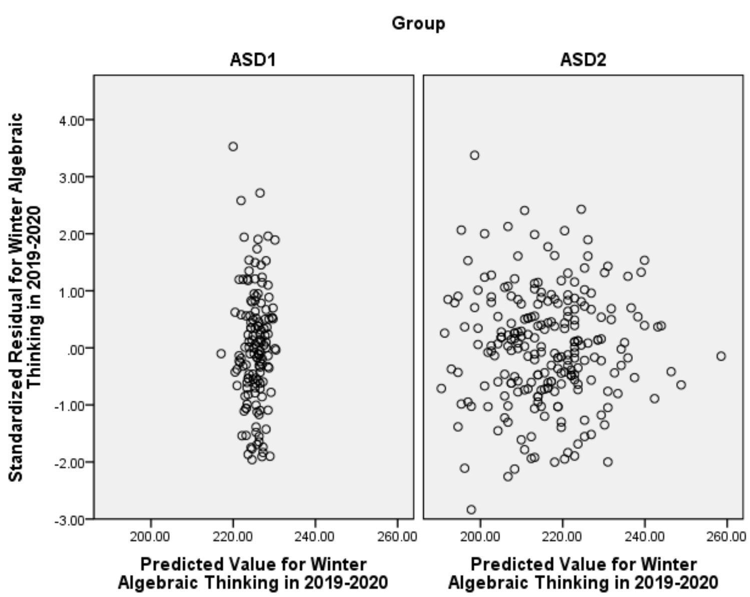


Table 5

Homogeneity of Regression Slopes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	40493.074[a]	3	13497.691	122.508	.000	.498
Intercept	11018.631	1	11018.631	100.007	.000	.212
Group	3601.894	1	3601.894	32.692	.000	.081
Winter Algebraic Thinking 2018	11790.714	1	11790.714	107.015	.000	.224
Group* Winter Algebraic Thinking 2018	3430.026	1	3430.026	31.132	.000	.077
Error	40876.084	371	110.178			
Total	18185638.000	375				
Corrected Total	81369.157	374				

After the data was transformed, an ANCOVA (see Table 6) was performed.

Table 6

ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	34055.606	2	17027.803	133.880	.000	.419
Intercept	3426597.986	1	3426597.986	26941.424	.000	.986
Winter Algebraic Thinking 2018	26517.046	1	26517.046	208.489	.000	.359
Group	708.091	1	708.091	5.567	.019	.015
Error	47313.551	372	127.187			
Total	18185638.000	375				
Corrected Total	81369.157	374				

Results for Null Hypothesis

An ANCOVA was performed to examine the hypothesis. There was a statistically significant difference in mathematics achievement between seventh grade students who were instructed by teachers who were trained in concept-based instructional strategies and students who were instructed by teachers who were not trained in concept-based instructional strategies for mathematics when controlling for achievement growth test scores in the previous year, $F(1, 372) = 5.56$, $p = 0.019$, partial $\eta^2 = 0.01$ (see Table 6). Thus, the null hypothesis was rejected. Students who received instruction from teachers who were trained in concept-based instructional strategies had significantly higher math achievement scores than students who did not.

CHAPTER FIVE: CONCLUSION

Overview

This chapter includes a discussion of the results regarding the effectiveness of professional development of teachers in concept-based instructional strategies on seventh grade students' math achievement while controlling for prior achievement. The discussion will include an examination of the question as it is related to the results, literature, other studies, and theory. In addition, there will be an examination of the study's implications, limitations, and suggestions for further research.

Discussion

The purpose of this quantitative, causal-comparative study was to determine the impact of concept-based instructional strategies when combined with the traditional curriculum for seventh grade mathematics students. The sample for this study was 423 seventh grade students from two middle schools in neighboring school districts. Both the treatment and control groups consisted of approximately 200 students. The Measurements of Academic Progress (MAP) Algebraic Thinking score was utilized to measure student achievement.

Results as Related to the Question

The researcher sought to discover if concept-based instructional strategies impacted student achievement in mathematics for seven grade students. The data indicated there was a statistically significant impact on seventh grade student mathematics achievement when teachers utilize concept-based instructional strategies. These findings are specific to seventh-grade students who were enrolled in an on-grade level mathematics course and cannot be generalized for all seventh grade students. The null hypothesis utilized for this study stated there would not be a statistically significant difference between students that received concept-based instructional strategies and those who did not. The data rejected the null hypothesis.

Results as Related to Literature and Other Studies

The data analysis examining the Algebraic Thinking scores, which address conceptual learning, revealed a statistically significant impact on student achievement for those receiving concept-based instructional strategies. This finding aligns with previous studies focused on targeted instructional strategies for mathematics (Bell, 2017). Clements-Stephens et al. (2012), Edodawatte and Stoilescu (2015), Erickson and Lanning (2014), Heinze et al. (2018), Lim (2109), McKee et al. (2017), Powell et al. (2018), Roman (2016) and Shockey and Pindiprolu (2015) also found that when targeted instructional strategies were utilized student achievement increased.

The studies noted above support the importance of conceptual understanding for improving mathematical student achievement. For example, Erickson and Lanning (2014) found transferability of knowledge occurs when there is conceptual understanding. Powell et al., (2018) revealed the role of language in gaining conceptual understanding. Both, Lim (2019) and Roman (2016) in separate studies determine that the use of magic in instruction increases students' conceptual understanding. Last, Shockey and Pindiprolu (2012) posited, mathematical conceptual understanding has greater influence on student achievement than mathematical technicality. Each of the studies demonstrated the impact of a targeted mathematical instructional strategy rooted in conceptual understanding. The study presented in this dissertation examined specifically the impact of concept-based instructional strategies. Therefore, it can be added to the body of literature in support of the implementation of targeted mathematical instructional strategies focused on conceptual understanding.

In contrast, other studies have been inconclusive or support mathematic technicality/automaticity in conjunction with concept-based instructional strategies. Heinze et al. (2018) determined there was not a significant difference between students that received explicit instruction when compared to those who received implicit instruction. However, it was posited that students receiving implicit instruction sustained their newly acquired strategies when compared to their counterparts who received explicit instruction (Heinze et al., 2018). Implicit instruction requires a student to construct their knowledge, which in turn requires conceptual understanding. Although this study did not demonstrate a difference between explicit and implicit instruction, it did suggest the importance of students constructing knowledge. Ironically, the suggestion is implicit rather than explicit.

Several studies McKee et al. (2017), Ojose (2015), and Shocky and Pindiprolu (2015), support mathematics technicality/automaticity in conjunction with conceptual understanding. Each of these studies assert that technicality/automaticity are contributors to student achievement. However, they each acknowledged that the method by which technicality/automaticity is taught impact a students' ability to develop conceptual understanding. Hence, the researchers while advocating for an emphasis on technicality/automaticity recognized the importance of conceptual understanding. Whereas the study presented herein promotes conceptual understanding over technicality/automaticity.

The importance of professional development and implementation cannot go unmentioned. It has been noted that professional development improves teacher competency and thereby improves student achievement (Pharis et al., 2019). Although this study did not examine the effect of professional development for teachers in implementing concept-based instructional strategies, it did determine that the teachers in the study who implemented concept-based instructional strategies received professional development for the same duration, frequency, and delivery model. In addition, the study did not focus on program implementation fidelity. However, the researcher determined teachers received regular observations and feedback.

As previously mentioned, the current study determined that a statistically significant difference is present in mathematical student achievement for seventh grade students that received concept-based instructional strategies opposed to students that did not receive concept-based instructional strategies. This aligns with other studies and adds to the body of literature supporting targeted instructional strategies, concept-based instructional strategies, and supports the constructivism theory. In addition, it examined mathematic achievement at one of the middle grades where literature has been lacking.

Results as Related to Theory

Constructivism theory emphasizes the importance of actively engaging learners in curriculum (Schunk, 2016). It has been asserted that it is through engaged learning that students construct and reconstruct deep understanding of concepts (Woolfolk Hoy & Hoy, 2003). The study presented herein provides additional support to the theory of constructivism. The results indicated that seventh grade student achievement increased when receiving instruction utilizing concept-based instructional strategies. Concept-based instructional strategies require the student to construct their knowledge through exploration, discussion, and teacher guidance. This aligns with constructivism theory as it also promotes exploration, discussion, and teacher guidance.

Another aspect of constructivism is self-regulation (Schunk, 2016). Two aspects of self-regulation that are known to increase student engagement, as related to constructivism theory, are metacognitive strategies and motivation (Preiss et al., 2018). Metacognitive strategies require the learner to monitor and be aware of their own thinking process (Preiss et al., 2018). Once again, the data from the study presented in this dissertation supports the constructivism theory in that it demonstrated an increase in student achievement for students receiving concept-based instructional strategies. A relationship exists because concept-based instructional strategies employ metacognition. Thus, this study can be added to the body of literature related to constructivism theory.

After an examination of previous literature, studies, and theory there is evidence that this study aligns with other studies that examined targeted instructional strategies, concept-based mathematics instructional strategies, and the theory of constructivism. Concept-based mathematic instructional strategies are targeted and require the utilization of constructivism. In addition, as noted in this study, they have an impact on seventh grade student mathematic student achievement.

Implications

Most of the mentioned studies in the discussion were conducted at the elementary or high school level. The two studies conducted at the middle school level examined a targeted strategy such as language or a specific skill deficit. Therefore, this study addresses a gap in the literature concerning concept-based mathematic instructional strategies at the middle school level.

As previously noted, this study adds to the body of literature related to targeted instructional strategies, concept-based mathematics instructional strategies, and the theory of constructivism. This acknowledgement calls for an exploration of the implications it may have on teacher preparation in higher education (theory), instruction (practice), increased possibilities for students and competitiveness in a global economy. All of which, are important as the United States has seen a decrease in college students seeking math-intense degrees (Vigdor, 2013).

Implications for Teacher Preparation

This study has implications for teacher preparation. During teacher preparation, universities provide instruction concerning the theory of learning and teaching. In addition, teacher preparation, in the area of mathematics is most often divided into categories of elementary, middle school, and high school. This allows the professor to prepare students more effectively for the mathematics classroom. When presenting the Constructivist Theory to prospective middle school mathematics teachers, this study could be utilized to extol the benefits of concept-based learning and the importance of students in the middle grades knowing how to construct and reconstruct their own knowledge. In addition, it could be utilized with prospective elementary teachers, as they are the preparers of middle school students. It will provide insight to the long-term goal of student success in mathematics. Likewise, the study could be utilized with prospective high school teachers to deepen their understanding of how to assist struggling students. Although it is in the university where theory is discussed, it is the classroom where practice takes place.

Implications for Instruction

Effective instruction is rooted in a theoretical framework. It is the process of moving theory to practice that sometimes becomes a barrier to effective instruction. In practice, teachers must believe in their ability to improve student achievement, be provided with ongoing professional development, and receive quality feedback (Darling-Hammond et al., 2017). The teacher participants in this study received ongoing professional development, classroom observation, and quality feedback regarding concept-based mathematic instructional strategies. As a result, the participants demonstrated a high-level of engagement, which in turn created a higher degree of implementation. It is also important to note that the feedback provided to participants for instruction was provided by a consultant, not an evaluator. This resulted in feedback conversations that allowed participants to be less guarded about their instructional practices. As teachers create their teaching style and delivery for seven grade mathematics classes, this study could be utilized to inform decisions related to the implementation of concept-based instructional strategies.

Implications for Competitiveness in a Global Economy

Math has been referred to as the gatekeeper of "powerful knowledge" (Hudson, 2018). An individual's mathematical ability either increases or decreases his/her options in selecting a profession. Often, high-income professions require a higher degree of mathematical accomplishment. Thus, those with a lower degree of mathematical ability cannot access higher income professions. As an educator the goal is to create equity for all. One way to create equity is to provide an education that increase possibilities and opportunities for students. This can be accomplished with effective instruction. This study demonstrated that effective instruction includes concept-based instructional strategies. Therefore, the utilization of concept-based instructional strategies in mathematics at the middle grade could improve performance in mathematics in the upper grades. Thus, providing the students with more possibilities and opportunities in post-secondary and the workforce. As a workforce emerges with an increase in math-intense degrees it would stand to reason that a competitiveness in the global economy would be realized.

Limitations

Every study has limitations, and this study is no exception. One obvious threat to internal validity was the short testing window. Due to COVID 19, which resulted in no spring testing in 2020, the test scores utilized for this study were fall to winter scores. This represents a short time period to measure academic achievement. In order to mitigate this threat, the researcher screened data for outliers. Another limitation regarding internal validity is socioeconomic status. The treatment group realized a 34% rate of students qualifying for free/reduced lunch, while the control group reported 52% of students qualifying for free/reduced lunch. Although, the difference is not significant it is notable. Boatwright and Midcalf (2019) reported, students that experience a higher rate of poverty often perform lower academically than their counterparts that experience a lower rate of poverty. In an effort to minimize this threat, only students that were enrolled in on-grade level classes were selected as participants.

A limitation regarding external validity, the study's ability to be generalized to other settings, was present. Due to the relatively small sample size (*n=424)*, it would be difficult to generalize the results to all seventh-grade math students throughout the United States. In addition, the sample does not represent students operating below or above grade level. Therefore, it should not be generalized for all seventh-grade students. However, it could be added to the body of literature that demonstrates the positive impact of concept-based instructional strategies on student achievement for on-grade level students.

Recommendation for Future Research

In order to more thoroughly understand the impact of concept-based mathematical instructional strategies, further research is needed. The following topics for future exploration are recommended by the researcher:

1. The impact of concept-based mathematical instructional strategies on student achievement for the middle grades.
2. The impact of concept-based mathematical instructional strategies on student achievement for students functioning below grade level.

3. The impact of concept-based mathematical instructional strategies on student achievement for students functioning above grade level.
4. The impact on teacher efficacy when implementing concept-based mathematical instructional strategies.
5. The impact of concept-based mathematical instructional strategies in the middle grades on high school math achievement.

REFERENCES

Arfken, C. L., & Balon, R. (2011). Declining participation in research studies. *Psychotherapy and Psychosomatics*, *80*, 325–328. http://dx.doi.org/10.1159/000324795

Avanzia, L., Schubb, S., Fraccarolia, F., & Van Dick, R. (2015). Why does organizational identification relate to reduced employee burnout? The mediating influence of social support and collective efficacy. *Work & Stress*, *29*(1), 1–10. https://doi.org/10.1080/02678373.2015.1004225

Baker, C., Galanti, T., Graham, J., Hayden, K., & Bailey, P. (2018). From book club to professional learning community: Empowering a network of mathematics specialists. *School-University Partnership*, *11*(4), 48–63. http://web.b.ebscohost.com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=6&sid=d9db7770-ad71-4b13-93ae-01919a17aa82%40pdc-v-sessmgr01

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148. http://homepages.se.edu/cvonbergen/files/2013/01/Perceived-Self-Efficacy-in-Cognitive-Development-and-Functioning.pdf

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W.H. Freeman .

Barradell, S., & Kennedy-Jones, M. (2015). Threshold concepts, student learning and curriculum: Making connections between theory and practice. *Innovations in Education and Teaching International*, *52*(5), 536–545. http://dx.doi.org/10.1080/14703297.2013.866592

Bell, A., & Thomson, K. (2018). Supporting peer observation of teaching: Collegiality, conversations, and autonomy. *Innovations in Education and Teaching International*, *55*(3), 276–284. https://doi.org/10.1080/14703297.2016.1212725

Bell, B. (2017). How to supercharge struggling readers with brain-based strategies. *The California Reader*, *50*(4), 12–17. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=4&sid=f0007e32-a173-4735-a62c-30913d9e1ab1%40sdc-v-sessmgr01

Benders, D., & Craft, T. (2016). The effect of flexible small groups on math achievement in first grade. *Networks: An Online Journal for Teacher Research*, *18*(1), Article 5. https://eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=EJ1152264

Bhagat, K. K., Chang, C.-N., & Chang, C.-Y. (2016). The impact of the flipped classroom on mathematics concept learning in high school. *Educational Technology & Society*, *9*(3), 134–142. vic_liberty&it=DIourl&s=RELEVANCE&p=AONE&go.galegroup.com.ezproxy.liberty.edu/ps

Blank, R. K. (2013). What research tells us: Common characteristics of professional learning that leads to student achievement. *Journal of Staff Development*, *34*(1), 50–53. https://eric.ed.gov/?id=EJ1005457

Block, P. (1996). *Stewardship: Choosing service over self-interest* (1st ed.). Berrett-Koehler Publishers.

Boatwright, P., & Midcalf, L. (2019). The effects of poverty on lifelong learning: Important lessons for educators. *The Delta Kappa Gamma Bulletin: International Journal for Educators*, *85*(3), 52–57. https://doi.org/https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=7&sid=8c066a6a-238e-4574-a24a-4ef35ed5dec5%40sessionmgr103

Bradshaw, L. D. (2015). Planning considerations for afterschool professional development. *Afterschool Matters*, *21*, 46–54. https://eric.ed.gov/?id=EJ1063855

Brigandi, C. B. (2019). Fidelity of implementation or an evidence-based enrichment practice. *Journal of Advanced Academics*, *30*(3), 268–297. http://dx.doi.org/10.1177/1932202X19862686

Brown, B. (2018). *Dare to lead*. Random House.

Brown, J. E. (2001). *The validity of using NWEA's MAP results to predict PSAE and ACT results*. https://pdfs.semanticscholar.org/e3b6/baa2f40ffc7a74a498f10986bee0f04f8931.pdf

Bruner, J. (1990). *Acts of meaning*. Harvard University Press .

Bruner, J. S. (1964). The course of cognitive growth. *American Psychologist*, *19*, 1–15. https://doi.org/10.1037/h0044160

Bruner, J. S. (1966). *Toward a theory of instruction*. Norton.

Calik, T., Sezin, F., Kavgaci, H., & Kilinc, A. C. (2012). Examination of relationships between instructional leadership of school principals and self-efficacy of teacher and collective teacher efficacy. *Educational Sciences: Theory & Practice*, *12*(4), 2498–2504. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=10&sid=794df1c9-5974-4f70-a778-599462dec587%40sessionmgr101

Candela, A. G., & Brown, M. (2019). *Mathematics' teachers' perceptions of the instructional quality assessment as a reflective tool* (Proceedings of the 41st Annual Meeting of PME-

NA). Psychology of Mathematics & Education of North America. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=16&sid=1f40571d-945e-4ce5-b9f5-d4f606a8f292%40sdc-v-sessmgr01

Carpenter, D., & Munshower, P. (2020). Broadening borders to build better schools: Virtual professional learning communities. *International Journal of Educational Management*, *34*(2), 296–314. https://www-emerald-com.ezproxy.liberty.edu/insight/content/doi/10.1108/IJEM-09-2018-0296/full/html

Casey, B. M., Lombardi, C. M., Pollock, A., Fineman, B., & Pezaris, E. (2017). Girls' spatial skills and arithmetic strategies in first grade as predictors of fifth-grade analytical math reasoning. *Journal of Cognition and Development*, *18*(5), 530–555. http://dx.doi.org/doi.org/10.1080/15248372.2017.1363044

Clements-Stephens, A. M., D, A., Materek, Eason, S. H., Scarborough, H. S., Pugh, K. R., Rimrodt, S., & Pekar, J. J. (2012). Neural circuitry associated with two different approaches to novel word learning. *Developmental Cognitive Neuroscience*, *2*, 99–113. https://doi.org/10.1016/j.dcn.2011.06.011

Cooper, L., Baron, C., Grim, L., & Sandling, G. (2018). Teaching teachers onsite: Using evaulation to develop effective professional development programs. *Journal of Museum Education*, *43*(3), 274–282. http://dx.doi.org/10.1007/s10763-017-9819-1

Corcoran, R. P. (2018). Preparing teachers' to raise students' mathematics learning. *International Journal of Science and Mathematics Education*, *16*, 1169–1185. http://dx.doi.org/10.1007/s10763-017-9819-1

Cromwell, A., & Aghajanian, A. (2017). How to find out what's really going on: Understanding impact through participatory process evaluation. *World Development*, *99*, 173–185. https://doi.org/10.1016/j.worlddev.2017.07.010

Cuevas, R., Ntoumanis, N., Fernandez-Busto, J., & Barthlomew, K. (2018). Does teacher evaluation based on student performance predict motivation, well-being, and ill-being?. *Journal of School Psychology*, *68*(154-162). https://doi.org/10.1016/j.jsp.2018.03.005

da Silva, R., & Oleveira, J. (2020). Support for teacher in challenging situations as a factor of change: Reflections from a continuing professional development programme in Guinea-Bissau. *Forum for International Research in Education*, *6*(3), 71–88. https://doi.org/10.32865/fire202062181

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf

Davis, J. D., McDuffie, A. R., Choppin, J., & Drake, C. (2017). Middle school mathematics teachers' perception of the common core state standards for mathematics and its impact on the instructional environment. *School Science & Mathematics*, *117*(6), 239–249. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/detail/detail?vid=5&sid=04f81658-a6c9-47fb-8096-35d96c9c0ea3%40pdc-v-sessmgr03&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=ehh&AN=125423625

Deci, E. E., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research*, *71*, 1–27. https://doi.org/10.3102/00346543071001001

Derrington, M. L. (2016). Implementing teacher evaluation: Lattice of leadership. *Journal on Research on Leadership Education*, *11*, 181–199. https://doi.org/DOI: 10.1177/1942775116658689

Dewey, J. (1916). *How we think*. Houghton Mifflin Company.

Donohoo, J. (2018). Collective efficacy research: Productive patterns of behavior and other positive consequences. *Journal of Educational Change*, *19*, 323–345. https://doi.org/10.1007/s10833-018-9319-2

Douglas, D., & Salzman, H. (2020). Math counts: Major and gender differences in college mathematics coursework. *The Journal of Higher Education*, *91*(1), 84–112. http://dx.doi.org/10.1080/00221546.2019.1602393

Dufour, R., Dufour, R., Eaker, R., & Karhanek, G. (2004). *Whatever it takes: How professional learning communities respond when kids don't learn*. National Educational Services.

Dweck, C. S. (2008). *Mindset: The new psychology of success*. Ballatine Books.

Eaker, R., DuFour, R., & Dufour, R. (2002). *Getting started: Recruiting schools to become professional learning communities*. National Educational Services.

Egodawatte, G., & Stoilescu, D. (2015). Grade 11 students' interconnected use of conceptual knowledge and procedural skills, and strategic competence in algebra: A mixed method study of error analysis. *European Journal of Science and Mathematics Education*, *3*(3), 289–305. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/detail/detail?vid=9&sid=b2c390a6-1db7-4450-a73d-

49d44506d1ca%40pdc-v-sessmgr02&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=EJ1107752&db=eric

Erickson, H. L., & Lanning, L. A. (2014). *Transitioning to concept-based curriculum and instruction*. Thousand Oaks, Ca.

Ertmer, P. A., Driscoll, M. P., & Wagner, W. W. (2003). The legacy of Robert Mills Gagne'. In *Educational psychology: A centruty of contributions* (pp. 303–330). Erlbaum.

Fazal, M., & Bryant, M. (2019). Blended learning in middle school math: The question of effectiveness. *Journal of Online Learning Research*, *5*(1), 49–64. https://eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=EJ1208816

Flippen Group. (2014). *Leadership blueprint: Building relational capacity and high performing teams* (18th ed.).

Gagne', R. M. (1984). Learning outcomes and their effects: Useful categories of human performance. *American Psychologist*, *39*, 3374–385. https://eric.ed.gov/?id=EJ1208816

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction* (8th ed.). Pearson.

Gargani, J., & Miller, R. L. (2016). What is program evaluation?. *American Journal of Public Health*, *106*(6), 13. http://web.a.ebscohost.com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=6&sid=033f3022-9665-45fb-b7ff-d1bc9fd36ca4%40sdc-v-sessmgr03

Goddard, R. D., Hoy, W. K., & Woolfolk Hoy, A. (2004). Collective efficacy beliefs: Theoretical developments, empirical evidence, and future directions. *Educational Researcher*, *33*(3), 3–13. https://doi.org/10.3102/0013189X03003003

Goodard, R. D., Hoy, W. K., & Woolfolk Hoy, A. (2000). Collective teacher efficacy: Its meaning, measure, and impact on student achievement. *American Educational Research Journal*, *37*, 479–507.

Greenberg, M. T., Domitrovitch, C. E., Graczyk, P. A., & Zins, J. E. (2005). *The study of implementation in school-based interventions: Theory, research, and practice* (Volume 3) [DHHS Pub. No. (SMA)_____]. Center for Mental Health Services, Substance Abuse and Mental Health Services Administration.

Guskey, T. (2000). *Evaluating professional development*. Corwin Press.

Hannula, M. S. (2018). Young learners' mathematics-related affect: A commentary on concepts, methods, and developmental trends. *Educational Studies in Mathematics*, *100*, 309–316. https://doi.org/doi.org/10.1007/s10649-018-9865-9

Hassel, E. (1999). *Professional development: Learning from the best*. http://publicimpact.com/web/wp-content/uploads/201511/Professional_Development_Learning_from_the_Best-Public_Impact.pdf

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning*. Routledge.

Hattie, J. (2018). *Hattie's 2018 list of updated factors related to student achievement: 252 influences and effects sizes*. www.visiblelearningplus.com/content/250-influences-student-achievement

Heinze, A., Arend, J., Gruessing, M., & Lipowsky, F. (2018). *Instructional Science*, *46*, 869–891. https://doi.org/10.1007/s11251-018-9457-1

Hofer, C. (2016). *The impact of classroom observations and collaborative feedback on evaluation of teacher performance, based on the Danielson framework for teaching*. Retrieved April 5, 2019, from http://digitalcommons.wayne.edu/oa_disserations/1640

Hudson, B. (2018). Powerful knowledge and epistemic quality in mathematics. *London Review of Education*, *16*(3), 384–397. http://dx.doi.org/10.18546/LRE.16.3.03

International comparisons of achievement. (n.d.). https://nces.ed.gov/fastfacts/display.asp?id=1

Jhanke, M. S. (2010). *How teacher collective efficacy is developed and sustained in high achieving middle schools* [Unpublished doctoral dissertation]. Retrieved from Proquest Dissertations and Thesis database (UMI: 3410320)

Johns, J. A., & Moyer, M. T. (2018). The attitudes, beliefs, and norms framework: A tool for selecting student-centered, theory-informed affective learning objectives in health education, *9*(1), 14–26. https://doi.org/https://eric.ed.gov/?id=EJ1179843

Jones, M. H., & Gallen, A.-M. (2016). Peer observation, feedback and reflection for development of practice in synchronous online teaching. *Innovations in Education and Teaching International*, *53*(6), 616–626. https://doi.org/10.1080/14703297.2015.1025808

Kikiakidis, P. P., & Johnson, T. (2015). Program evaluation: Integration of educational software into the elementary school math curriculum. *Revista Romaneasca pentru Educatie Multidimensionala*, *7*(2), 55–65. http://dx.doi.org/doi.org/10.18662/rrem/2015.0702.05

Kim, K. R., & Seo, E. H. (2018). The relationship between teacher efficacy and students' academic achievement: A meta-analysis. *Social Behavior and Personality*, *46*(4), 529–540. https://doi.org/10.2224/sbp.6554

King, F. (2016). Teacher professional development to support teacher professional learning: Systemic factors from Irish case studies. *Teacher Development*, *20*(4), 574–594. https://doi.org/10.1080/13664530.2016.161661

Klassen, R., Usher, E., & Bong, M. (2010). Teachers' collective efficacy, job satisfaction, and job stress in cross-cultural context. *The Journal of Experimental Education*, *78*(4), 464–486. https://doi.org/10.1080/00220970903292975

Kong, J. E., & Orosco, M. J. (2016). Word-problem-solving strategy for minority students at risk for math difficulties. *Learning Disability Quarterly*, *39*(3), 171–181. http://dx.doi.org/doi.10.11770731948715607347

Kong, S. C. (2014). Developing information literacy and critical thinking skills through domain knowledge learning in ditgital classrooms: An experience of practicing flipped classroom strategy. *Computers and Education*, *78*, 160–173. http://dx.doi.org/10.1016/j.compedu.2014.05.009

Kouzes, J. M., & Posner, B. Z. (2017). *The leadership challenge: How to make extraordinary things happen in an organization* (6th ed.). John Wiley & Sons.

Kraft, M., & Gilmour, A. (2017). Revisiting the widget effect: Teacher evaluation reforms and the distribution of teachers. *Educational Researcher*, *46*(5), 234–249. https://doi.org/10.3102/0013189X17718797

Kramer, B. J., & Howe, J. L. (2014). The role of education in implementation science. *Gerontology & Geriatrics Education*, *35*(1), 1–3. https://doi.org/10.1080/02701960.2014.876845

Krupa, E. E., & Confrey, J. (2017). Effects of a reform high school mathematics curriculum on student achievement: Whom does it benefit?. *Journal of Curriculum Studies*, *49*(2), 191–215. http://dx.doi.org/doi.org/10.1080/00220272.2015.1065911

Kuhfeld, M. (2019). Surprising new evidence on summer learning loss. *Phi Delta Kappan*, *101*(1), 25–29. https://doi.org/10.1177/0031721719871560

Lakin, J. M., & Rambo-Hernandez, K. (2019). Fidelity of implementation: Understanding why and when programs work. *Gifted Child Today*, *42*(4), 205–214. https://doi.org/10.1177/1076217519862327

Lampert-Shepel, E., & Murphy, C. (2018). Learning to reflect: Teachers' mastery and development of mediational means and psychological tools of reflective practice. *Journal of Cognitive Education and Psychology*, *17*(3), 278–300. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=10&sid=a9d43212-9337-4f20-b495-6e09e2eb1951%40pdc-v-sessmgr03

Larrivee, B. (2008). Development of a tool to assess teachers' level of reflective practice. *Reflective Practice*, *9*, 341–360. https://doi.org/10.1080/14623940802207451

Learning Policy Institute, Bradley, K., & Hernandez, L. E. (2019). *Big picture learning: Spreading relationships, relevance, and rigor ones student at a time* [Report]. Learning Policy Institute . learningpolicyinstitute.org/deeper-learning-networks

Lepper, M. R., & Hodell, M. (1989). Intrinsic motivation in the classroom. In *Research on motivation in education* (pp. 73–105). Academic Press.

Li, Y., & Krasny, M. E. (2020). Development of professional networks among environmental educators. *Professional Developemnt in Education*, *46*(2), 337–353. https://www-tandfonline-com.ezproxy.liberty.edu/doi/full/10.1080/19415257.2018.1562957

Lim, K. H. (2019). using math magic to reinforce algebraic concepts: An exploratory study. *International Journal of Mathematical Education in Science and Technology*, *50*(5), 747–765. https://doi.org/10.1080/0020739X.2018.1537450

Linking the Alaska AMP assessments to NWEA MAP growth tests. (n.d.). https://www.nwea.org/content/uploads/2017/06/AK-MAP-Growth-Linking-Study-FEB2016.pdf

Liu, Y., & Liao, W. (2019). Professional development and teacher efficacy: Evidence from the 2013 TALIS. *An International Journal of Research, Policy and Practice*, *30*(4), 487–509. https://www-tandfonline-com.ezproxy.liberty.edu/doi/full/10.1080/09243453.2019.1612454

Maeng, J. L., Whitworth, B. A., Bell, R. L., & Sterling, D. R. (2020). The effect of professional development on elementary science teachers' understanding, confidence, and classroom implementation of reform-based science instruction. *Science Teacher Education*, *104*, 326–353. http://dx.doi.org/DOI: 10.1002/sce.21562

Malloy, J. (2020). Entangled educator evaluation apparatuses: Contextual influences on new policies. *Education Policy Analysis Archives*, *28*(60). https://doi.org/10.14507/epaa.28.5016

MAP growth. (n.d.). https://www.nwea.org/map-growth/

Martin, C., Polly, D., Mraz, M., & Algozzine, R. (2019). Examining focus, duration, and classroom impact of literacy and mathematics professional development. *Teacher Development*, *23*(1), 1–17. https://www-tandfonline-com.ezproxy.liberty.edu/doi/full/10.1080/13664530.2018.1530695

Matthews, M. S., Ritchotte, J. A., & McBee, M. T. (2013). Effects of schoolwide cluster grouping and within-class ability grouping on elementary school students' academic achievement. *High Ability Studies*, *24*(2), 81–97. https://doi.org/10.1080/13598139.2013.846251

Max, B., & Welder, R. M. (2020). Mathematics teacher educators' addressing common core standards for mathematical practice in content course for prospective elementary teachers: A focus on critquing the reasoning of others. *Mathematics Enthusiast*, *17*(2/3), 843–881. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=4&sid=04f81658-a6c9-47fb-8096-35d96c9c0ea3%40pdc-v-sessmgr03

Mayer, R. E. (2012). Information processing. *APA educationhal psychology habndbook*, *1*, 85–99.

Mazur, J. (2016). *Fluke: The math and myth coincidence*. Basic Books.

McGee, D., Brewer, M., Hodgson, T., Richardson, P., Gonulates, F., & Weinel, R. (2017). A districtwide study of automaticity when included in concept-based elementary school mathematics instruction. *School and Science Mathematics*, *117*(6), 259–268. https://doi.org/10.1111/ssm.12233/full

Moncher, F. J., & Prinz, R. J. (1991). Treatment fidelity in outcome studies. *Clinical Psychology Review*, *11*, 247–266. http://dx.doi.org/10.1016/0272-7358(91)90103-2

Moon, T. R., & Park, S. (2016). Fidelity of intervention of English/language arts elementary curriculum for gifted students: An exploratory investigation in different service delivery models. *Journal for the Education of the Gifted*, *39*, 62–79. http://dx.doi.org/10.1177/0162353215624161

Murata, A., Siker, J., Kang, B., Baldinger, E. M., Kim, H.-J., Scott, M., & Lanouette, K. (2017). Math talk and student strategy trajectories: The case of two first grade classrooms. *Cognition and Instruction*, *35*(4), 290–316. http://dx.doi.org/doi.org/10.1080/07370008.2017.1362408

Murcia, K., & Pepper, C. (2018). Evaluating the social impact of a science centre's STEM professional learning strategies for teachers. *Issues in Educational Research*, *28*(2), 438–452. http://www.iier.org.au/ierr28/murcia.pdf

NWEA. (2019). *MAP growth technical report*. Author.

Ojose, B. (2015). Proportional reasoning and related concepts: Analysis of gaps and understanding of middle grade students. *Universal Journal of Education Research*, *3*(2), 104–112. https://doi.org/https://eric.ed.gov/?id=EJ1056108

Paul, C. M. (2018). Building disciplinary literacy: An analysis of history, science, and math teachers' close reading strategies. *Literacy*, *52*(3), 161–170. http://dx.doi.org/doi.org/10.1111/lit./12127

Pharis, T. J., Wu, E., Sullivan, S., & Moore, L. (2019). Improving teaching quality: Professional development implications from teacher prefessional growth and effectiveness system implementation in rural Kentucky high schools. *Educational Research Quarterly*, *42*(3), 29–48. http://web.b.ebscohost.com.ezproxy.liberty.edu/ehost/detail/detail?vid=3&sid=d9db7770-ad71-4b13-93ae-01919a17aa82%40pdc-v-sessmgr01&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=135266873&db=asn

Piaget, J. (1972). *The psychology of the child*. Basic Books.

Powell, S. R., Stevens, E. A., & Hughes, E. M. (2018). Math language in middle school: Be more specific. *Council for Exceptional Children*, *51*(4), 286–295. https://doi.org/10.1177/0040059918808762

Preiss, D. D., Grau, V., Irribarra, D. T., & Calcagni, E. (2018). Metacognition, self-regulation, and autonomy support in the Chilean mathematics classroom: An observational study. *New Directions for Child and Adolescent Development*, *162*, 115–136. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=8&sid=2eff0c05-eed5-454e-9a6c-e3a867ab4435%40sdc-v-sessmgr03

Prenger, R., Poortman, C. L., & Handelzalts, A. (2019). The effects of networked professional learning communities. *Journal of Teacher Education*, *70*(5), 441–452. https://doi.org/http://dx.doi.org.ezproxy.liberty.edu/10.1177/0022487117753574

Putney, L. G., & Jones, S. H. (2019). Introduction to the special issue on fostering collective and self-efficacy: Examining new directions on efficacy in education. *Journal of Ethnographic & Qualitative Research*, *13*, 231–233. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=6&sid=5f6f0cc0-9c22-403d-ba66-42c477dc2786%40pdc-v-sessmgr04

Rempe-Gillen, E. (2018). Primary school teacher experiences in cross-phase professional development collaborations. *Professional Development in Education*, *44*(3), 356–368. https://www-tandfonline-com.ezproxy.liberty.edu/doi/full/10.1080/19415257.2017.1328455

Robertson-Kraft, C., & Zhang, R. S. (2018). Keeping great teachers: A case study on the impact and implementation of a pilot teacher evaluation system. *Educational Policy*, *32*(3), 363–394. https://doi.org/10.1177/0895904816637685

Roegman, R., Goodwin, A. L., Reed, R., & Scott-McGlaughlin II, R. (2016). Unpacking the data: An analysis of the use of Danielson's (2007) framework for professional practices in a teaching residency. *Education Assessment, Evaluation Accountability*, *28*, 111–137. https://doi.org/10.1007/s11092-015-9228-3

Roman, H. T. (2016). The math card game challenge. *Technology & engineering teacher*, *76*(1), 38–39. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=11&sid=1d15ee0d-36e8-4082-adec-3c867d0dc71e%40pdc-v-sessmgr05

Romanov, P. Y., Smirnova, L. V., & Torshina, O. A. (2019). Teaching ways of compiling tasks as the fundamentals of the development of professional competence of future mathematics teachers. *Perspectives of Science and Education*, *38*(2), 442–452. https://doi.org/10.32744/pse.2019.2.33

Roney, P., Rose, J., & McKeown, S. (2019). Predicting effort regulation in mathematics in acolescents. *The Psychology of Education Review*, *43*(2), 48–54. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=6&sid=2eff0c05-eed5-454e-9a6c-e3a867ab4435%40sdc-v-sessmgr03

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs*, *80*(1), Whole No. 609.

Schunk, D. (2016). *Learning theories: An educational perspective* (7th ed.). Pearson.

Schwartz, C., Walkowiak, T. A., Poling, L., Richardson, K., & Polly, D. (2018). The nature of feedback given to elementary student teachers from university supervisors after observations of mathematics lessons. *Mathematics Teacher Education and Development*, *20*(1), 62–85. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=28&sid=89bec243-ea25-49db-a29b-11fd9d953066%40sessionmgr101

Shockey, T., & Pindiprolu, S. (2015). Uniquely precise: Importance of conceptual knowledge and mathematical language. *Journal on School Educational technology*, *11*(1), 28–33. https://search-proquest-com.ezproxy.liberty.edu/docview/1752593595?accountid=12085

Shrestha, M. (2019). Where lies the reality of mathematics for common people?. *Philosophy of Mathematics Education Journal*, (35), 1–30. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=9&sid=389a5a36-f334-42a3-b2b1-7c8e79b3b8b4%40sdc-v-sessmgr02

Silver, H. F., Hanson, J. R., Strong, R. W., & Schwartz, P. B. (1996). *Teaching styles and strategies* (3rd ed.). Thoughtful Education Press.

Skaalvik, E. M. (2018, March 8). Mathematics anxiety and coping strategies among middle school students: Relations with students' achievement goal orientations and level of performance.. *Social Psychology Education*, *21*, 709–723. https://doi.org/https://doi.org/10.1007/s11218-018-9433-2

Skaalvik, E. M., & Skaalvik, S. (2007). Dimensions of teacher self-efficacy and relations with strain factors, perceived collective teacher efficacy, and teacher burnout. *Journal of Educational Psychology*, *99*, 611–625. http://dx.doi.org/https:/doi.org/bj3nf5

Spargo, A. V., & Ellsworth, K. A. (2019, January 10). Interpreting district MAP data. In M. Graham (Chair). Alaska Superintendents Association, Anchorage.

Standards for mathematical practice. (2020). Common Core State Standards Initiative. http://www.corestandards.org/Math/Practice/

Steffe, L. P. (2016). Towards a model of constructivist mathematics teaching. *Constructivist Foundations*, *12*(1), 75–77. https://web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=6&sid=389a5a36-f334-42a3-b2b1-7c8e79b3b8b4%40sdc-v-sessmgr02

Sterrett, W. L., Parker, M. A., & Mitzner, K. (2018). Maximizing teacher time: The collaborative leadership role of the principal. *Journal of Organizational & Educational Leadership*, *3*(2). digitalcommons.gardner-webb.edu/joel/vol3/iss2/2

Stringfield, S., Schaffer, E., & Roberta, Devlin-Scherer. (2017). A study of the generalizability of teacher change quasi-experiments. *Journal of Classroom Interaction*, *52*(1), 25–35. web-a-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=5&sid=acd10ae6-eaab-425a-af83-4a586a686e3b%40sessionmgr4007

Tallman, T. O. (2019). How middle grades teachers experience a collaborative culture: An interpretative phenomenological analysis. *Research in Middle Level Education*, *42*(8). web-b-ebscohost-com.ezproxy.liberty.edu/ehost/detail/detail?vid=39&sid=89bec243-ea25-49db-a29b-11fd9d953066%40sessionmgr101&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=138887610&db=ehh

Tanis, H., & Barker, I. (2017). E-mentoring at a distance: An approach to support professional development in the workplace. *Turkish Online Journal of Distance Education*, *18*(3). https://eric.ed.gov/?id=EJ1147719

Tee, K. N., Leong, K. E., & Rahim, S. S. (2019). Modeling relationships of affective and metacognitive factors on grade eleven students' mathmatics achievement. *International*

Journal of Research in Education and Science, *5*(1), 295–308. https://eric.ed.gov/?id=EJ1197989

Torres, D. D. (2017). Cultural discontinuity between home and scchool and American Indian and Alaska Native childrens' achievement. *The Jounral of Educational Research*, *110*(4), 331–347. http://dx.doi.org/10.1080/00220671.2015.1103686

Tschannen-Moran, M., & Woolfolk Hoy, A. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education*, *23*, 944–956. https://www-sciencedirect-com.ezproxy.liberty.edu/science/article/pii/S0742051X06000953?via%3Dihub

Tyagi, T. K. (2017). Mathematical intelligence and mathematical creativity: A causal relationship. *Creativity Research Journal*, *29*(2), 212–217. https://doi.org/10.1080/10400419.2017.1303317

Vigdor, J. (2013). Solving America's math problem. *EducationNext*, *13*(1). https://www.educationnext.org/solving-america%E2%80%99s-math-problem/

Volk, M., Cotic, M., Zajc, M., & Starcic, A. I. (2017). Tablet-based cross curricular maths vs. traditional maths classroom practice for higher-order learning outcomes. *Computers & Education*, *114*, 1–23. http://dx.doi.org/10.1016/j.compedu.2017.06.004

Vygotsky, L. (1978). *Mind in society*. Harvard University Press.

Vygotsky, L. (1987). *The collected works of L.S. Vygotsky: Vol. 2 problems of general psychology*. Plenum.

Wang, S., McCall, M., Jiao, H., & Harris, G. (2013). Construct validity and measurement invariance of computerized adaptive testing: Application of measures of academic progress (MAP) using confirmatory factor analysis. *Journal of Educational and Developmenet Psychology*, *3*(1), 88–100. http://dx.doi.org/10.5539/jedp.v3n1p88

Wan-shuai, L., Xiao-Wen, L., & Yu-mei, Z. (2019). The formation of teachers' intrinsic motivation in professional development. *Integrative psychological and behavioral science*, *53*(3), 418–430. https://doi.org/10.1007/s12124-018-9465-3

Woolfolk Hoy, A., & Hoy, W. K. (2003). *Instructional leadership: A learning-centered guide*. Allyn and Bacon.

Yang, R., Porter, A. C., Massey, C. M., F, J., Merlino, & Desimone, L. M. (2020). Curriculum-based teacher professional development in middle school science: A comparison of training focused on cognitive science principles versus content knowledge. *The Journal of Research in Science Teaching*, *57*, 536–566. https://www-tandfonline-com.ezproxy.liberty.edu/doi/full/10.1080/19415257.2018.1562957

Yeaton, W. H., & Sechrist, L. (1981). Critical dimensions in the choice and maintenance of successful treatments: Strength, integrity, and effectiveness. *Journal of Consulting and Clinical Psychology*, *49*, 156–167. http://dx.doi.org/10.1037//0022-06X.49.2.156

Young, J. L., Young, J. R., & Capraro, M. M. (2017). Black girls' achievement in middle grades mathematics: How can socializing agents help?. *The Clearing House: A Journal of Educational Strategies, Issues, and Ideas*, *90*(3), 70–76. http://dx.doi.org/10.1080/00098655.2016.1270657

Yu, R., & Singh, K. (2018). Teacher support, instructional practices, student motivation, and mathematics achievement in high school. *The Journal of Educational Research*, *111*(1), 81–94. https://web-b-ebscohost-com.ezproxy.liberty.edu/ehost/pdfviewer/pdfviewer?vid=4&sid=81e8322a-f6ff-4712-890c-ec02c6dbdd5a%40pdc-v-sessmgr04

Appendices

Appendix A

Letters from School Districts Approving Data Collection

[redacted]

OFFICE OF THE SUPERINTENDENT

August 6, 2020

[redacted]

Dear Katherine Ellsworth:

After careful review of your research proposal entitled IMPACT OF CONCEPT-BASED MATHEMATICS INSTRUCTIONAL STRATEGIES ON SEVENTH GRADE STUDENT ACHIEVEMENT, I have decided to grant you permission to receive Measurement of Academic Progress for a cohort of students. The data will include scores for students enrolled in an on-grade level mathematics course as a sixth grader during the 2018-2019 and as a seventh grader in an on-grade level mathematics course for the 2019-2020. The data set will include fall and winter mathematics scores, with the score overall score and the score on the strand Algebraic Thinking visible. In addition, demographic data will be provided for the cohort of students and their teachers.

Check the following boxes, as applicable:

☒ The requested data WILL BE STRIPPED of all identifying information before it is provided to the researcher.

☐ The requested data WILL NOT BE STRIPPED of identifying information before it is provided to the researcher.

☒ I/We are requesting a copy of the results upon study completion and/or publication.

Sincerely,

[redacted]

Superintendent [redacted]

[redacted]

We prepare all students for success

August 24, 2020

Katherine Ellsworth
[redacted]

Dear Katherine Ellsworth:

After careful review of your research proposal entitled IMPACT OF CONCEPT-BASED MATHEMATICS INSTRUCTIONAL STRATEGIES ON SEVENTH GRADE STUDENT ACHIEVEMENT, I have decided to grant you permission to receive Measurement of Academic Progress for a cohort of students. The data will include scores for students enrolled in an on-grade level mathematics course as a sixth grader during the 2018-2019 and as a seventh grader in an on-grade level mathematics course for the 2019-2020. The data set will include fall and winter mathematics scores, with the score overall score and the score on the strand Algebraic Thinking visible. In addition, demographic data will be provided for the cohort of students and their teachers.

Check the following boxes, as applicable:

☒ The requested data WILL BE STRIPPED of all identifying information before it is provided to the researcher.

☐ The requested data WILL NOT BE STRIPPED of identifying information before it is provided to the researcher.

☒ I/We are requesting a copy of the results upon study completion and/or publication.

Sincerely,

[redacted]
Director, Assessment and Evaluation
[redacted]

Appendix B

Institutional Review Board Approval Letter

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

September 7, 2020

Katherine Ellsworth
Lisa Foster

Re: IRB Application - IRB-FY20-21-42 IMPACT OF CONCEPT-BASED MATHEMATICS INSTRUCTIONAL STRATEGIES ON SEVENTH GRADE STUDENT ACHIEVEMENT

Dear Katherine Ellsworth, Lisa Foster:

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study does not classify as human subjects research because:

(1) it will not involve the collection of identifiable, private information.

Please note that this decision only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

[redacted]

Administrative Chair of Institutional Research
Research Ethics Office