A QUASI-EXPERIMENTAL STUDY ON THE EFFECTS OF SMALL GROUP LEARNING ON MATHEMATICAL RESILIENCE IN UPPER ELEMENTARY STUDENTS

by

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Liberty University

2024

A QUASI-EXPERIMENTAL STUDY ON THE EFFECTS OF SMALL GROUP LEARNING ON MATHEMATICAL RESILIENCE IN 5th GRADE STUDENTS

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Liberty University, Lynchburg, VA

2024

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ABSTRACT

The purpose of this quantitative, quasi-experimental study was to determine the effect of small group learning during the core mathematics block on 5th-grade students' mathematical resilience, compared to a control group. Student collaboration and mathematical discourse decreased during the COVID-19 pandemic, leading to a drop in math proficiency levels in the United States. Approximately 80 5th-grade students from the southwest United States were divided into two sample groups of about 40 each. These groups were assessed using the Upper Elementary Mathematics Resilience Scale. One group primarily experienced teacher-centered whole group instruction, while the other group spent half of their daily core learning block in student-centered small group instruction. Differences between the two groups were analyzed using ANCOVA on the two measures of the Mathematical Resilience Scale: value and growth mindset. The ANCOVA tested for differences in the post-test, using the pre-test as the covariate. Data for the value subscale showed a statistically significant change between the groups, though the direction of the change was unexpected. Data for the growth subscale did not reach appropriate levels of significance. For future research, it is recommended that the scale be administered at the beginning of the school year instead of the end, and that the sample size be increased in both groups.

Keywords: whole group instruction, small group learning, mathematical resilience, progressive classroom

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Zone of Proximal Development (ZPD)

Programme for International Student Assessment (PISA)

Science, Technology, Engineering, and Mathematics (STEM)

National Assessment of Educational Progress (NAEP)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quasi-experimental static group design study is to determine if there is a difference in mathematical resilience between elementary students who consistently experience small group learning during the core math block and students who primarily experience whole group instruction. Chapter One presents the background and significance of poor mathematics achievement levels and their relationship to students' resilience in the subject. This relationship will also demonstrate the significance of the study. The research question and purpose will be established, along with key terms and definitions.

Background

Mathematics educators in the United States are facing a conundrum. There is considerable research linking fixed mindsets and math anxiety to lower achievement in youth and adults alike (Gunderson et al., 2018; Zhang et al., 2019), while poor performance in mathematics links back to math anxiety (Zhang et al., 2019). In the United States, policy and pedagogy have focused on elevating math achievement in the United States, including a massive overhaul of the K-12 content standards in 2010 known as the Common Core State Standards for Mathematics (CCSS-M) and the movement towards school and teacher accountability in the 21st century (Smith, 2020). However, the approach of increasing mathematical proficiency to improve math resiliency in students has yet to yield the desired results, as measured by the Programme for International Student Assessment (PISA) over the last 20 years (Programme for International Student Assessment, 2019), as well as the National Assessment of Educational Progress (NAEP) (NAEP Mathematics: Mathematics Highlights, 2022). Strategies towards lowering math anxieties and building mathematical resilience in our students is a new approach that could solve this conundrum and make the United States competitive on the world stage.

During the COVID-19 pandemic beginning in 2019, educators, parents, and students had to quickly adapt to online instruction and learning. This effectively removed most, if not all mathematical discourse and collaborative learning from mathematics instruction. Teachers scrambled to implement digital tools to increase engagement, but instruction within this setting was forced to adapt to more traditional practices where the teacher did the majority of the talking and students had little opportunity to converse with their peers. Learning suffered because of the massive shift for all parties involved. Based on NAEP data, math scores in the United States experienced the first statistically significant drop since the inception of the assessment in 1973 (Gilligan, 2022; USA Facts, 2022). Once in person learning returned to American schools in 2021, math scores have rebounded based on state assessment data (Barnum & Belsha, 2023).

Historical Overview

The role of the federal government in education in the United States has been debated since the signing of the Constitution. The Tenth Amendment of the United States does make it clear that any right or power that is not given to the national government in the Constitution shall be given to the state. Interestingly, as Ronald Reagan attempted to dismantle the Department of Education in the early 1980s, he also called for national requirements for high school graduation (LaVenia et al., 2015). Although Reagan's attempts were far from nationalized K-12 standards, it was the first movement towards a united set of goals and specific outcomes. The National Council on Education Standards and Tests, under the G.H.W. Bush and Clinton administrations, was a stronger movement toward a national set of standards but ultimately failed because of differences in opinions, beliefs, and philosophies of education throughout the states. Republicans wanted to hinder the influence of the national government in education, and Democrats feared the impact of assessments on students who were not prepared (McDonnell & Weatherford, 2013).

In 2001, the American Diploma Project was developed to ensure graduating seniors were prepared for higher education and the workforce. From the work of the ADP, sixteen states agreed to align their high school graduation requirements, fifteen created a common Algebra II assessment, and five agreed to develop a common Algebra I assessment. Although 16 is a relatively low number of the total states working together, but the work of American Diploma Project showed that states could work together to create common goals and expectations in education (McDonnell & Weatherford, 2013).

Following poor performance on the National Assessment of Educational Progress and an obvious lag behind other countries based on the Program for International Student Assessment (PISA), an increase in support for nationalized standards in education began in the mid-2000s (LaVenia et al., 2015). The United States became unified following the attacks on September 11th, 2001, which helped to easily pass G.W. Bush's No Child Left Behind Act (NCLB) (Smith, 2020). Based on student data falling well below levels of proficiency in mathematics and expectations from NCLB, in 2006, two former governors (Hunt Jr. from North Carolina and Wise from West Virginia) felt that something impossible a decade earlier may have the support to be successful (McDonnell & Weatherford, 2013).

Through organizations Hunt Jr. and Wise led, they first set to identify the need for nationalized standards. They described the deficiencies in the current state of education as such (McDonnell & Weatherford, 2013):

- Data are low compared to competing counties.

- The United States has an achievement gap between races and social classes.
- Graduating seniors are not properly prepared for college or the workforce.
- High-performing countries have standards that are “focused, rigorous, and coherent” (McDonnell & Weatherford, 2013, p. 9).
- State standards in the United States cover an abundance of content, but with very little depth for understanding.

Because of these inadequacies in our current system, Hunt Jr. and Wise felt that common standards were the key element to improving student performance (McDonnell & Weatherford, 2013).

To ease the resistance against federal initiatives in education, state governors agreed to take control of the development of the common state standards. All but two states agreed to assist in creating the standards, along with common assessments to measure student, teacher, school, district, and state success. The first step in development was to determine what graduating students should know. From there, they worked in a backward design model, determining what should be learned in each grade level. The research and data from the PISA and the Trends in International Mathematics and Science Study guided the writers and developers of the nationalized standards (McDonnell & Weatherford, 2013). The result was the Common Core State Standards (CCSS) for Mathematics and English Language Arts. Obama’s Race to the Top initiative was a monetary award for states showing positive reform, and points were given to states that adopted the CCSS. By 2011, 46 states adopted and began transitioning to a set of common, nationalized standards (LaVenia et al., 2015). Since this time, multiple states have veered away from the label of the CCSS and revised the standards to create state specific guidelines for teaching mathematics. However, most of the revisions by these states resulted in standards that closely resembled, if not identical to, the CCSS for Mathematics.

In 2000, the National Council of Teachers of Mathematics released the *Principles and Standards for School Mathematics* (2000). These standards were the first formalized attempt for a massive shift in mathematics curriculum and instruction, which this research proposal is looking to analyze. However, these shifts were brought to the masses by the writing and adoption of the Common Core State Standards ten years later. As these movements have increased Constructivist philosophies in mathematics classrooms, research began to recognize the need for students to possess mathematical resilience.

Society-at-Large

Essentialistic instructional practices in mathematics have led educators in the United States to believe that math is a set of facts and procedures memorized to arrive at a correct answer (Gordon et al., 2019). Conceptual understanding is often overlooked when working to arrive at a correct answer as fast as possible. A common conjecture is that this approach has led to the following United States' rankings for mathematics on the PISA (see Table 1).

Table 1
United States Ranking of the PISA for Math

Year	Ranking
2003	28th out of 41
2006	33rd out of 55
2009	29th out of 65
2012	34th out of 65
2015	40th out of 72
2018	38th out of 79

Source: Programme for International Student Assessment, 2019

Ramirez et al. (2018) conducted a study that concluded that math anxiety and a fixed mindset in the instructor leads to lower student achievement. Furthermore, the student perception of the teacher's mindset played the key role, and this judgment was determined through instructional practices utilized by the teacher. While focusing on memorization and procedural skills, students felt less confident about their teacher, lowering their belief in themselves to achieve (Ramirez et al., 2018).

A glaring concern about mathematics instruction and learning in the United States is data on remedial math courses at the university level. Ngo (2019) shared that 30% of four-year university students require remedial math courses for admission, while 60% of community college students require remediation. The cultural status of mathematical understanding and proficiency in the United States needs to be altered to see growth in future generations. Students benefit when teachers see themselves as mathematicians, utilize cognitively guided instructional practices, and fill their students with the belief that everyone can be successful in the field (Boaler, 2022).

Theoretical Background

Research in the theory of mindset has shifted common beliefs of potential in all skill and knowledge areas. Not only can potential be maximized with the correct belief system, but potential can also actually be extended and grown. A fixed mindset locks in a belief that a person can only perform up to a certain level and slows motivation and determination. The key is what happens to the learner when something becomes complex or difficult. A learner with a growth mindset attacks, while a learner with a fixed mindset falls away (Dweck, 2008).

Research supports the need for a growth mindset to maximize learning in all subjects (Dweck, 2008). Fixed mindsets in mathematics are particularly prevalent in the United States among children and adults (Lin & Muenks, 2023). J. Boaler (2022) coined the term *Mathematical Mindsets*, drawing attention to the achievement gap between fixed and growth mindsets. Data from the 2012 Mathematics PISA demonstrates that students with a growth mindset outperformed peers with a fixed mindset by over 60 points (Programme for International Student Assessment, 2019). “The difference in mathematics is not because of the nature of the subject… It is due to some serious and widespread misconceptions about that subject” (Boaler, 2022, p. 35). These misconceptions have contributed more to a fixed mindset approach to mathematics than any other subject. Addressing misconceptions can help create stronger growth mindsets and improve mathematical proficiency (Boaler, 2022).

Mathematical resilience is a term first used by Johnston-Wilder and Lee (2010) which not only incorporates the theory of mindset but also describes the importance of placing value in mathematics and the necessity of productive struggle. Successful math students overcome an initial negative response to a challenge by having confidence and strategies to transcend adversity. Mathematical resilient students display a growth mindset, accept challenges and struggles as a part of the learning process, and find importance in their work. The objective is to use and understand mathematics, rather than a traditional belief system of simply performing mathematics to pass an exam (Johnston-Wilder & Lee, 2010).

Collaborative learning structures center around constructivist philosophies (Piaget, 1926), particularly those of Vygotsky (1978) and the sociocultural theory. These theories are brought to life when teachers transform their classrooms from essentialistic strategies to progressive style teaching. Instead of being asked to sit and listen, students become active in the learning process and create knowledge through experience (Gordon et al., 2019). Vygotsky's Zone of Proximal Development (ZPD) guides teachers to find the *just right* problem or activity, which requires support but is not out of reach from the student's current level of understanding (Vygotsky, 1978).

Problem Statement

Mathematics educational leaders in the United States overwhelmingly support the transition to the CCSS-M or similarly modeled standards (McDonnell & Weatherford, 2013). However, as students in the United States continue to achieve higher than the worldwide average on the PISA assessment in reading and science, they have tested below the average in mathematics with no statistically significant changes since 2003 (Programme for International Student Assessment, 2019). Math anxiety (Zhang et al., 2019) and fixed mindsets (Boaler, 2022) continue to be a major obstacle for students and adults alike. A concern is that many teachers are utilizing essentialistic classroom practices and instructional strategies to teach standards that are to be delivered in a constructivist context, and not all teachers themselves have resilience in mathematics (Boaler, 2022). To create mathematical resilient learners, which would raise achievement levels, researchers recommend educational leaders support teachers in the transition to progressive classroom strategies and build teachers' confidence and capacity in teaching mathematics to create strong growth mindsets (Boaler, 2022).

The negative correlation between a fixed mindset and math achievement is well-researched and documented (Boaler, 2022; Gunderson et al., 2018). Most of the research suggests strategies to improve achievement; however little research has been conducted on how to improve a growth mindset, except for *Mathematical Mindsets* by J. Boaler (2022).

Mathematical resilience is a concept that incorporates a growth mindset, including the necessity of finding value in mathematics and struggle (Johnston-Wilder & Lee, 2010). Tools for measuring a student's mathematical resilience were created (Kooken et al., 2016) enabling researchers to use these tools to determine the most effective ways to increase these beliefs and values. The problem is research has not tested the effects of small group instruction on upper elementary students' mathematical resilience.

Purpose Statement

The purpose of this quantitative, quasi-experimental study is to determine the effect of small group learning during the core mathematics block on 5th grade students' mathematical resilience in comparison to a control group. *Mathematical resilience*, identified as the independent variable, is defined as "a learner's stance towards mathematics that enables pupils to continue learning despite finding setbacks and challenges in their mathematical journey (Johnston-Wilder & Lee, 2010, p. 38). The two factors analyzed when measuring mathematical resilience are the value of mathematics and growth mindset. These were measured using a scale for upper elementary students in the form of a pre-test, which is the covariate, and a post-test, which is used as the dependent variable. From a population of 5th-grade students in a district in the suburbs of Phoenix, Arizona, two sample groups were selected based on the independent variable which are those who consistently experience 30 minutes or more of small group learning during the core mathematics block, and those typically experiencing less than 10 minutes. There are many definitions and different criteria in research for teaching and student grouping practices to be considered small group instruction. For the purposes of this study, small group learning is defined as student-centered, differentiated instruction focused on developing conceptual understanding through problem solving and mathematical discourse. Flexible groupings are typically up to 6 students and range from 10-20 minutes per group (Sammons, 2019).

Significance of the Study

The positive correlation between a growth mindset and increased levels of achievement, especially in mathematics, has been well-researched and documented (Boaler, 2019, 2022). Conversely, fixed mindsets and math anxiety hinder growth and decrease effort, confidence, and willingness to take risks (Boaler, 2019, 2022; Dweck, 2008; Gonzalez-DeHass et al., 2023). The results of small group learning for reading and mathematics intervention have yielded positive results (Barrett-Zahn, 2019; Pai et al., 2015; Utaminingtyas et al., 2017). During these small group experiences for interventions, students' specific needs are being met through differentiated instruction, and the reduced student-to-teacher ratio during instruction increases the opportunity for specific feedback and redirection through questioning.

This study links small group learning and a growth mindset, which then in turn leads to higher achievement in mathematics. Going beyond Dweck's (2008) work with growth mindset, this study focuses on using small group instruction to develop mathematical resilient students, which includes a student's value of mathematics and the theory of mindset (Johnston-Wilder & Lee, 2010). The sample size focused on 5^{th}-grade students, typically 10-11 years old, because of their ability to provide accurate feedback through surveys.

Research Questions

RQ1: Is there a difference in how 5^{th} grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

RQ2: Is there a difference in 5th grade students' growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

Definitions

1. *Constructivist Learning Theory* – A philosophy of learning in which the teacher acts as a facilitator of learning, and the student is a responsible and active part of the learning process (Gordon et al., 2019).
2. *Educational progressivism* – A belief of student-centered instruction through active participation and learning through experience (Gordon et al., 2019).
3. *Essentialism* – A teacher-centered instructional philosophy focused on reading, writing, and arithmetic (Gordon et al., 2019).
4. *Fixed Mindset* – The belief that intelligence is something specific to you and it cannot be improved (Dweck, 2008).
5. *Growth Mindset* – The belief that natural abilities can be improved upon through effort. (Dweck, 2008).
6. *Math Anxiety* – A state of fear and apprehension that a learner may have when approaching mathematical tasks (Zhang et al., 2019).
7. *Mathematical Resilience* – A learner's stance towards mathematics that enables pupils to continue learning despite finding setbacks and challenges in their mathematical journey (Johnston-Wilder & Lee, 2010, p. 38).

8. *Small Group Learning* – Student-centered, differentiated instruction focused on developing conceptual understanding through problem solving and mathematical discourse. Flexible groupings are typically up to 6 students and range from 10-20 minutes per group (Sammons, 2019).
9. *Value* – The extent to which mathematics plays a role in attaining future ambitions (Kooken et al., 2016).
10. *Whole Group Learning* – A teacher-centered instructional approach which all students are given the same information at the same time. “Teachers plan a single lesson at one instructional level” (Sammons, 2019, p. 128).

CHAPTER TWO: LITERATURE REVIEW

Overview

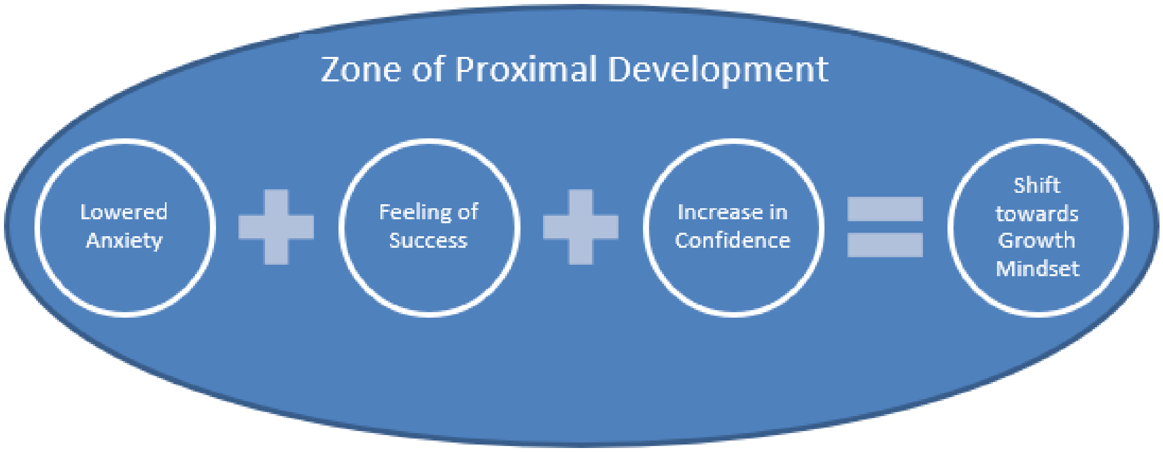
A systematic literature review was conducted to explore small group learning in elementary mathematics and its effect on mathematical resilience. This chapter presents a review of the current literature related to the topic of study. The first section will discuss the ZPD within Vygotsky's sociocultural theory, the theory of mindset, and the negative link between math anxiety and proficiency. The so-called "pendulum swing" in math education is later described, which can be defined by the differences in essentialistic and progressive education philosophies (Gordon et al., 2019; Smith, 2020). Following is a synthesis of recent literature regarding mathematical resilience and the effects of small-group learning. The literature surrounding research on the most effective instructional strategies for student learning in a 21st-century mathematics classroom will also be explored. A gap in the literature will be identified, presenting a viable need for the current study.

Theoretical Framework

This theoretical framework connects Vygotsky's (1978) ZPD, Dweck's (2008) Theory of Mindset, and research on mathematics anxiety on their influence on students' values and beliefs in mathematics education. Through experiencing success when working within the learner's ZPD, a student's mindset shifts as math becomes obtainable knowledge, skills, and understanding, further creating positivity around the subject. Engagement, motivation, confidence, and enjoyment are increased through success, and students are encouraged to push the limits of their own ZPD (see Figure 1) (Gusrayani et al., 2019).

Figure 1

Benefits of ZPD



Note: The benefits of working with a student's ZPD can support progress towards a growth mindset. Tasks should be challenging but accessible, or as Boaler (2022) refers to the tasks *low floor*, *high ceiling*.

Theory of Mindset

Dweck's theory of mindset is a measurable attribute of the belief in oneself (Dweck, 2008). The theory states that humans have either a fixed or growth mindset. People with a growth mindset believe that humans are built with a particular ability level and that a "ceiling" exists that they cannot overcome. This often aligns with negative self-talk, lower self-confidence, and decreased motivation in work that requires perseverance. The opposite end of the spectrum is a growth mindset, in which a person acknowledges that humans are designed with a particular set of natural abilities but denies the suggestion that they do not influence expanding that ability. There is no "ceiling" of possibilities. Through hard work and determination, humans can go beyond their natural talents. A growth mindset requires positive self-talk, which builds self-confidence and motivation for tasks that can cause struggle (see Table 2) (Dweck, 2008).

Table 2

Self-Talk to Shift to a Growth Mindset

Fixed Mindset	Growth Mindset
I'm not good at this.	What am I missing?
I don't want to do this!	Let me try this.
I give up!	I'll try again.
I'm really bad at this, and I can't do anything about it.	I'm not great at this, but I will get better.
I'm not going to try because I will just end up failing.	I can ask questions if I get confused.
I'm as good as I'm going to get.	I can always improve with effort.

Note: Adapted from Robinson (2017) and Boaler (2022).

To maximize student learning, the goal of every educator and curriculum, research has shown that a growth mindset supports learners to overcome the struggles they will encounter (Boaler, 2022; Dweck, 2008). To connect to the sociocultural theory, the aim is to provide tasks and scaffolding for each student within their ZPD (Schunk, 2020; Vygotsky, 1978). Without a growth mindset, students may be unwilling to try, which disrupts the learning environment established by the facilitator (Dweck, 2008). Using the most appropriate teaching strategies with a highly rated curriculum, even the strongest teacher will struggle to overcome a student who does not believe he/she can perform the tasks presented before them. To be successful in mathematics, Boaler (2022) suggests that learners understand that mistakes and struggle are a valuable part of the learning process. Mindset and value of struggle are interwoven within a learner, as one will continue to impact the other in a positive or negative correlation.

Constructivist Learning Theory

Piaget is often referred to as the father of constructivism. His work on the constructivist learning theory has again become the forefront of mathematics education, as new standards have shifted classrooms away from behaviorist teaching styles to progressive learning theories. Students learn best by becoming engaged with the content and owning the process. As the name suggests, students construct their knowledge and skills by building upon previous understandings and experiences, known as schema (Piaget, 1926). This starkly contrasts with a teacher-centered behaviorist classroom, where the instructor is recognized as the source of all knowledge. This knowledge is dispersed to the learner through direct instruction and lectures. The teacher will provide the knowledge, but it is up to the learner what to do with it (Schunk, 2020).

Fosnot (2005) described a very different environment and philosophy in a constructivist classroom: “When learning and teaching are so closely related, they will be integrated into learning/teaching frameworks: teaching will be seen as closely related to learning, not only in language and thought but also in action. If learning does not happen, there has been no teaching” (p. 175). This belief creates a partnership between a facilitator and learner, one in which both take ownership of learning. The instructor is not seen as a distributor of knowledge but rather a provider of experiences and scaffolding which allows students to create their knowledge. This is the basis for mathematics instruction in the 21st century (Fosnot, 2005). By blending these theories within their classrooms, mathematics educators create an optimal learning environment for student success. Both teacher and student need to possess a growth mindset to become successful partners and owners of learning (Dweck, 2008). By having both parties ultimately engaged in learning, the facilitator can create rich experiences that can build growth and achievement within the students and the teacher (Fosnot, 2005).

The current study looks to advance and solidify the theories of constructivism, specifically Vygotsky's (1978) Sociocultural Theory and the ZPD, by describing the impact of learning with small groups of peers on a growth mindset, the value of mathematics, and the importance of struggle. Therefore, the current study aims to extend the constructivist learning theories' impact beyond learning into confidence, anxiety, risk-taking, beliefs, and attitude. The current study also looks to extend the cognitive effects of teaching strategies typically found within a progressive classroom to move further away from traditional tendencies commonly found in the United States.

Sociocultural Theory in Mathematics

Critical aspects of Vygotsky's sociocultural theory include moving away from *telling* learners what they need to know, and moving towards building an environment in which a question is presented and learners interact to investigate and propose solutions (Mallamaci, 2018). A learner grows within their ZPD with the assistance of a facilitator providing scaffolding and peer support. This again removes the teacher as the center of the learning within a mathematics classroom and replaces it with partnerships among the student, their peers, and the teacher/facilitator. The mathematical discourse during learning is primarily between peers, with a facilitator prepared to guide students only when needed. (Wachira & Mburu, 2019).

While the teacher takes a back seat while learning takes place, the bulk of the teacher's responsibility comes in the preparation and planning to ensure that each student is working within their ZPD. To be successful, it is recommended that teachers bring a variety of tools to a lesson designed for problem-based learning. These learning experiences require multiple tasks reaching various levels through the progression of the content and appropriate scaffolding that may be required for each student to meet those levels. When adequately prepared, the teacher can facilitate learning by changing tasks and supplying or removing scaffolding supports. The teacher can then focus on the level of understanding of each student and use questioning to push students further along in the progression (Wachira & Mburu, 2019).

Essentialism

A teacher's philosophy for learning guides instructional practices within the classroom. Two distinct philosophies have been frequently present in America's education system, and both have a differing effect on developing students' mathematical resilience. Essentialism has been the primary philosophy in American education. From the first schools established in the colonies in the 1600s to the work of Dewey's progressivism in the late 1800s, essentialism was the consistent belief structure of education in the United States (Smith, 2020). Progressivism gathered steam through the 1950s until the space race led to a "back to basics" push in education (Gordon et al., 2019). This traditional theory has remained the guiding force in education until the 21st century, which has experienced another push towards progressivism (Smith, 2020).

The essentialism philosophy is comprised of the idea that schools are responsible for teaching "core knowledge that makes people culturally literate so they can be successful in their vocations and as contributing citizens" (Smith, 2020, p. 200). Emphasis is put on the three Rs: reading, writing, and arithmetic. The instructor is the source of knowledge, and the student has a passive approach to their learning. The traditionalist structure, as described in Table 2, follows behaviorist tendencies, whereas the progressive approach has a constructivist underlining (Gordon et al., 2019). Although still prevalent in traditional schools, charter schools, and homeschooling programs (Smith, 2020), and is commonly known as the simplest philosophy to understand and administer, Gordon et al. (2019) suggests these practices are not recommended in 21st century learning environments.

Progressivism

Within a progressivist's classroom, the discourse between student to student and student to teacher is the essential evaluative tool and the key to pushing learning forward through questioning. As students create their own understanding, it is important that teachers keep their focus on each child's development through differentiated instruction. Education is not a set of specific skills or knowledge that is gained, rather learning is seen as an ongoing process throughout one's life (Gordon et al., 2019). Teachers provide the necessary tools and structure while the students "learn by doing" (Gordon et al., 2019, p. 122). In these ways, a progressive classroom closely resembles a Constructivist framework for learning (Gordon et al., 2019). This research aims to measure mathematical resilience of students in both progressive classrooms which include small group instruction and essentialistic classrooms which focus primarily on direct instruction.

This transition back to progressive classrooms has been difficult because the majority of the current generation of teachers have been taught in essentialistic classrooms. As detailed in Table 2, educators are being asked to go against many of their philosophies absorbed through years of student and teacher experiences. There is a drastic difference in classroom types, which creates difficulty for leadership to establish change (see Table 3).

Table 3

Comparison of Essentialistic and Progressive Classrooms

Characteristic	**Essentialistic Classroom**	**Progressive Classroom**
Who does most of the talking?	The teacher	The students
What is the primary goal?	Procedural skills and memorized facts	Conceptual understanding, critical thinking, and problem-solving skills.
What strategies are used to reach the primary goal?	Memorization, gradual release model (I do, we do, you do)	Discovery and problem-based learning
How is computational fluency taught?	Drill and kill	Number Talks
What does a worksheet look like?	Many problems, Level 1 Depth of Knowledge	Few problems, Level 2 and 3 Depth of Knowledge
How is the classroom arranged?	Desks are in rows facing the teacher	Desks are connected in groups
Teacher acts as:	Source of all knowledge	A facilitator using probing questions to push student thinking

Source: Gordon et al., 2019

This study looks to advance these theoretical frameworks by assessing students' mathematical resilience in relation to their experiences with varied types of instruction. Two factors are measured when considering a student's mathematical resilience: value of mathematics and growth mindset. This study looks to measure these factors within an essentialistic style classroom and a progressive style classroom.

Related Literature

Based upon the theories and philosophies of instructional practices and learning, the following research describes the effects of these theories on the learner. Mathematical resilience is described in detail, which encompasses how a learner values mathematics, views mistakes and struggles, and where they fall on the spectrum of growth and fixed mindset. Math anxiety is also described as a hinderance for developing mathematical resilience. Differentiation is recognized as a key to reaching each student's ZPD, and small group instructional practices an important structure for success.

Mathematical Resilience

The three factors of mathematical resilience, identified as *value, struggle,* and *growth*, have been extensively researched as individual components. Since the seminal work by Johnston-Wilder and Lee (2010), the development of the Mathematical Resilience Scale by Kooken et al. (2016), and the numerous adaptations of the scale, the effects of instructional practices on mathematical resilience have been studied through action research. Resilience can be defined as one's "ability to recover quickly from difficulties" (Xenofontos & Mouroutsou, 2022, p. 1) and "the ability to respond positively in the face of a difficulty" (Gürefe & Akçakın, 2018). Mathematical resilience, a term coined by Johnston-Wilder and Lee (2010), describes a learner's attitude and approach to mathematics when encountered with setbacks and challenges. Student expectations and accountability measures have historically placed a demand on content and instruction with little thought to the feelings and attitudes towards the subject. Things such as skill-based learning, memorization, and high stakes testing have placed pressure on learners and teachers, which Johnston-Wilder and Lee (2010) describe as "a form of cognitive abuse…resulting in anxiety and avoidance patterns, diminishing the desired positive outcome which we have called mathematical resilience" (p. 39). This anxiety towards mathematics, as described in a later section, has demonstrated a negative correlation with mathematical resilience (Lovelace, 2022).

When creating the Mathematical Resilience Scale, Kooken et al. (2016) defined mathematical resilience using three dimensions: growth, value, and struggle. The researchers describe each dimension as the following:

Growth – Aligned with the work of Dweck's Theory of Mindset (2008), growth is a belief that anyone can learn mathematics.

Value – The extent to which mathematics plays a role in attaining future ambitions.

Struggle – Struggle is a normal part of learning and not an indication of failure (Kooken et al., 2016).

Mathematics is an area of particular importance to develop these beliefs because of the negative effect of anxiety in the subject. As mathematical resilience increases, it is natural that mathematics anxiety decreases. Lovelace (2022) edited the Mathematical Resilience Scale by Kooken et al. (2016) to be used to survey high school students and cross-examined the results with a Mathematics Anxiety Scale developed by Betz (1978). Lovelace found a negative correlation with math anxiety and all three subsets of mathematical resilience: value, struggle, and growth.

Every learner, child and adult, will face adversity when developing an understanding of mathematics. Determining a student's level of mathematical resilience can help to predict if the student will respond by functioning at his/her highest level in the face of a challenge or will continue the cycle of increased anxiety and decreased achievement. Research suggests that these affective traits are just as important as cognitive ability when studying achievement in math. Mathematics can be challenging, and researchers recommend resilience be developed in students so they can persevere in complex tasks and situations. The need for resilient students has increased (Gürefe & Akçakın, 2018) as mathematics education has shifted towards a progressive style of teaching, which places more ownership and responsibility on the learner.

As a student approaches a task, self-efficacy has already played a role in the student's persistence and successful completion of the task (Gokhool et at., 2022). Math anxiety is a debilitating disorder in which previously negative experiences with mathematics can create misconceptions about the subject as well as negative emotional responses when engaged in the subject. These emotion-based responses can include self-sabotaging and avoidance behaviors, which affect student performance before beginning a task (Gokhool et al., 2022). In a study of university level students, Gokhool et al. (2022) found a negative correlation between math anxiety and mathematical resilience, although it was a weak correlation of $r = -.221$ and multiple outliers did exist.

As progressivism has reappeared in mathematics classrooms in the 21st century, a massive shift has moved from teacher-centered instruction to student-centered experiences. Boaler (2019) is working to change the role of the student and teacher and, in doing so, is changing the mindset of both children and adults. Boaler (2019) emphasizes that "nobody is born with or without a math brain" (p. 424), the productive struggle is the optimal time for learning, and making connections between visual representations is key to brain growth. This is not only important for students to realize, but some researchers suggest these shifts need to begin with the teacher's personal beliefs (Boaler, 2022). "It is easy (to communicate positive expectations) with students who appear motivated or who seem to learn easily or quickly. But it is even more important to communicate positive beliefs and expectations to students who learn slowly or appear unmotivated" (Boaler, 2022, p. 185).

Boaler (2019) conducted action research during an algebra summer camp for 83 middle school students who were identified by having a negative attitude towards mathematics, and each indicated they did not consider themselves to be a math person. For 18 lessons during the summer camp, the students participated in small group problem-solving lessons which promoted creative and critical thinking. The students showed an average of 50% growth in algebraic understanding based on a pre- and post-test, which Boaler (2019) attributes to an increase in reasoning skills and confidence in mathematics.

Rather than a traditional approach to mathematics, where the answer is the essential piece of mathematics, Boaler (2019) emphasizes problem-solving and critical thinking. Research supports that teachers adopt a growth mindset for themselves and assist in developing it in their students. “For students to see mathematics as a growth subject, they need mathematics questions through which they can grow and give them many ways to be successful” (Boaler, 2019, p. 427). Teachers who show confidence in their own math expertise will breed confidence in their students (Winheller et al., 2013).

Traditional mathematics instruction in an essentialistic classroom has created environments that breed anxiety and stifle resilience (Johnston-Wilder & Lee, 2010). Johnston-Wilder and Lee (2010) identified five traditional practices that continue to hinder a student’s development of mathematical resilience.

Mathematics Connections

Mathematics can be taught with little to no connections to the real world. Therefore, it only exists in the math classroom, which lowers student motivation and the acknowledged value of mathematics (Johnston-Wilder & Lee, 2010). When students are only given inauthentic tasks, the usefulness of mathematics is lost and “many students perceive math as alien, they don’t understand it, and they drop it as soon as possible” (Vos, 2018, p. 2).

The necessary shift in instruction is to provide authentic activities and tasks that students can relate to and make connections to other areas of their academic and social lives. “Realistic tasks can be very effective and motivating. The principles on which they are designed ensure openness in the tasks, and give room to students’ creativity, collaboration, inquiry, and so forth” (Vos, 2018, p. 5). Mathematics becomes centered around reasoning, creativity, and collaboration, and motivation and engagement increase. Math becomes a useful part of the learners’ everyday lives as students consider how real people would carry out real tasks (Davidson & Bragg, 2019; Vos, 2018).

Speed Plays No Role

Although “knowing your facts” can free your working memory to focus on more complex concepts, Johnston-Wilder and Lee suggest that mathematical thinking should take precedent over speed and memory. Students who struggle to calculate quickly are not necessarily lower achievers, though the use of timed calculation assessments can diminish mathematical resilience and build anxiety for a large portion of the student population (Johnston-Wilder & Lee, 2010). Commodari and La Rosa (2021) surveyed 58 teachers in the New York City area on their perceptions of high-ability students. The research conducted a survey and followed up with interviews of three teachers, concluding that computational fluency assessments, particularly for primary students, should not be implemented in a way that puts undue pressure on students, particularly during the initial years of learning mathematics (Commodari & La Rosa, 2021). Their research suggests that timed tests, for example, not only builds anxiety for students who struggle with memorization, they can create tension for all students. “While computational recall is important, it is only part of a comprehensive mathematical background that includes more complex computation, an understanding of mathematical concepts, and the ability to think and reason to solve problems" (Seeley, 2009, p. 93).

Parrish and Dominicks's (2016) work on Number Talks has provided a conceptual framework to develop number sense and fluency while avoiding traditional "drill and kill" and speed-related, anxiety-creating strategies. Number sense cannot be taught, but rather is developed over time. It is the role and responsibility of the instructor to create environments and opportunities which promote flexible thinking, computational accuracy, and efficient and appropriate mental math strategies (Parrish, 2016). Within a Number Talk, both teachers and students "reason about quantitative information, discern whether procedures make sense, check for reasonableness of solutions, and communicate mathematically to others" (Parrish & Dominick, 2016, p. 14-15). Number Talks move beyond basic memorization of facts and allows the time and opportunity for students to make connections between facts while learning new and possible more efficient computation strategies through conversations with their peers (Parrish, 2016).

Productive Struggle is the Key to Learning

When procedural algorithms are the emphasis, a mistake is seen as a failure to correctly follow the rules of the procedure. If the focus of the learning is on "answer getting," mathematics becomes a field of black and white. Mistakes are looked upon as a sign of struggle and incompetence, which signals the need for more repeated practice for memorizing procedures and facts (Johnston-Wilder & Lee, 2010).

When a teacher creates a challenging, student-centered learning environment, struggle becomes a part of the mathematics experience. Russo et al. (2020) suggests, "it is frequently suggested that teachers need to incorporate more cognitively demanding mathematical tasks into their lessons and employ problem-based approaches to learning where students are afforded opportunities to explore concepts prior to any teacher instruction" (p. 1). This is a reverse of the gradual release model, commonly known as the "I do, we do, you do" approach. By beginning with the "you do", students are encouraged to explore, and mistakes become a part of a daily math lesson and the culture of the classroom (Russo et al., 2020).

Productive struggle does require a shift in teaching philosophies and can feel counterproductive to traditional teachers. Russo et al. (2020) found that 69 of the 98 kindergarten through 3rd grade teachers that participated in the study held positive beliefs about the value of productive struggle. However, the researchers found a disconnect in holding positive beliefs and providing experiences for students to struggle. Teachers shared that students' mindset, time, classroom culture, and space as blockers in providing these meaningful experiences. Teachers also noted that struggle can mean something very different for a high achieving student compared to a low-performing student (Russo et al., 2020). In a study by Lee and Ward-Penny (2022) of 12 teachers' responses to developing mathematical resilience, teachers reported the belief in the importance of struggle, but only two teachers implemented strategies to create a culture where mistakes were a part of learning. Research concludes that the teachers are accepting of the change in philosophy but lack the appropriate training to implement the approach in their classrooms (Russo et al., 2020).

When considering productive struggle, it is also worth again noting the work of Vygotsky and the ZPD. When asking students to persevere, it is a necessity to choose tasks which fit the Goldilocks principle for each student. The task need not be too easy or too complex based on the student's level of understanding. Research recommends that each task be within the ZPD, meaning students can achieve the task through struggle and may need support from a peer or teacher (Vygotsky, 1978).

Flexible Thinking

The “one right way” approach to solving problems discourages flexible thinking and decreases the likelihood that students will make connections to other mathematical concepts, other disciplines, and the real world. This creates a reliance on the teacher and a feeling of helplessness within the students. The learners are not required to think about mathematical ideas, but rather simply perform procedures to arrive at a result with little understanding of the why or how (Johnston-Wilder & Lee, 2010).

Simanjuntak et al. (2018) conducted a study comparing instructional strategies and how they related to mathematical resilience and problem-solving ability. Simanjuntak et al. (2018) concluded that guided discovery learning is substantially more effective in increasing problem-solving ability over a direct learning model. In both cases, small group learning has shown better results than a traditional setting where the teacher does most of the speaking.

Memorization Does Not Equal Understanding

In a traditional, essentialistic classroom, the students who are strong memorizers are typically the top achievers. This prioritization on memorized facts and procedures is the product of the philosophical belief that mathematics is focused on answer getting. When the emphasis is placed on memorization, critical thinking and problem-solving skills are not developed appropriately. Students are taught *what* to think instead of *how* to think (Johnston-Wilder & Lee, 2010).

Research by Pieronkiewicz and Szczygiel (2020) stresses the importance of developing communication skills in early childhood education through high quality math talks facilitated by teachers in classroom settings and parents at home. Parents are encouraged to read to children every night, but little emphasis is placed on discussing mathematics in their daily lives. “It is too easy to underestimate the beauty of mathematics hidden in simple, daily life moments. We would like to encourage parents to become sensitive to those moments when their children reveal glimpses of mathematical potential (Pieronkiewicz & Szczygiel, 2020, p. 1610-1611). By teachers planning mathematics instruction that creates mathematical discourse between teacher and student and student to student, mathematics becomes an interactive process which students can explore and develop conceptual understanding of content. Learning becomes a collaborative effort as students work together to problem solve and develop mathematical resilience (Pieronkiewicz & Szczygiel, 2020).

Research conducted by Sun (2018) emphasizes the critical role of teaching mathematics in a way that promotes a growth mindset. By creating a classroom environment that emphasizes effort, perseverance, and the value of making mistakes, teachers can help students develop a positive attitude towards learning and a willingness to take on challenges. Sun (2018) suggests that teachers can achieve this by providing students with opportunities to work collaboratively, offering feedback that focuses on effort rather than outcome, and modeling a growth mindset themselves. Ultimately, the goal is to help students see themselves as capable of growing and learning, rather than being limited by fixed abilities (Sun, 2018).

Math Anxiety

Anxiety surrounding mathematics has consistently been found to affect academic performance negatively. Recent research has also found that math anxiety negatively correlates with a student’s mathematical resilience (Lovelace, 2022). Math anxiety is a state of fear and apprehension that a learner may have when approaching mathematical tasks (Zhang et al., 2019).

Math anxiety levels vary and can vary based on gender, grade level, and geographical region. The negative link between math anxiety and math performance is most troublesome when assessing problem-solving skills, which requires confidence to take risks and perseverance to be wrong but willing to try again (Zhang et al., 2019).

A meta-analysis by Barroso et al. (2021) examined the relationship between math anxiety and math achievement. The results indicate a statistically significant negative correlation between the two variables. Specifically, individuals who experience higher levels of math anxiety tend to perform worse in math. The study further revealed that math anxiety has a more substantial adverse effect on performance in arithmetic and algebra, as opposed to geometry and calculus. The meta-analysis also found that interventions to reduce math anxiety can improve math achievement. These findings have important implications for educators and policymakers in addressing math anxiety in students and enhancing math education.

A meta-analysis by Zhang et al. (2019) also investigated the relationship between math anxiety and math performance. They found that math anxiety has a moderate negative correlation with math performance, meaning that as math anxiety increases, math performance decreases. Additionally, the study suggests that interventions aimed at reducing math anxiety may improve math performance. Their findings highlight the importance of addressing math anxiety to improve math education outcomes.

Math anxiety has been found to have a negative association with addition and subtraction fluency skills in early elementary students in a study by Commodari and La Rosa (2021). This study concluded that general math anxiety has a negative effect on written calculations. Specific to math test anxiety, anxiety was shown to be negatively correlated with mental math computation, including number sense and calculation accuracy. In both instances, it is recommended to reduce the stress and tension created by pressures of achievement, especially during a student's early years in education (Commodari & La Rosa, 2021). This early stress creates an ever-growing cycle of increased anxiety and decreased levels of achievement. Ensuring success in mathematics at a young age is necessary in developing a growth mindset, confidence, and motivation (Gunderson et al., 2018).

Student Motivation

Motivation is a fundamental aspect of learning and academic achievement. Understanding the factors influencing student motivation is essential for educators to create supportive learning environments primed for student success. Motivational climate theory provides a framework for understanding how classroom environments influence student motivation and engagement. Ames (1992) conceptualized classrooms as dynamic social systems characterized by distinct motivational climates, including mastery-oriented and performance-oriented climates. Mastery-oriented climates emphasize learning goals, effort, and improvement, fostering intrinsic motivation and a focus on mastery. In contrast, performance-oriented climates prioritize normative comparisons, rewards, and competition, leading to extrinsic motivation and a focus on demonstrating ability relative to others.

Schools serve as critical developmental contexts that shape students' academic motivation and psychological adjustment (Eccles & Roeser, 2011; Roeser & Eccles, 1998). Adolescents' perceptions of their school environments, including the presence of supportive teachers and challenging academic tasks, influence their motivation and engagement in learning activities. Understanding the developmental dynamics of motivation within school contexts is essential for promoting positive academic outcomes and well-being among students.

Individual differences are crucial in shaping students' academic motivation and achievement orientations (Nicholls, 1989; Nicholls et al., 1985). Students' perceptions of their abilities, goals, beliefs, and values influence their motivation to engage in learning tasks and pursue academic goals. Exploring the interplay between individual differences and motivational processes can provide valuable insights into the complexity of student motivation and inform targeted interventions to support diverse learners.

Research on student motivation based on race suggests complex dynamics influenced by various factors. Harackiewicz et al. (2019) highlight how stereotypes and societal expectations can impact students' motivation from minority racial groups. For instance, African American and Latinx students may face stereotype threat and academic disengagement due to cultural mismatches in educational settings (Harackiewicz et al., 2019; Steele, 1997). Additionally, studies by Destin et al. (2019) emphasize the importance of promoting a sense of belonging and cultural identity in educational environments to enhance motivation among racially diverse students. As Yeager et al. (2021) suggested, culturally responsive teaching practices play a crucial role in fostering intrinsic motivation and academic engagement among students from different racial backgrounds. Similarly, Oyserman and Destin (2010) discuss identity-based motivation and its implications for intervention, providing insights into how cultural identities shape motivation and academic outcomes.

Furthermore, research indicates that interventions aimed at closing achievement gaps can positively impact student motivation. Harackiewicz et al. (2019) suggest that utility-value interventions, emphasizing the relevance and importance of academic tasks, can effectively address achievement gaps among students from diverse racial backgrounds. By disentangling the effects of race and social class, these interventions enhance motivation and academic success for all students (Harackiewicz et al., 2019; Yeager et al., 2021). Additionally, fostering a growth mindset, as proposed by Yeager et al. (2021), can lead to improved achievement outcomes among racially diverse student populations. Creating a supportive and inclusive learning environment where all students feel valued and capable of success is essential for promoting motivation and closing racial achievement gaps.

Teachers play a pivotal role in shaping the motivational climate of their classrooms through their instructional practices, communication styles, and feedback mechanisms (Patrick et al., 2009; Skinner & Belmont, 1993). Effective communication of goal orientations, provision of autonomy-supportive environments, and promotion of intrinsic goal contents are associated with positive motivational outcomes among students (Reeve, 2012; Vansteenkiste et al., 2006). Examining the reciprocal effects of teacher behavior and student engagement is essential for understanding the mechanisms through which motivational climates influence learning outcomes.

Recent research has extended motivational climate theory to encompass broader conceptualizations of classroom motivational support, climate, and microclimates (Robinson, 2023). By disentangling these components, researchers aim to elucidate the complex interactions between teacher practices, classroom environments, and student motivation. Integrating insights from motivational climate theory with contemporary frameworks, such as self-determination theory (Ryan & Deci, 2020), provides a holistic understanding of motivational processes in educational settings.

Motivational climate theory offers valuable insights into the varied nature of student motivation and its determinants within educational contexts. Future research should continue to explore the nuanced relationships between motivational climate components and their implications for promoting student engagement and academic achievement.

Growth Mindset in Mathematics

Displaying and practicing a growth mindset is one of the pillars of developing mathematical resilience. The belief that some learners have a math mind and others do not has contributed to a lack of confidence and an unwillingness to take risks. Dweck (2008) believes lacking basic proficiency skills in mathematics is socially acceptable in the United States, which further perpetuates the assumption that your ability in mathematics is passed down from your parents. “The fixed mindset limits achievement. It fills people’s minds with interfering thoughts, it makes an effort disagreeable, and it leads to inferior learning strategies” (Dweck, 2008, p. 67). Boaler (2022) goes as far to label experiences as traumatic events that are caused by anxiety, negative beliefs about the subject, and a fixed mindset.

Not only has research supported a positive correlation between growth mindset and achievement in mathematics (Zhang et al., 2019), it has also been shown as a predictor for future career aspirations in Science, Technology, Engineering, and Mathematics (STEM) fields. Mindset has been shown to have a greater effect on females, who have historically been less likely to pursue fields in STEM than male counterparts. Seo et al. (2019) measured math mindsets of 10th grade students and the likelihood that students with a growth mindset pursue a STEM related field. They found that White, Latina, and Black females with a math growth mindset were more likely to pursue STEM careers than their male counterparts. According to research by Degol et al. (2018), targeting women’s motivation and mindset in the field of mathematics has shown success in decreasing the gender gap within STEM university majors and careers.

Macnamara and Burgoyne (2023) delve into the topic of growth mindset interventions and their effectiveness in improving students' academic achievement. The authors conducted a thorough review of numerous studies on the subject matter and determined that the interventions, including videos, interactive activities, and teacher feedback, do indeed have a positive impact on academic performance. However, the authors emphasize the critical role of proper implementation, which includes providing clear guidance and support to both students and teachers. The article ultimately recommends that growth mindset interventions be integrated into a comprehensive educational program that highlights the significance of effort, perseverance, and resilience.

Binning et al. (2019) examined whether the message of persistence mindset is effective for all students or only some groups. They found that students who have a growth mindset and who perceive themselves as academically competent are more likely to benefit from the persistence mindset message. Additionally, female students seem to benefit more from the message than male students. Overall, the findings suggest that the persistence mindset message can be a useful tool to help adolescents overcome academic struggles, but its effectiveness may vary depending on students' individual characteristics.

In the study conducted by Seo et al. (2019), the beliefs of adolescents about their math abilities were examined in relation to their attainment of STEM careers, considering both gender and race/ethnicity. The results showed that there were statistically significant differences in math ability beliefs across gender and race/ethnicity, with boys and Asian American students having higher beliefs about their math ability. These beliefs were also found to be predictive of future STEM career attainment, highlighting the importance of addressing and challenging gender and racial/ethnic stereotypes in math education. "Female adolescents' math self-concept was more negative than male adolescents among Whites and Latinxs but not among Blacks and Asians" (Seo et al., 2019, p. 306).

Boaler (2022) targets introduction to procedural knowledge (algorithms, memorization, etc.) at an early age as a root issue for creating fixed mindsets in mathematics in the United States. A very common, simple phrase, such as "carrying the 1," does not describe the actual mathematics occurring when performing addition. Using abstract procedures early in math development leads students to believe that they have little understanding, but that it must make sense to everyone else.

By shifting early childhood and elementary mathematics on "conceptual, investigative mathematics teaching and mindset encouragement, students learn to shed harmful ideas that math is about speed and memory, and that they either get it or they don't" (Boaler, 2022, p. 57). Through games, reflection, and rich mathematical tasks, teachers can develop the 5 Cs of mathematics engagement: *curiosity*, *connection making*, *challenge*, *creativity*, all through *collaboration* (Boaler, 2022). Teachers can create a culture of growth mathematical mindsets by developing positive classroom norms (see Table 4) (Boaler, 2022, p. 289).

Table 4

Positive Norms to Encourage in Math Class

1. Everyone can learn math to the highest levels.
2. Mistakes are valuable.
3. Questions are really important.
4. Math is about creativity and making sense.
5. Math is about connections and communicating.
6. Depth is much more important than speed.
7. Math class is about learning, not performing.

Note. Adapted from *Mathematical Mindsets: Unleashing Students' Potential Through Creative Mathematics, Inspiring Messages and Innovating Teaching,* by J. Boaler, 2022, p. 289. Copyright 2022 by J. Boaler.

Not only can a student's anxiety hinder their performance, but parents' feelings towards the subject also play an important role in a student's feelings towards mathematics and, therefore, their achievement. Most adults in the United States experienced an essentialistic style learning environment in a mathematics classroom, relying heavily on memorization of facts and procedures and very little focus on problem-solving or critical thinking skills (Gordon et al., 2019). A study conducted by Maloney et al. (2015) focused on the intergenerational effects of parents' math anxiety on their children's math achievement and anxiety. The researchers found that parents with high levels of math anxiety tend to have children who also experience higher levels of math anxiety and lower math achievement. This suggests that parents' attitudes and beliefs about math can greatly impact their children's academic performance and attitudes towards the subject. The study highlights the importance of addressing parents' math anxiety and providing support for both parents and children to improve math skills and reduce anxiety.

Mathematics content also plays a role in the mindset of a child and an adult. Many adults have expressed confidence in mathematics when working with whole numbers but recall the anxiety and lowered performance in later elementary when working with fractions (Sidney et al., 2021). Just as early elementary teachers work slowly to develop a child's number sense, research supports that the same be done when beginning work on the unit fraction in 3rd grade. A study by Sidney et al. (2021) concluded that attitudes towards fractions was lower than whole numbers in both adults and children. The diminished value and negative attitude developed towards fractions have created fixed mindsets in many adults, which many parents pass on to their children.

A study by Wu et al. (2022) concluded, "Math homework may be a less constructive context as parents are generally less positive and more negative in the math homework context" (p. 1362). Parents and guardians pass their beliefs onto their children, and math anxiety and a negative demeanor toward the subject are no exception (Wu et al., 2022). Although parental involvement is a crucial factor in student success in education (Gordon et al., 2019), parental support in mathematics may have the opposite of the intended effect (Wu et al., 2022).

Zone of Proximal Development

Although Lev Vygotsky's work did not center around education, researchers have continued his research on the need for collaboration to maximize learning. The sociocultural theory emphasizes three factors in the pursuit of human development: socialization, cultural background, and individual characteristics. When studying Vygotsky's work with an educational lens, most attention has been on the social aspect of learning (see Figure 2) (Schunk, 2020).

Figure 2

3 Zones of Student Expectations

Note: Adapted from Vygotsky (1978)

A key contribution to educational philosophy guiding today's mathematics instruction, specifically from Vygotsky, is the ZPD. By analyzing the expectations and complexity of work given to students, the instructor can place the work within 3 zones, which is dependent on the learner. The first zone is work students can complete independently with little assistance. This would be considered reinforcement of previously learned skills or knowledge within a mathematics classroom. The student can complete the second zone with support from an adult facilitator or a more knowledgeable peer. This level of complexity is known as the ZPD, where new learning occurs. This creates the necessity for social interaction in human development. The third zone is tasks that cannot be completed successfully, even with support, which is recommended to be avoided within all content areas (Vygotsky, 1978). When students are engaged within their ZPD, math anxiety is lowered as students experience success with appropriate questioning and scaffolding. Students are more likely to experience a feeling of success, the infamous "aha moments" many teachers live for. Meeting the needs of all learners by facilitating tasks within every student's ZPD requires differentiated instruction, which is described later in this literature review.

Educational philosophers have developed applications of Vygotsky's work, which has increased the sociocultural theories meaning and reach. One such term is scaffolding, the support given when a task is within the learner's ZPD. Whether an instructional tool or guidance, this support is only temporary until the student can complete the task independently. Reciprocal teaching and peer collaboration also apply the sociocultural theory, which describes student-to-student interactions. Students work within small groups to assist each other in reaching and becoming successful in each child's ZPD through discussion and, at times, acting as the instructor (Schunk, 2020).

Constructivism in Mathematics

The shift in mathematics instruction has brought the students to the center of the classroom rather than the teacher, which is aligned with suggestions for building students' growth mindset (Boaler, 2022). The role of the teacher is changing from the distributor of knowledge to the facilitator of rich mathematical tasks. In recent years, the pendulum has swung once again, creating a renewed emphasis on constructivist learning theories. For constructivist teaching philosophies to be successful in the classroom, the students must be active participants in the learning process as they develop their understanding with the assistance of a facilitator. Traditional approaches to instruction in mathematics, such as direct instruction and memorization, have been successful for many students. However, constructivist strategies, such as problem-based learning and exploration, have been supported by research to reach culturally diverse student populations with various learning styles and abilities (Wachira & Mburu, 2019).

The theory of Constructivism in Mathematics, as expounded by Mallamaci (2018), is based on the notion that acquiring knowledge is an active process where learners construct their own understanding of concepts based on their experiences and interactions with the world around them. This approach to mathematics education has been demonstrated to be highly effective in promoting deeper comprehension and long-term retention of mathematical concepts. Mallamaci (2018) also describes the pivotal role of providing students with opportunities to engage in meaningful and authentic mathematical tasks while creating a supportive and collaborative learning environment. Mathematics is not a set of steps to follow to achieve a correct answer. Mathematics is problem-solving, critical thinking, and exploring new situations that build upon previous knowledge. Teachers act as facilitators in a constructivist classroom, allowing students' natural curiosity to lead them to understand through exploration (Wachira & Mburu, 2019).

Differentiation

Learners walk into a classroom with different experiences and varied levels of ability and mathematical resilience. Reaching students where they are in their abilities and knowledge creates the need for teachers to adapt given tasks through support and scaffolding. Differentiating instruction can include manipulating factors during instruction to meet the needs of all learners. These factors include content, rate/pace, learning preference or style, and environment (Johnsen et al., 2020), which includes small group learning structures. Research by Linder et al. (2021) showed that differentiation strategies are most present in special education classrooms, and the least amount of differentiated instruction takes place in the regular classroom. Differentiated instruction does not refer to ability grouping, where students are placed in static groups and have little chance to move between groups. Differentiation is adapting lessons and activities to reach each student within their ZPD (Barrett-Zahn, 2019).

Addressing the needs of high-ability students in inclusive math classrooms is a critical challenge facing educators. Freedberg et al. (2019) conducted a study aimed at exploring effective strategies teachers can use to challenge these students while also supporting their learning needs. Through their research, they identified several successful approaches, including personalized instruction and differentiation, collaboration with other educators, and the use of open-ended tasks and projects. The study also emphasized the importance of providing teachers with adequate training and professional development to support them in meeting the diverse needs of their students. These findings offer valuable insights for educators who aim to create inclusive classrooms that cater to the needs of all learners.

There are multiple obstacles, particularly for self-contained elementary teachers, making it challenging to provide differentiated instruction for all students. Some teachers indicate little to no support from purchased curriculums when highly structured, and sequenced resources offer little flexibility for individual student needs. Increasing class sizes create a greater need for classroom management which can take away from time spent on objectives for learning (Betts & Shkolnik, 1999). When providing lessons to large groups of students, teachers struggle to differentiate instruction to meet the needs of an increasingly diverse population of cultures and achievement levels. When teachers are responsible for multiple subjects, planning for all content areas is time-consuming, and asking each learner to differentiate each lesson can become unattainable (Johnsen et al., 2020).

Tarng et al. (2022) define attention as “the ability that an individual can concentrate and persist in a particular activity” (p. 1). Attention has historically been a concern for teachers and parents alike. A student's attention span can affect motivation, engagement, and effectiveness of instruction and learning (Tarng et al., 2022). Poor attention span can lead to behavior struggles, including withdrawing and aggressive/disruptive responses. Academic success is also hindered, as researchers have linked attention to reading achievement along with other indicators for later success (Su & Swank, 2018).

Although attention is affected by many contributors in a student's life, attention-deficit/hyperactivity disorder (ADHD) is a medically diagnosed disability which can cause a child to daydream, fidget, and talk too much. All children experience symptoms of ADHD, but children diagnosed simply do not grow out of these behaviors. Using data from 2016-2019, the Center of Disease Control (CDC) 2.4 million children from the ages of 6-11 have been diagnosed with ADHD, which is approximately 10% of students (Center for Disease Control and Prevention, 2022). Based on this data, in a 5th grade classroom of 30 students, on average, 3 students have a medical diagnosis with a disorder causing serious struggles to focus.

The need for focus and attention in the classroom is clear (Su & Swank, 2018; Tarng et al., 2022), and diagnosed medical conditions of ADHD have continually increased (Center for Disease Control and Prevention, 2022), administrators, teachers, and parents have searched and experimented for the most effective teaching strategies to hold a child's attention for as long as possible. Some of these strategies include real world tasks, adjusting the classroom structure and environment, student engagement routines, ignoring disruptive behaviors or giving extra time and attention to those in need (Tegtmejer, 2019). These strategies acknowledge that most upper elementary students can stay focused on a given task for less than 30 minutes, although the data on the exact number of minutes is varied. Executive functions increase in students from ages 7-9 when provided some type of brain break either between activities or during an extended task.

Research has provided evidence of the effectiveness of short bursts of instruction with periodic breaks of physical activity and movement over requiring children to hold long spells of focus (Egger et al., 2019).

Research supports pairing and small-group learning to be a successful instructional strategy for providing constructivist tasks in a sociocultural theory-focused environment (Utaminingtyas et al., 2017). Engaging with peers to apply learning within new contexts is an effective strategy for on- and above-level students, but research also supports heterogeneous groupings that offer peer support for struggling students (Utaminingtyas et al., 2017). Research also supported small-group learning's positive effect on transferring knowledge to new situations, which is one of the established objectives of a 2^{1s}t-century mathematics classroom. Pai et al. (2015) conducted a meta-analysis on 24 existing studies focused on the effects of small group learning on transfer. This research found that on average, students working in groups outperformed those working individually by almost one-third of a standard deviation. Whole group instruction creates an individualistic learning environment, and research supports that small group learning has more positive outcomes (Pai et al., 2015).

There are multiple approaches to teaching core learning within small groups. Guided Math is an instructional framework which includes a whole class warm-up, a short whole class mini lesson when necessary, and small group lessons delivered to flexible, heterogenous groups. While the teacher is working within a small group, the other students work independently, in pairs, or small groups on differentiated tasks specific to the needs of each student (Sammons, 2019). A workshop model works as a center rotation, where students spend a certain amount of time at each center, one of which is the "teacher group." Although the heterogenous groups are not flexible daily, the objective of meeting with small groups to facilitate core instruction is still met (O'Connor et al., 2021).

Small group instruction does create a heightened demand on the teacher, which in many post-pandemic environments could be considered too much for an elementary teacher to attempt (Sammons, 2019). Most elementary teachers are responsible for multiple subjects, which increases the time requirements for planning. Planning small group instruction can take longer than planning one lesson at one instructional level delivered to the whole group, especially when first attempting the transition from whole group learning but is even more important when developing a small group environment (Davidson & Bragg, 2019). Elementary teachers are recognized as specialists in all content areas, and that is especially true when delivering small group math instruction. It benefits student learning when teachers know the progression of understanding within each concept to be able to address specific student needs as they arise. This in no way implies that elementary teachers are not experts in mathematics, but rather states that the demand for that knowledge is heightened when implementing small group instruction. Moving away from a simple whole group structure also increases the necessity of expert classroom management. Although teachers may acknowledge small group instruction during core is best for students, many can find these extended requirements prove to be too much to accomplish (Sammons, 2019).

Studies have concluded a positive correlation between small group learning during mathematics intervention and motivation (Codding et al., 2020). Research supports small group learning in dampening the effect of complex mathematical tasks on children's motivation and confidence (Baten et al., 2020). However, a gap in research exists on small group learning during the core mathematics block and its effect on a child's mathematical resilience. Xenofontos and

Mouroutsou (2022) completed a systematic review of the research conducted since Johnston-Wilder and Lee's (2010) article describing mathematical resilience as understanding, building confidence that a student can understand, and is able to learn new mathematics. Xenofontos and Mouroutsou (2022) indicated four categories which research on mathematical resilience has focused on:

1. "The characteristics of mathematical resilient individuals.
2. The processes through which psychological and/or social/environmental factors facilitate or prohibit the development of mathematical resilience.
3. The implementation of interventions to help learners expand their mathematical resilience capacities.
4. The psychological components of mathematical resilience" (Xenofontos & Mouroutsou, 2022, p. 9).

The effect of problem-based learning on mathematical resilience has been studied to varying degrees of success, as research in this chapter has demonstrated. However, a gap in the literature exists when considering the structure and grouping of the core mathematics block and its effect on mathematical resilience in upper elementary students.

Whole group instruction in elementary mathematics is often linked to essentialistic teaching strategies. A traditional, high school classroom may come to mind, which the teacher talks, and the students listen. The teacher presents knowledge or procedural steps, and it is up to the students to absorb the information for learning to take place. The strongest memorizers are the strongest math students, and conceptual understanding of content is a happy, but unintended coincidence (Sammons, 2019).

There are benefits to this teacher-centered approach to learning, some of which creates its necessity. As described in the previous section, consistent use of small group instruction requires planning, structure, and classroom management. Whole group instruction eases part of the burden on teachers by only requiring planning for one lesson at one instructional level, a consistent structure of the classroom and core math block, and direct instruction from the teacher to every student, which simplifies classroom management. There are also benefits to creating a classroom community, as all students share common experiences. The cyclical nature of education, and the ebbs and flows of what is considered to be best instructional practices, creates hesitation within teachers to make a change. It is not the fault of a teacher to rely on the ease of whole group instruction, which has been labeled as best practice in the past and is most common in teachers' own experiences as learners. However, with the heightened demands of differentiated instruction in 21st century classrooms, which the learning gap continues to increase, Sammons (2019) suggests that teachers are encouraged to limit the amount of time spent facilitating whole group learning.

Summary

Resilience, self-awareness, self-confidence, and mindset each play a key role in increasing growth and maximizing performance in mathematics. External factors for learning include the environment, the task, and the instructional strategies implemented by a teacher. The Common Core State Standards for Mathematics (CCSM) were written with a constructivist backdrop (LaVenia et al., 2015; McDonnell & Weatherford, 2013). At the same time, many of the instructional strategies found to be most successful have been within the sociocultural learning theory (Vygotsky, 1978). This differentiated instruction can be cumbersome and overwhelming, especially for elementary teachers who teach multiple subjects (Johnsen et al., 2020).

Mathematical resilience has numerous definitions (Xenofontos & Mouroutsou, 2022), although Johnston-Wilder and Lee (2010) described it simply as “the capacity to transcend adversity” (p. 38). Growth, value, and productive struggle are all key characteristics in ensuring student success in mathematics (Johnston-Wilder & Lee, 2010;). The research on mathematical resilience has been varied since the Johnston-Wilder and Lee (2010) was published. More studies need to be conducted to continue the exploration of feelings and attitudes towards mathematics, the causes of those feelings and attitudes, and how instructors, parents, and students can improve mathematical resilience (Xenofontos & Mouroutsou, 2022).

Small group structures for learning are often the primary instructional technique for interventions when only a select group of students require tasks or instruction. Students benefit from the smaller environment because of the closer attention and immediate feedback the teacher can provide each student. Elementary students have a shorter attention span than adults, and these faster, targeted instruction blocks have been successful in closing learning gaps (Utaminingtyas et al., 2017). Students also feel more comfortable taking chances within the small group, which means a growth in confidence and mindset (Codding e al., 2020). This research aims to close a gap in the research that exists on the effects of small group instruction on how students value mathematics and the importance of struggle to build a growth mindset.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative, quasi-experimental study is to determine the effect of small group learning during the core mathematics block on 5th grade students' mathematical resilience in comparison to a control group. Mathematical resilience is measured as two factors: value of mathematics and growth theory of learning. A nonequivalent control-group design will be used to address the research question and null hypothesis. The chapter begins by introducing the study's design, including complete definitions of all variables. The research questions and null hypotheses follow. The participants and setting, instrumentation, procedures, and data analysis plans are presented.

Design

A quasi-experimental nonequivalent control-group design was used to analyze students' mathematical resilience of two samples after experiencing two distinct types of instruction in their core mathematics block. Quasi-experimental designs are utilized when random assignment of participants is not possible (Gall et al., 2007). Students did not change schools or classrooms for the purpose of this study. The researcher identified teachers who primarily use whole group instruction during the core mathematics block and those that emphasize small group instruction during a large portion of the core block. The difference in these instructional strategies is the independent variable. Teachers are identified through instructional strategy screening instruments. The researcher utilized the control-group design by using a pre-test as a covariance and a post-test as the dependent variable (Gall et al., 2007). Although students have experienced multiple teachers utilizing many different instructional strategies during their elementary years leading up to this study, the pretest limits the statistical differences between the sample groups before students experience a specific type of instruction.

Utilizing a static-group design is a limitation because “differences between groups can be attributed to characteristics of the groups other than the experimental conditions to which they were assigned” (Gall et al., 2007, p. 416). The researcher limited variables of student experiences as identified below in the Procedures section. However, it is acknowledged that not all variables can be controlled within this design model. Students are placed in a classroom, which is not in the control of the researcher. A pre-test acted as a covariate to increase the power of the study. Although small interventions were recommended by the researcher to the teachers that utilize small group instruction, the study is designed to identify teachers who already practice the requirements for students to qualify for both sample groups.

Research Question(s)

RQ1: Is there a difference in how 5th grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

RQ2: Is there a difference in 5th grade students’ growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

Hypothesis(es)

$H_0$1: There is no difference in how 5th grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score as measured by the Upper Elementary Mathematics Resilience Scale?

H_02: There is no difference in 5th grade students' growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score as measured by the Upper Elementary Mathematics Resilience Scale?

Participants and Setting

The independent variable for this study is the primary type of instruction students receive during the core mathematics block of learning. This section will provide information on the selected participants for the study. It will also describe the district and elementary school where the study took place.

Population

The population selected for this study are 4th and 5th grade students in the United States. The Upper Elementary Mathematics Resilience Scale was validated in English only (Kooken & Costelnock, 2023), therefore only students who can read English are eligible for this study. A student who receives exceptional student services, such as special education, are eligible if the student can independently read and respond to the survey items.

Participants

Students from School GWP were selected using a convenience sample, as the researcher previously worked 's the site's elementary mathematics specialist. School GWP is a Title I school with a 40% population of students on free/reduced lunch status. The population ranges from low-income transitional housing to upper middle class and is predominately white, though it is more diverse than schools in the surrounding area. The largest demographic groups included white (47%), Hispanic (30%), black (9%), and two or more races (8%). The student body consists of 47% females and 53% males. School GWP's state test scores in math, English, and science are typically around the state average (Great Schools, n.d.).

The school has a full-time math specialist who focuses on coaching core instruction and supporting students within an intervention period. Through discussions with the current math specialist, and by confirmation using the Instructional Strategy Screener and Interview, two 5th grade classrooms were selected for the study. The four 5th grade sections are split into dyads. One instructor teaches math and science, and the students switch classrooms for English Language Arts and social studies. In 5th grade at School GWP, 55 students have Teacher WG for a 60-minute core math period, and 55 students have Teacher SG. The 110 participants are well above the 66 students required for a one-way ANCOVA with two groups when assuming a medium effect size with statistical power of .8 at the .05 alpha level (Gall et al., 2007). All 110 students attend School GWP for onsite instruction. Four questions on demographics were also used at the conclusion of the Upper Elementary Mathematical Resilience Scale (see Table 5).

Table 5

Participant Demographics

Demographic Characteristic	*n*	%
Gender		
Male	48	57.1%
Female	35	41.7%
Choose not to answer	1	1.2%
Race		
Indian or Alaskan Native	2	2.4%
Asian	2	2.4%
Black or African American	9	10.7%
Native Hawaiian or other Pacific Islander	1	1.2%
White	26	31.0%
Multiple Races	27	32.1%
Not sure	17	20.2%
Hispanic		
Yes	19	22.6%
No	39	46.4%
Not Sure	26	31.0%

Setting

Site approval was gained from an A-rated school district (Arizona State Board of Education, 2022) located in an east valley suburb of Phoenix, Arizona, during the 2023-2024 school year. The unified school district consists of 9 elementary schools, 2 middle schools, 2 high schools, and a virtual academy. The school selected to conduct the study is a Title I elementary school with a B rating from the state of Arizona.

Instrumentation

The following section describes the primary instrument used in the study. Once informal survey tools were used to establish groups, the Upper Elementary Mathematical Resilience Scale (Kooken & Costelnock, 2023) assessed students' mathematical resilience in both sample groups.

This scale is used as a pre-assessment during the 2023/2024 school year and as a post-assessment five weeks later.

The first published Mathematics Resilience Scale (Kooken et al., 2016) was written to evaluate university-level students' attitudes toward mathematics. The scale consists of three correlated factors: Value, Struggle, and Growth. The scale is used to measure the likelihood of persistence in mathematics and the level of participation. Lovelace (2022) adapted and validated the scale for high school-level students, focusing on the connection between mathematical resilience and math anxiety. The original scale by Kooken et al. (2016) has been adapted and utilized worldwide, including validation studies in Nigeria (Awofala, 2021) and Turkey (Gürefe & Akçakın, 2018).

The Upper Elementary Mathematical Resilience Scale (Kooken & Costelnock, 2023) is an adaptation of the Mathematical Resilience Scale (Kooken et al., 2016), developed for 4th and 5th grade students. The twenty-six items used a seven-point Likert scale (1 = *completely disagree* to 7 = *completely agree*). Six of the twenty-six items use reverse scoring. The scale was then studied for use with upper elementary school students. Using results from 168 4th and 5th grade students, Kooken and Costelnock (2023) tested the original construct definitions and found the original three factor model did not fit data from elementary students. A variety of models were reviewed concluding with a two-factor model with 16 questions to create the Upper Elementary Mathematics Resilience Scale (see Appendix A). The original construct of value showed strong internal consistency reliability with Coefficient alpha .848. However, 4th and 5th grade students were not able to differentiate between items in the original struggle scale and the original growth scale. When combined, these two scales showed strong psychometric properties including coefficient alpha = .728 This final model consisting of 16 items on two factors, 8 questions for each factor, fit the data and was recommended for use with a 5^{th} grade population.

The value of mathematics is measure based on classroom experiences and beyond. Value is defined as the extent to which mathematics plays a role in attaining future ambitions (Kooken et al., 2016). An example statement from the Upper Elementary Mathematics Resilience Scale is *Math is important for my future.* A student that agrees with the statement recognizes the value of mathematics in their everyday lives and the role it will play in their future. A student who does not agree with the statement looks at math as an in-school subject only that will play little to no role in their lives. Growth mindset represents students' attitude towards struggling and making mistakes as an integral part of growth in mathematics. A growth mindset is defined as the belief that natural abilities can be improved upon through effort. (Dweck, 2008). An example statement from the Upper Elementary Mathematics Resilience Scale is *Everyone struggles with math at some point.* A student who agrees with this statement recognizes that there are not "math and non-math people," and that everyone has needed to persevere while learning mathematics. A student who does not agree with this statement believes that their math ability is pre-determined and unchangeable. A few of the items in the scale use reverse scoring, such as *Only smart people can do math.*

Scoring consists of the researcher calculating the mean score for each subscale. Each subscale has a total of 8 questions. The instrument used a seven-point Likert scaled that ranged from Completely Agree to Completely Disagree. Responses were as follows: Strongly Agree = 7, Mostly Agree = 6, Kind of Agree = 5, Neither Agree or Disagree = 4, Kind of Disagree = 3, Mostly Disagree = 2, and Completely Disagree = 1. For the validation of the Upper Elementary Scale by Kooken and Costelnock (2023), the average for the subscale value of mathematics was

5.29 with a standard deviation of 1.03. For the growth mindset subscale, the average was 5.98 with a standard deviation of .82. The prior study reported descriptive statistics for value of *M* =5.29 and *SD* = 1.03 and for growth mindset of *M* = 5.98 and *SD* = 0.82 (Kooken & Costelnock, 2023). A high score for the subscale value of mathematics indicates that a student understands the importance of the subject, while a low score indicates a student places little value on learning math. A high score for growth mindset represents a student that believes they can overcome obstacles and persevere, while a low score indicates a fixed mindset.

The means of the pre-test is compared to the means determined by the posttest assessment. This enabled the researcher to measure the changes using the same metric as the Likert scale for a simpler interpretation of the results. Also, by calculating the means, the number of students in each sample group did not need to be identical, although they should be similar (Gall et al., 2007). Permission to use the Upper Elementary Mathematics Resilience Scale was granted by J. Kooken (See Appendix I). The pre- and post-assessments took students approximately 10 minutes to complete.

Procedures

A study description, instruments, and consent forms were emailed to the school district leadership, including the interim superintendent, the executive director of elementary education, and the site principal. Permission was granted via email on July 14, 2023 (see Appendix F). The research proposal was defended and approved on February 19, 2024. IRB approval was sought and approved through Liberty University on April 10, 2024 (see Appendix J for IRB approval). The scale was inputted into Google Forms, and paper copies of parent and student consent were printed.

The study first identifies the 5th grade classrooms from the population which consistently utilize 30 minutes or more of a form of small group learning during the 60-minute core mathematics block, and those classrooms that primarily rely on teacher-led, whole group instruction for close the full 60-minute period. The Instructional Strategy Screener (see Appendix B) was developed by the researcher to determine which teachers primarily utilize whole group instruction and teachers that develop an environment with small group learning. The questionnaire, created and submitted through Google Forms, first required teachers to determine the amount of time spent dedicated to mathematics during the school day and then the range of minutes spent during the core mathematics block. This was done to separate intervention blocks or other daily routines from the core learning block. The next three questions focused on instructional strategies and student grouping primarily done during the core mathematics block. As stated in Chapter 2, the objective was to identify students who experienced core learning within a small group setting (O'Connor et al., 2021). This screener was used to determine which teachers consider themselves to utilize small group instruction. However, to ensure the small group environment is aligned with the requirements for this study, a follow up questionnaire, which is described below, was also necessary.

A key piece of information was included in Question 5 of the screener. The question had teachers select one or two instructional strategies that best match the students' experience in their classroom. The researcher included choices based on structure, such as small group rotations and a center-based workshop model, The research also included the gradual release model, also known as the *I do, we do, you do* instructional plan. This was a key indicator for the researcher. The gradual release model is a common, traditional approach to mathematics instruction. This strategy, based on an essentialistic philosophy for learning, leads students to believe that the teacher is the provider of information, and nothing can be gained without direct instruction. Although students may experience small groups during the class, the direct instruction involved with the gradual release model indicates that the bulk of learning takes place during whole group direct instruction, and therefore may not be an appropriate group to identify for Sample A.

The screener was field tested with two 4th-grade and two 5th-grade teachers in a K-6 school in the southwest United States. After reviewing the completed screeners, the researcher predicted that three classrooms could qualify for Sample A because they strongly relied on small-group learning and partner work. The researcher concluded that one teacher's responses suggested possible candidates for Sample B. This teacher indicated that she rarely had students working with others and spent most of the 60-minute math block using direct instruction and independent work. After meeting with the school's K-6 Mathematics Specialist, who supports math interventions and coaches teachers for the core block, she confirmed the predictions of the four teachers that participated in the field test. The current research study used the same procedure to sort possible candidates for both sample groups.

To confirm the findings of the screening data before finalizing possible sample groups, the Instructional Strategy Questionnaire (see Appendix C) was used as a follow-up interview for teachers whose students were possible candidates for either Sample A or Sample B based on the teachers' responses to the Instructional Strategy Screener. This questionnaire, also developed by the researcher, enabled the researcher to gather more information on students' experiences and classroom information, which was beneficial to remove as many differentiators as possible between the two samples.

As indicated in Chapter 2, *small groups* are defined in the survey as "Contexts in which students work together in small groups to achieve shared learning goals" (Pai et al., 2015). Small group learning was also described as times during the lesson when the teacher did not frequently talk with the whole group. The appropriate number of students in a small group varies in research. Small groups are considered between 2 to 8 students for this survey.

The questionnaire was administered via Google Forms, phone, or in person when possible. After reviewing the information gathered from these questions, the researcher selected two classrooms of students for each Sample A and Sample B. The site selected uses a dyad schedule for 5th grade, so each sample group consists of two classrooms ranging between 50-55 students. This was an ideal scheduling format because it enabled the instruction to identify and limit variables between only two mathematics teachers.

The two samples were chosen from the population based on the results of the Instructional Strategy Screener (see Appendix B) given to teachers from selected schools from the population. This 5-question survey is used to determine possible classrooms where students experience each type of instructional practice. A key factor was distinguishing the independent variable representing the grouping. For example, a whole group may include engagement strategies, such as a Timed-Pair-Share or Round Robin strategies (Kagan, 2011). However, it would still be considered whole group instruction since the teacher contains the most control. Because of these possible misconceptions, a one-on-one interview was conducted to determine the teachers who meet the criteria to be considered for the small group learning sample. Once two sample groups are formed, the study used the Upper Elementary Mathematical Resilience Survey (Kooken & Costelnock, 2023) to compare the mathematical resilience of the two sample groups. Two sample groups are labeled by identifying the independent variable of student experience with small group learning. The first sample group is students who consistently experience small group learning, defined as contexts in which students work together in small groups to achieve shared learning goals (Pai et al., 2015) during at least half of the core learning block of mathematics. The second sample group consists of students who primarily experience whole group instruction during the math block and are cooperatively working with peers for a minimal time during 60-minute math block. For this study, minimal time is recognized as 10 minutes or less of core learning time. Randomizing the two sample groups was not possible, as the students were placed in a classroom at the beginning of the school year.

The study did not include an intervention. Instead, teachers were identified through screening instruments and interviews to determine consistently used instructional strategies during math instruction and, therefore, whether their students could be part of either sample group. However, some recommendations for small groups (see Appendix H) were provided to only the teacher that typically utilized small group instruction. This was done as a reminder to the teacher, and as support in guided their instruction through this 4–5-week study. These suggestions include the following:

- Circles of Learning – Students work together and possibly divide tasks to accomplish a collective goal (Johnson & Johnson, 1975).
- Jigsaw – Students divide tasks or learning, and then share so all group members receive the necessary information (Aronson et al, 1978).
- Student Teams-Achievement Division – Students work together to prepare each other for a competition against other groups (DeVries & Slavin, 1979).
- Team-Accelerated Instruction – Heterogenous groups are given appropriately leveled tasks and support each other to build an understanding of the content (Slavin, 1984).

- Group Investigation – Students work together to accomplish a collective goal, while the teacher acts as a resource and asks questions to promote thinking (Sharan & Sharan, 1976).
- Game-Based Learning – Students participate in high-engagement math games and puzzles, with or without a competitive element (Gocheva et at., 2022).

While students are working on given tasks within their group, this enables the instructor to teach small group lessons in a group rotation (Kuntz et al., 2001). Although the time may seem limited as the instructor rotates through groups, the small groups enable an intense learning session, which can prepare students to complete their work while working as a group independent from the teacher (Sammons, 2019).

After determining both sample groups and receiving all necessary approvals, the researcher met in person with the site principal, site math specialist, and the two participating teachers to review procedures and expectations to conduct the study. All forms were provided to the teachers, including the parental consent form (see Appendix E). This form was agreed to be sent home to families in December 2023, which provided parents multiple weeks to return before the pre-assessment was administered in early January. Copies of the student assent form (see Appendix D) were also provided at this time. It was agreed that a student would be provided a laptop to participate in the survey when the student agreed to participate by signing the consent form. Students who decided not to sign the consent form were not provided a laptop, and therefore did not participate in the study. Students who signed the consent form were provided with a laptop and emailed a link to the survey. Direction and a script (see Appendix G) were provided to teachers to direct students on how to take the survey. Permission to use the Upper Elementary Mathematical Resilience Scale was provided by Kooken and Costelnock.

Using a class list, each teacher assigned a student a 3-digit number. This number was shared with each student after signing the consent form. This class list with numbers was kept in a secure location under lock and key by the math specialist until needed by the teachers for the post-assessment. Upon completion of the post-assessment, the class lists were destroyed. At no point did the researcher have an opportunity to connect a number to a student. Student emails only receive emails from the school district's domain, so the link to the Google Form was sent to the math specialist, who then forwarded it onto student emails at each appropriate time.

Four weeks after the conclusion of the pre-test, a post-assessment using the same scale was administered similarly. Using the class lists with the number codes, the math specialist emailed a link for the post-test only to students who had previously taken the pre-assessment. Students were not required to sign the consent form before taking the post-assessment because only the students who had previously sign the form for the pre-assessment were eligible to take the assessment.

The only identifiable information submitted with the data was a number generated by the classroom teacher, which the researcher had no knowledge or access to. The assigned student number enabled the researcher to identify pre- and post-data but still maintain anonymity. Data was automatically collected through Google Sheets, encrypted and password protected. There were no downloads, printed forms, or external devices used to access the data. The data will remain password protected until the conclusion of the dissertation process, and then will be deleted after a 3-year period.

Data Analysis

The researcher used an analysis of covariance (ANCOVA) with a nonequivalent control-group design. The Mathematical Resilience Scale for Upper Elementary Students was administered as a pre-test during the school year's first quarter. The same scale was used as a post-test after the first quarter. ANCOVA was selected to adjust the post-test scores for differences between the two sample groups based on the pre-test, which was the covariate (Gall et al., 2007). Two ANCOVAS were used to test the differences between two groups of an dependent variable. Each measures the change of one of the two factors of mathematical resilience: value of mathematics and growth mindset.

Assumption tests (Laerd Statistics, 2017) were run using SPSS (IBM Corp., 2020) based on the requirements necessary for a study using ANCOVA design. The dependent variable was measured as a post-test using the Upper Elementary Mathematical Resilience Scale. One covariate was measured using the same scale as a pre-test. The independent variable was determined using informal survey tools to determine the instructional techniques used consistently in each classroom. It was determined that no students were in both sample groups, and a boxplot was used to check for and remove extreme outliers to increase the reliability of the results. Using the same boxplot, which checked for outliers, the relationship between the pre-test and post-test was measured for each style of instruction to check for similar slopes. A Shapiro-Wilk test was used to check for normality in distribution. Normal distribution is assumed if the p-value from the test is greater than 0.05. Levene’s test of equality of variances was used to assume homogeneity of variates between the pre-test and independent variable, which is the style of instruction received for each sample group. Linearity was tested by using a grouped scatterplot of the post-test against the pre-test for each sample group. Using the same boxplot, the relationship between the pre-test and post-test was measured for each style of instruction to check for similar regression slopes.

The null hypothesis was planned to be rejected at a confidence level of 95%. However, because two ANCOVA tests were used, a Bonferroni adjustment was used to reduce the risk of an inflated Type I error rate. Therefore, the research used a *p*-value of 0.025 instead of 0.05. The effect size is measured with a partial eta squared.

CHAPTER FOUR: FINDINGS

Overview

In this chapter, the findings of the analyses of covariance (ANCOVA) with a nonequivalent control-group design revealed the effects of small group and whole group instruction on 5th grade students' mathematical resilience. The research questions are stated and the null hypotheses are indicated. Descriptive statistics provide the sample characteristics including means and standard deviations of the measures. The mean and standard deviation are given. The results of the ANCOVA test are provided to determine if there is a difference in mathematical resilience between students who primarily experience whole group instruction compared to small group learning, as measured using the Upper Elementary Mathematics Resilience Scale when controlling for the pretest. All assumption tests were conducted and reported. Inferential statistics were conducted for each hypothesis. This information is presented in tables and charts. The probability of a type I error was set at $\alpha = 0.05$.The effect size is reported using partial eta squared, η^2. The researcher failed to reject the null hypothesis on growth but did reject the null hypothesis on value.

Research Questions

RQ1: Is there a difference in how 5th grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

RQ2: Is there a difference in 5th grade students' growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

Null Hypotheses

$H_0$1: There is no difference in how 5th grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score as measured by the Upper Elementary Mathematics Resilience Scale?

$H_0$2: There is no difference in 5th grade students' growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score as measured by the Upper Elementary Mathematics Resilience Scale?

Descriptive Statistics

This study examined the effects of whole group instruction and small group learning on mathematical resilience. The convenience sample of 5th grade students, sample size 84, were assigned to classrooms by the school's administration, not randomly assigned to treatment and control group. The students were given a pretest and post-test to measure the effectiveness of small group learning (treatment group) compared to whole group instruction (control group). The researcher conducted two ANCOVA's to test whether exposure to small group instruction had an effect on mathematical resilience as compared to traditional, whole group instruction. The treatment group and control group were approximately equal in size, and there was no attrition (see Table 6). Descriptive statistics indicate that the two groups were very similar at pretest and posttest for both value and growth (see Tables 7 and 9). Data are also provided for the dependent variable (see Tables 8 and 10).

Table 6

Descriptive Statistics (Number of Participants)

Group	*n*	Percent
Control Group	43	51.2
Treatment Group	41	48.8
Total	84	100.0

Table 7

Descriptive Statistics (Pre-test for Value)

Group	*M*	*SD*	*n*
Control Group	5.5	1.1	43
Treatment Group	5.6	0.9	41
Total	5.5	0.9	84

Table 8

Descriptive Statistics (Post-test for Value)

Group	*M*	*SD*	*n*
Control Group	5.7	1.1	43
Treatment Group	5.4	0.9	41
Total	5.5	1.0	84

Table 9

Descriptive Statistics (Pre-test for Growth)

Group	*M*	*SD*	*n*
Control Group	6.2	0.7	43
Treatment Group	6.2	0.5	41
Total	6.2	0.6	84

Table 10

Descriptive Statistics (Post-test for Growth)

Group	*M*	*SD*	*n*
Control Group	6.3	0.8	43
Treatment Group	6.1	0.7	41
Total	6.2	0.7	84

Results for $H_0 1$

Data Screening

The results of the ANCOVA test for the subscale value were presented to determine if there was a difference in mathematical resilience between students primarily experiencing whole group instruction compared to students primarily experiencing small group learning when controlling for the pretest. All assumptions of ANCOVA were tested. Data screening was conducted to detect data inconsistencies and outliers. Box and whisker plots were used to detect outliers for each variable. Although outliers were identified, data were re-checked and all were within three standard deviations from the mean. Due to a small sample size, all data points were included. A box and whisker plot on the covariate for value (see Figure 3) and a box and whisker plot of the dependent variable for value (see Figure 4) are provided.

Figure 3

Box and Whisker Plot (covariate – pre-test value)

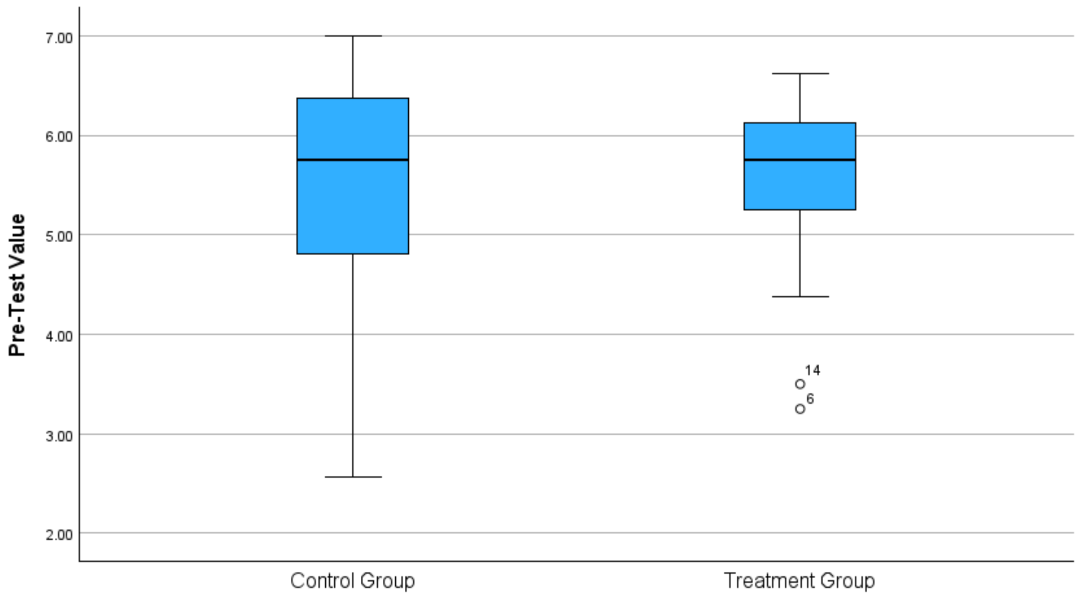
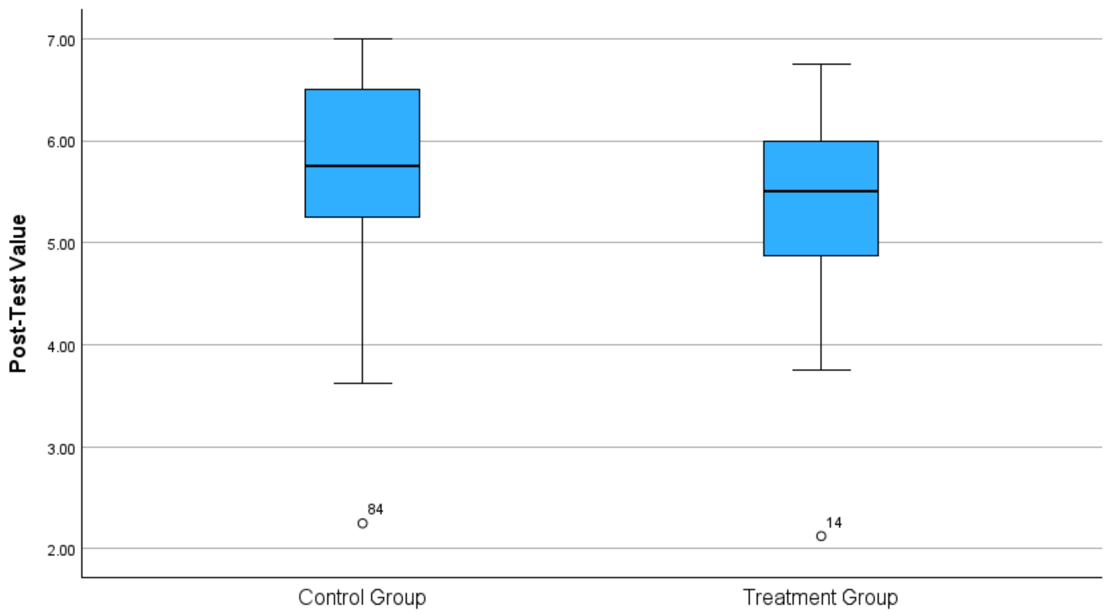


Figure 4

Box and Whisker Plot (dependent – post-test value)



Assumptions

An Analysis of Covariance (ANCOVA) was used to test the null hypothesis, which required 9 assumptions to be met. The first three were met based upon the design of the study, as discussed in Chapter 3. The assumption of linearity was tested by preparing and examining the scatterplots of the pretest and posttest scores for each group (see Figures 5 and 6). The scatterplots indicate the relationship is linear and approximately parallel for each group. When measuring how students value mathematics, there was homogeneity of regression slopes as the interaction term was not statistically significant, p = .720 (see Table 11).

The Shapiro-Wilk test for normality of residuals indicated the standardized residuals are not statistically significantly different from the normal distribution. Therefore, the assumption is that the distributions are approximately normal. The Shapiro-Wilk test was not significant (p = 0.290), which is greater than α = .05 (see Table 12). Levene's test was used for the assumption that the variances are equal across groups, which was met(see Table 13). These confirm that the assumptions of normality and equal variance were met. For further clarification, the plots are provided and there are no patterns to suggest they are not equal (see Figure 7).

Figure 5

Scatterplot for Control Group on Value

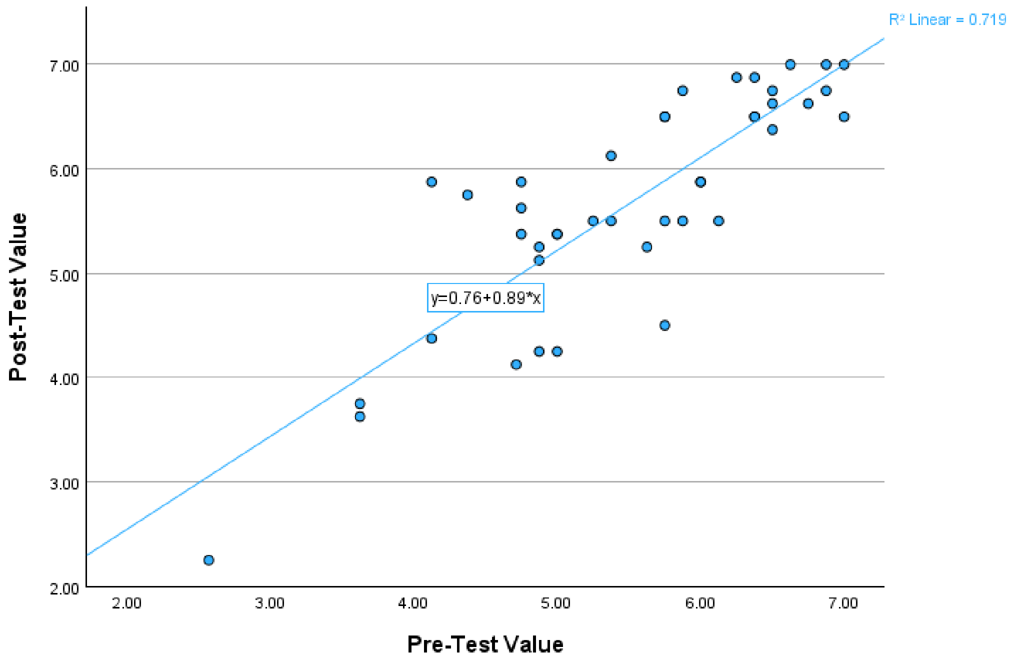


Figure 6

Scatterplot for Treatment Group on Value

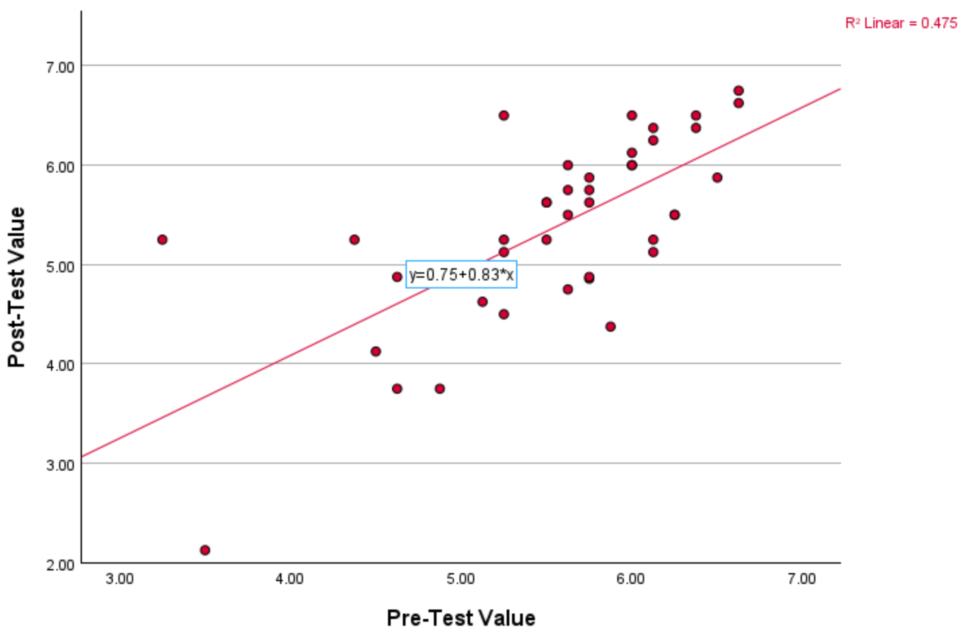


Table 11

Tests of Between-Subjects Effects
Dependent Variable: Post-Test Value

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Corrected Model	52.87	3	17.62	44.54	0.000
Intercept	1.12	1	1.12	2.83	0.097
Treatment	5.449E-05	1	5.449E-05	0.0	0.991
Pre-Test Value	45.40	1	45.40	114.75	0.000
Treatment*Pre-Test Value	0.05	1	0.05	0.13	0.720
Error	31.65	80	0.40		
Total	2645.79	84			
Corrected Total	84.52	83			

Table 12

Tests of Normality

		Shapiro-Wilk		
Group		Statistic	*df*	*p*
Standardized Residual for Post-Test Value	Control	0.990	43	0.972
	Treatment	0.958	41	0.130

Table 13

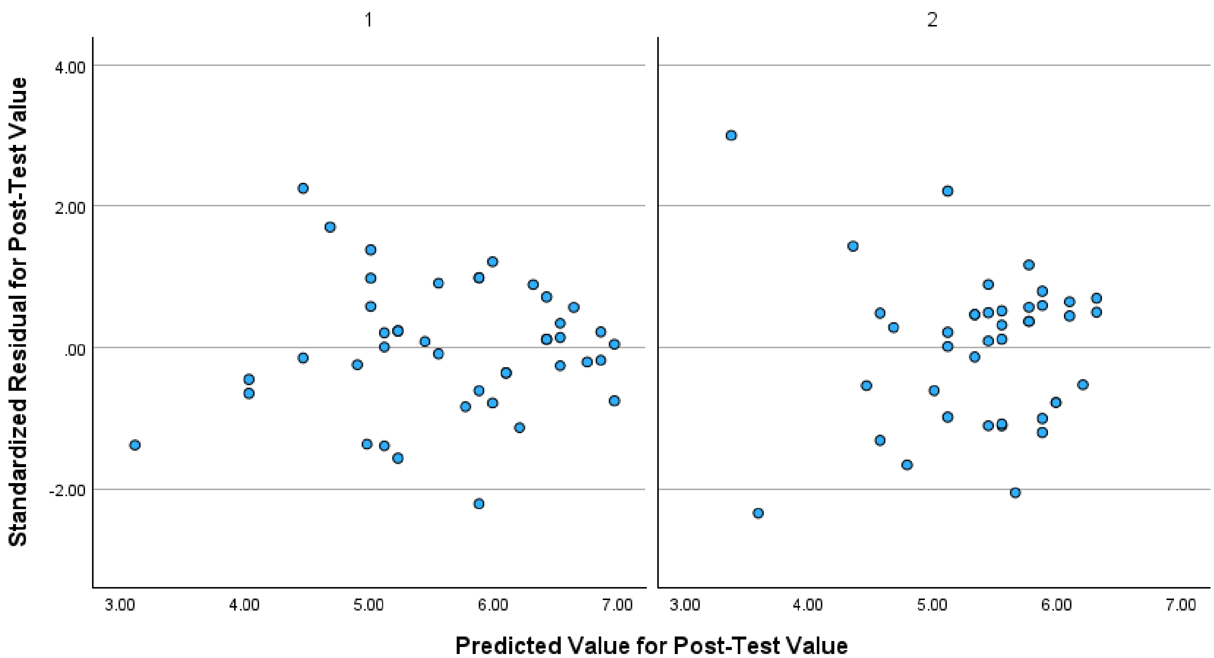
Levene's Test of Equality of Error Variances
Dependent Variable: Post-Test Value

F	*df1*	*df2*	*p*
1.13	1	82	0.290

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Figure 7

Scatter Plot of Standardized Residual by Predicted Value for Post-Test Value



Note. 1 indicates the control group and 2 indicates the treatment group.

In summary, nine assumption tests are required to met the requirements of an ANCOVA analysis. The first three assumptions, which are continuous, categorical, and independence, were met by the study design, as described in Chapter 3. The remaining assumption tests were met, as described above.

Outcomes for $H_0$1

An ANCOVA was used to test the null hypothesis regarding the effects of whole group instruction and small group learning on 5th grade students' mathematical resilience for the value subscale. The null hypothesis was rejected at a 95% confidence level were $F(1, 81) = 5.88$, $p = 0.018$, $\eta_p^2 = 0.070$ (see Table 14), but results were unexpected because the control group had higher scores on the subscale value than the treatment group (see Figure 8).This is further discussed in Chapter 5.

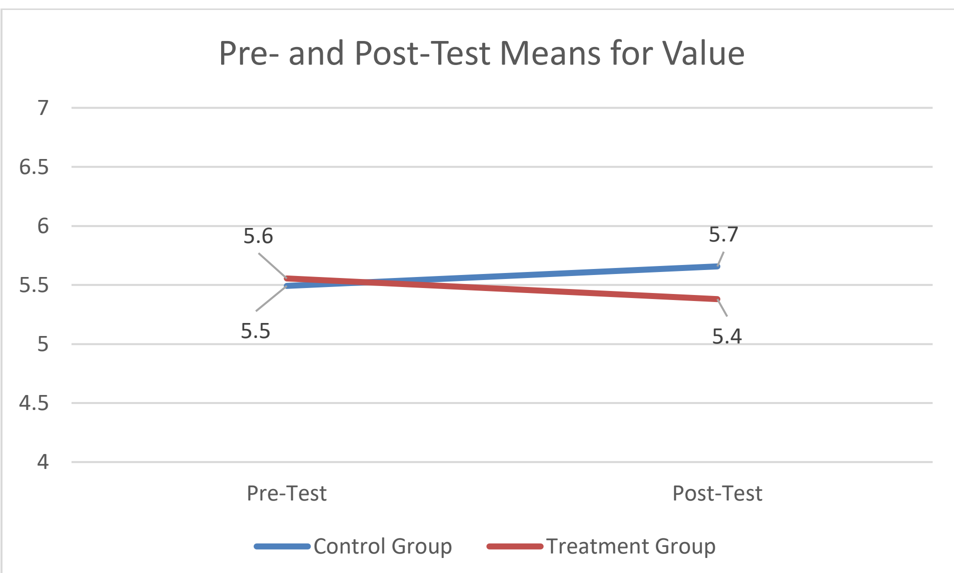
Table 14

Tests of Between-Subjects Effects
Dependent Variable: Post-Test Value

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*	Partial Eta Squared
Corrected Model	52.818[a]	2	26.41	67.48	0.000	0.63
Intercept	1.08	1	1.08	2.75	0.101	0.03
Pre-Test Value	51.21	1	51.21	130.84	0.000	0.62
Treatment	2.30	1	2.30	5.88	0.018	0.07
Error	31.70	81	0.39			
Total	2645.79	84				
Corrected Total	84.52	83				

Note. a. R Squared = .625 (Adjusted R Squared = .616)

Figure 8



Results for H_02

Data Screening

The results of the ANCOVA test for the subscale growth were presented to determine if there was a difference in mathematical resilience between students primarily experiencing whole group instruction compared to students primarily experiencing small group learning when controlling for the pretest. All assumptions of ANCOVA were tested. Data screening was conducted to detect data inconsistencies and outliers. Box and whisker plots were used to detect outliers for each variable. Outliers were identified, and after the data were re-checked, all but 1 outlier were within 3 standard deviations from the mean. The scores from Line 60 in the data set for growth were removed before conducting assumption tests. Due to a small sample size, all other data points were included. A box and whisker plot on the covariate for value (see Figure 10) and a box and whisker plot of the dependent variable for value (see Figure 11) are provided.

Figure 9

Box and Whisker Plot (covariate – pre-test growth)

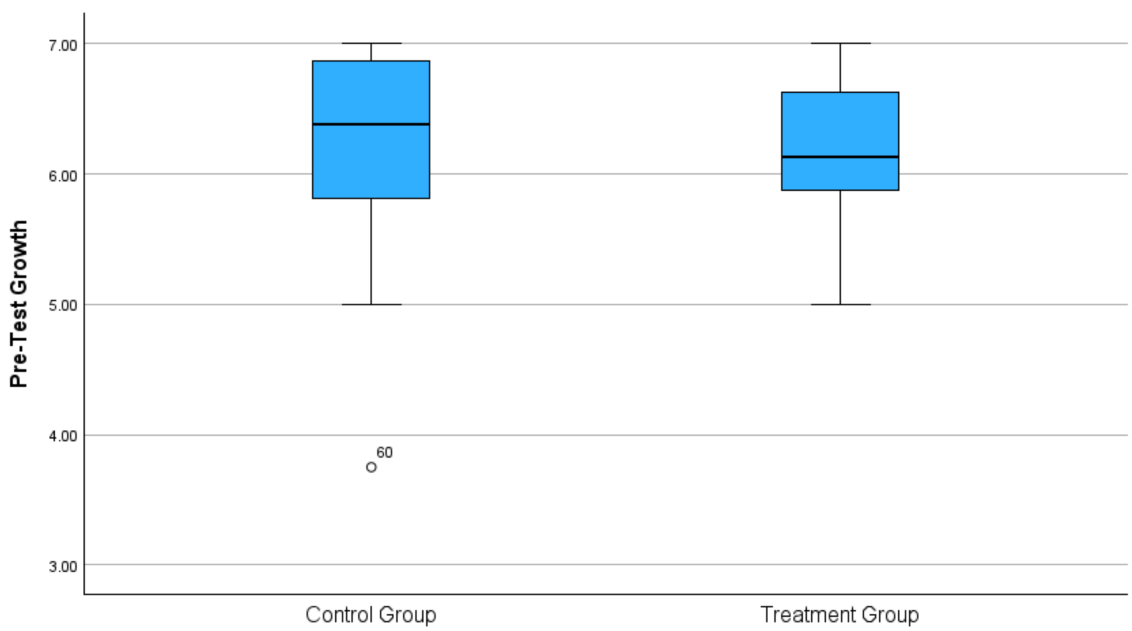
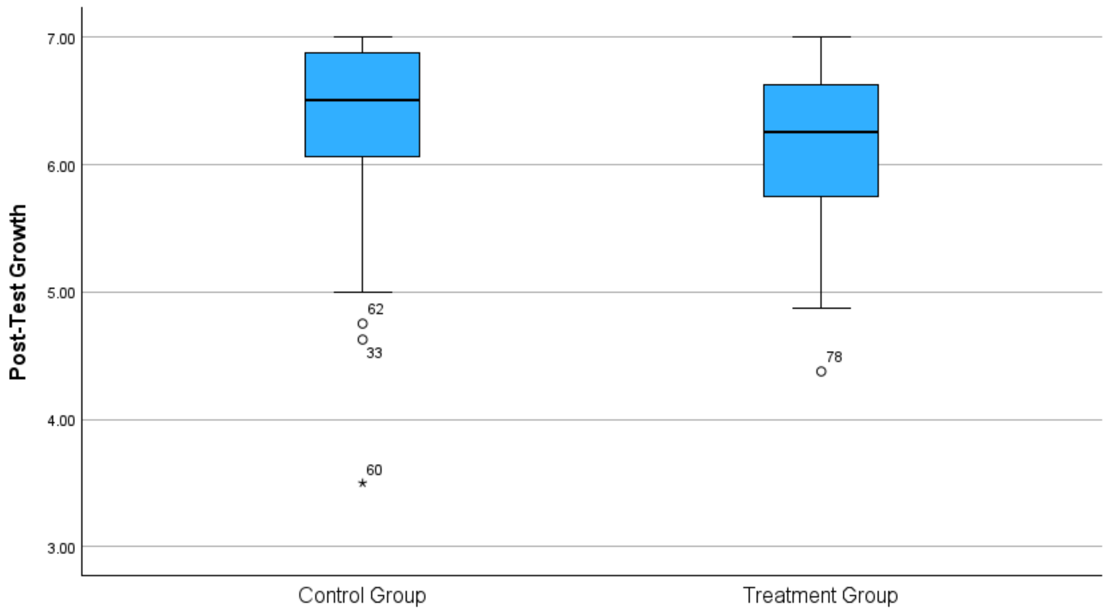


Figure 10

Box and Whisker Plot (dependent – post-test growth)



Assumptions

An Analysis of Covariance (ANCOVA) was used to test the null hypothesis, which required 9 assumptions to be met. The first three were met based upon the design of the study, as discussed in Chapter 3. The assumption of linearity was tested by preparing and examining the scatterplots of the pretest and posttest scores for each group (see Figures 11 and 12). The scatterplots indicate the relationship is linear and approximately parallel for each group. For measuring how students' growth mindset, there was homogeneity of regression slopes as the interaction term was not statistically significant, $p = .087$ (see Table 15).

The Shapiro-Wilk test for normality of residuals indicated the standardized residuals are not statistically significantly different from the normal distribution. Therefore, the assumption is met because the distributions are approximately normal. The Shapiro-Wilk test was not significant ($p = 0.292$), which is greater than $\alpha = .05$ (see Table 16). This denotes that the assumption of equal variance was met. Levene's test was used for the assumption that the variances are equal across groups, which was not met (see Table 17). For further clarification, the plots are provided showing the control group displays a decreasing funnel formation (see Figure 13).

Figure 11

Scatterplot for Control Group on Growth

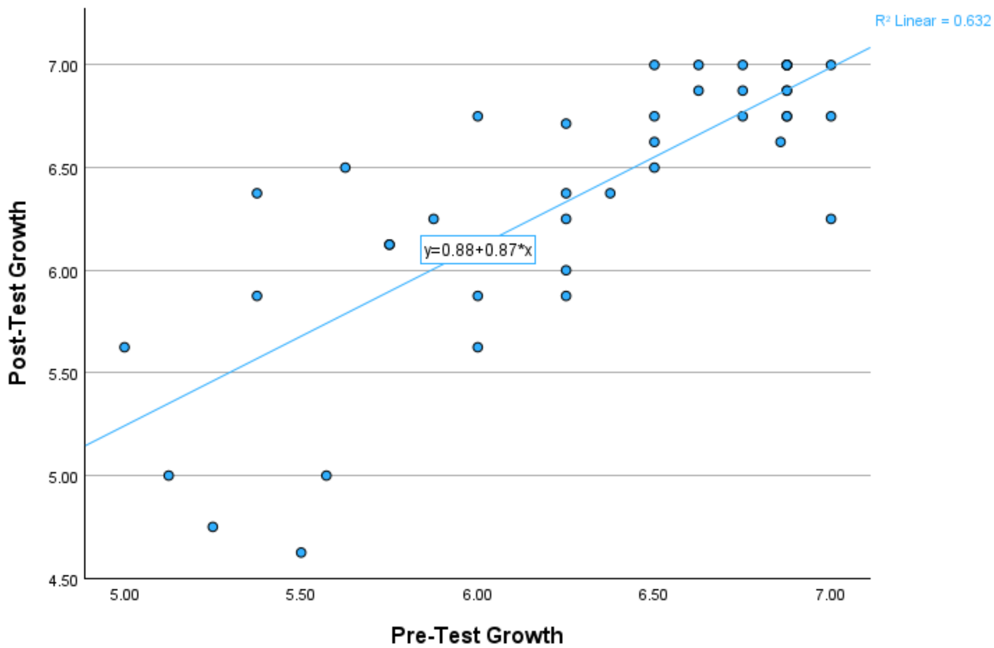


Figure 12

Scatterplot for Treatment Group on Growth

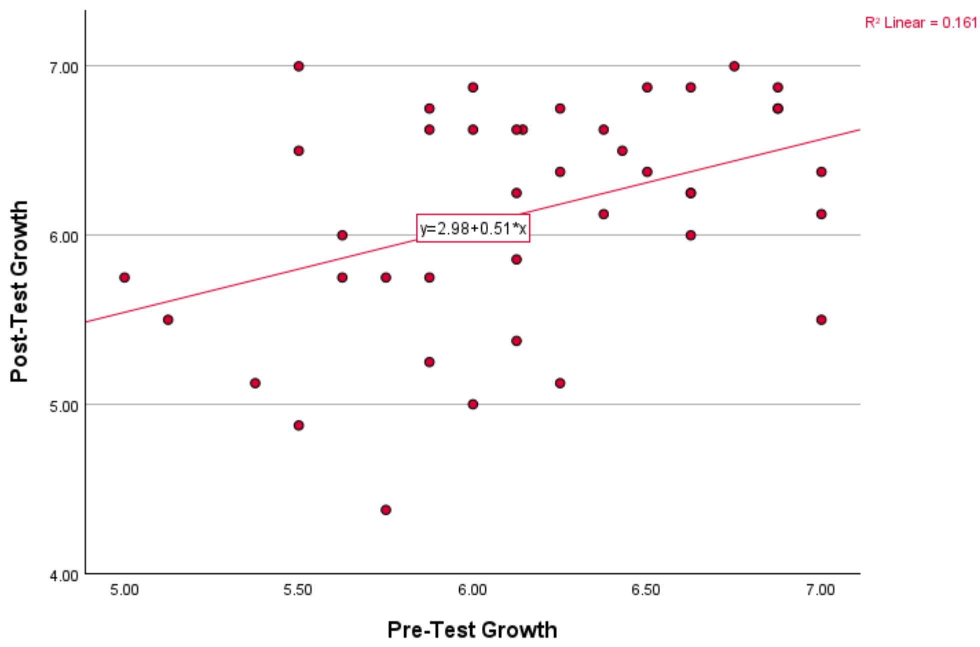


Table 15

Tests of Between-Subjects Effects

Dependent Variable: Post-Test Growth

Source	Type III Sum of Squares	df	Mean Square	*F*	*p*
Corrected Model	14.67	3	4.89	18.26	0.000
Intercept	2.36	1	2.36	8.80	0.004
Treatment	0.70	1	0.70	2.62	0.110
Pre-Test Growth	11.80	1	11.80	44.08	0.000
Pre-Test Growth	0.80	1	0.80	2.99	0.087
Error	21.15	79	0.27		
Total	3283.59	83			
Corrected Total	35.82	82			

Table 16

Tests of Normality

Group		Shapiro-Wilk		
		Statistic	df	*p*
Standardized Residual for Post-Test Growth	Control	0.968	42	0.292
	Treatment	0.964	41	0.215

Table 17

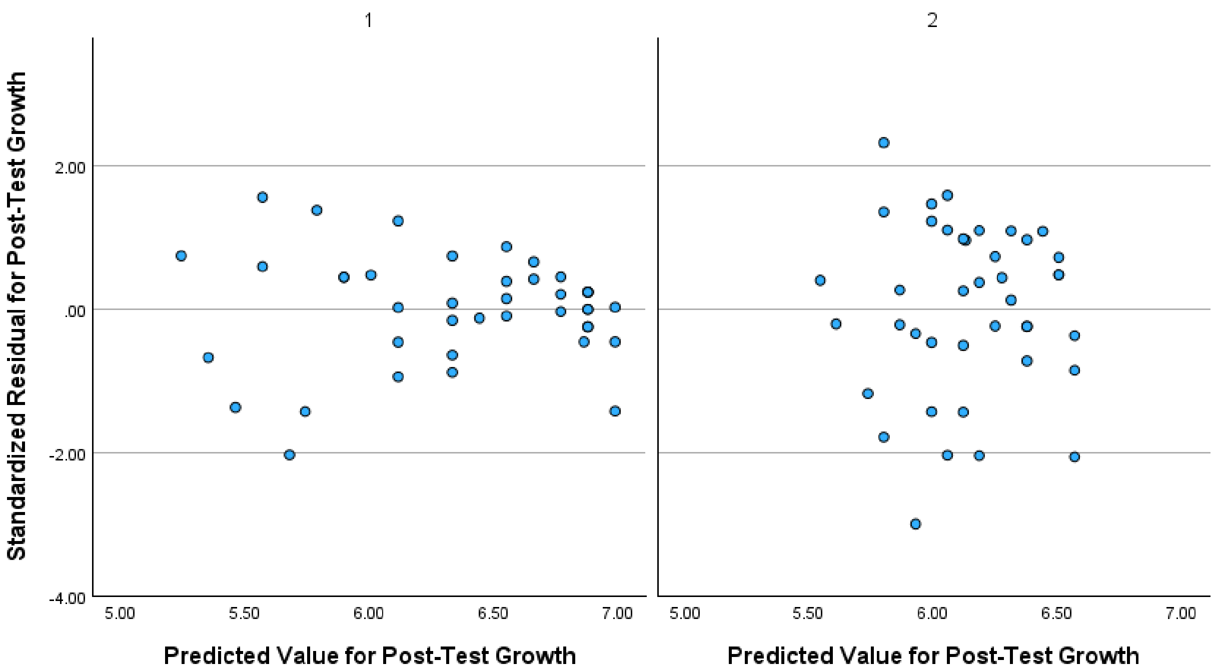
Levene's Test of Equality of Error Variances[a]
Dependent Variable: Post-Test Growth

F	df1	df2	*p*
7.55	1	81	0.007

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Figure 13

Scatter Plot of Standardized Residual by Predicted Value for Post-Test Value



Note. 1 indicates the control group and 2 indicates the treatment group.

In summary, nine assumption tests are required to met the requirements of an ANCOVA analysis. The first three assumptions, which are continuous, categorical, and independence, were met by the study design, as described in Chapter 3. Of the remaining assumption tests, homogeneity of variances was not met as indicated above. The other assumption tests for the growth subscale were met.

Outcomes for $H_0$2

An ANCOVA test was used to test the null hypothesis regarding the effects of whole group instruction and small group learning on the growth subscale of 5th grade students' mathematical resilience. The null hypothesis failed to be rejected at a 95% confidence level were $F(1, 80) = 1.42$, $p = 0.237$, $\eta_p^2 = 0.020$ (see Table 18). There were very little changes to means for both groups (see Figure 14). This level of significance was confirmed by testing with robust errors (see Table 19). This is further discussed in Chapter 5.

Table 18

Tests of Between-Subjects Effects

Dependent Variable: Post-Test Growth

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*	Partial Eta Squared
Corrected Model	13.87	2	6.93	25.27	0.000	0.39
Intercept	2.08	1	2.08	7.58	0.007	0.08
Pre-Test Growth	12.79	1	12.79	46.59	0.000	0.37
Treatment	0.39	1	0.39	1.42	0.237	0.02
Error	21.95	80	0.27			
Total	3283.59	83				
Corrected Total	35.82	82				

Figure 14

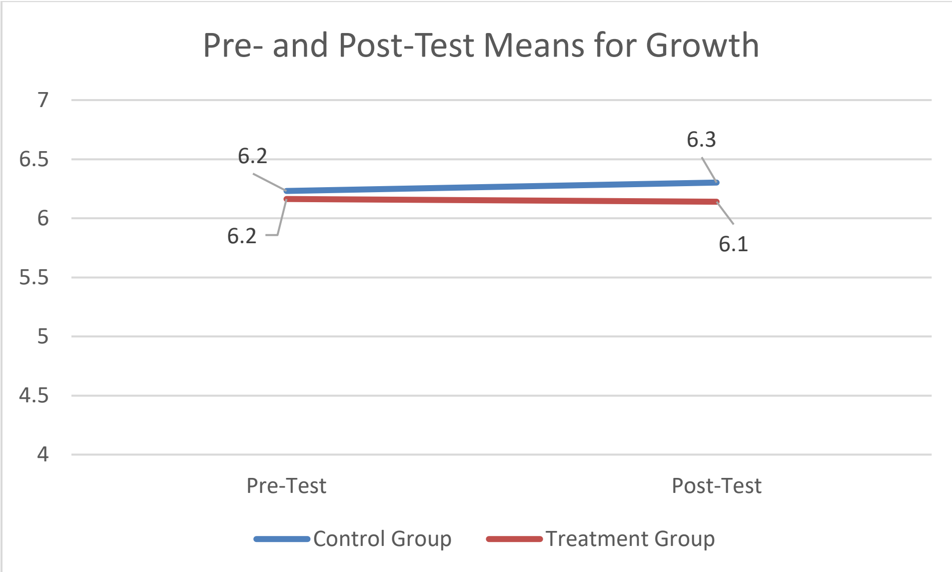


Table 19

Parameter Estimates with Robust Standard Errors

Dependent Variable: Post-Test Growth

Parameter	B	Robust Std. Error[a]	t	*p*	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	1.73	0.74	2.36	0.021	0.269	3.198
Pre-Test Growth	0.71	0.12	6.19	0.000	0.485	0.945
[Treatment=1]	0.14	0.12	1.15	0.255	-0.102	0.377
[Treatment=2]	0[b]					

Note. a. HC3 method

b. This parameter is set to zero because it is redundant.

CHAPTER FIVE: CONCLUSIONS

Overview

The last chapter of this dissertation focuses on measuring mathematical resilience using the Upper Elementary Mathematics Resilience Scale to evaluate the effectiveness of small group learning. This chapter discusses the statistically significant and unexpected results of the study, along with a subscale that did not show a statistically significant difference between groups. The hypothesis will be restated in light of the results. Additionally, the discussion will address how these results relate to other studies and research reviewed in the literature. The limitations of the study will be described, identifying the suspected roadblocks encountered. Recommendations for future research will also be provided to help avoid these issues.

Discussion

The purpose of this quantitative, quasi-experimental study was to determine the effect of small group learning during the core mathematics block on 5th grade students' mathematical resilience in comparison to a control group. The discussion is centered on the hypothesis that students who experience small group learning have stronger mathematical resilience compared to similar peers who primarily experience whole group instruction in mathematics. Mathematical resilience refers to the capacity to persist in the face of challenges and difficulties in learning mathematics, which requires students to value the subject and possess a growth mindset. These two sub-factors were assessed to determine students' level of mathematical resilience.

The intended and optimal timing for the current study was at the beginning of the school year, when students have not yet adjusted to the differences between their current teacher and prior classroom experiences. The actual timing of the study was the end of the school year, after the close of the curriculum calendar and after state testing. Both teachers implemented a project-based approach to mathematics to conclude the school year, which was a drastically different experience for the control group. The control group typically experienced whole group instruction focused on direct instruction. The project-based approach was similar to the small group instruction the treatment group typically experienced, however it was not the typical structure that students experienced throughout the school year. The treatment group teacher had worked with groups throughout most of the year but did not pull groups during this time, and instead supported students when needs arose. These changes to instructional practices are believed to have lowered treatment fidelity and, therefore, contributed to a reduction of the validity.

RQ1: Is there a difference in how 5th grade students value mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

Based on the theories of Piaget (1926), Vygotsky (1978), and other constructivist philosophies, it is well established that students construct knowledge through active experiences. Piaget emphasized the importance of hands-on learning and discovery in cognitive development, while Vygotsky highlighted the role of social interactions and scaffolding provided by more knowledgeable others. These theories collectively suggest that students learn most effectively when they are engaged in meaningful, experiential learning activities, particularly those involving peer interaction and discourse.

In educational practice, small group learning is often employed to create these rich, interactive experiences. It facilitates mathematical discourse among peers, enabling students to articulate their thought processes, confront different viewpoints, and collaboratively solve problems. Research has demonstrated that collaborative learning environments can notably enhance learning outcomes, as students build deeper understanding through social interactions and shared experiences (Baten et al., 2020; Betts & Shkolnik, 1999; Boaler, 2019; Codding et al., 2020; Gusrayani et al., 2019; Kuntz et al., 2001; Linder et al., 2021).

However, the results of this study were in contrast to these well-founded educational theories. Despite the theoretical support for small group learning, the data did show a statistically significant change was measured, though not in the expected direction for the subscale value, which is the extent to which mathematics plays a role in attaining future ambitions (Kooken et al., 2016). It is likely that the threat to validity influenced by history and maturation may have modified students in both groups to be quite similar to each other. One limitation of the study that might have influenced the results is the small sample size, which can affect the reliability and generalizability of the findings. This outcome contradicts the original hypothesis of the study, which predicted that small group learning would enhance mathematical resilience.

Furthermore, there was a statistically significant difference between the two groups on the value subscale. The control group mean at post-test (M = 5.66) was statistically significantly higher than the treatment group mean score (M=5.38), (F (1, 81) = 5.883, p=0.018). However, the direction of this difference was contrary to expectations. While it was anticipated that students in small group settings would demonstrate a higher value for mathematics, the data indicated the opposite. Students in the control group representing whole class instructional settings showed a greater appreciation for the subject.

While constructivist theories advocate for the benefits of experiential and collaborative learning, this study's findings suggest that these benefits may not extend to enhancing mathematical resilience among upper elementary students. The unexpected results highlight the complexity of educational interventions and suggest that the effectiveness of small group learning may vary depending on the specific context and implementation. Further research with larger sample sizes and varied instructional settings is needed to better understand the conditions under which small group learning can most effectively promote mathematical resilience and value for the subject.

RQ2: Is there a difference in 5^{th} grade students' growth mindset in mathematics between those that consistently experience small group learning to students in classrooms which predominately employ whole group learning when controlling for the pretest score?

Based on the research of Boaler (2019, 2022), there is evidence supporting the positive impact of project-based learning and other small group learning structures on students' mindsets. The theory of mindset (Dweck, 2008), which distinguishes between fixed and growth mindsets, posits that individuals who believe their abilities can be developed through dedication and hard work (growth mindset) are more likely to achieve success. Boaler's (2019) research further underscores the importance of fostering a growth mindset, particularly in the context of learning mathematics, through innovative teaching methods such as collaborative projects.

However, despite these theoretical foundations and empirical support for the benefits of such educational strategies, the data from this study did not demonstrate a statistically significant difference between the control group and the treatment group on the post-test in terms of developing a growth mindset as part of mathematical resilience. Mathematical resilience refers to a student's capacity to overcome challenges and persist in learning mathematics. The control group mean score (M=6.30) was not statistically significantly higher than the treatment group mean score (M = 6.14), (F (1, 81) = 1.418, p = 0.237).

While the theory of mindset (Dweck, 2008) and research by Boaler (2019, 2022) advocate for the effectiveness of project-based and small group learning in fostering a positive mindset, the specific data from this study did not align with these expectations in terms of enhancing growth mindset related to mathematical resilience. The difference in slopes between the control and treatment groups when measuring for the growth subscale (see Figures 11 and 12) indicates the need to increase the number of participants as well as apply specific interventions to have teachers adhere to the guidelines and principles of the study. The curriculum was unexpectedly altered to a project-based learning approach, which did not align with the structure of the study.

Implications

The implications of this study are primarily addressed in the limitations and recommendations for future research sections of this chapter rather than the discussion. The results of the study indicated there was no statistically significant difference in the growth subscale of mathematical resilience. Although the study did show statistically significant effects on the value subscale, the direction of the difference between the treatment and control was not anticipated. This limits the immediate practical implications of the findings.

Specifically, the data did not support the hypothesis that students experiencing small group learning would have higher scores in value and growth than students in traditional whole class instruction in fact, it suggested the opposite in some cases. Consequently, the direct implications for educational practice based on this study's measurements are minimal. Given these unexpected and largely inconsequential results, it is crucial to examine the limitations of the study that may have influenced the findings. Key limitations include the small sample size, which can affect the reliability and generalizability of the results, and potential variability in how small group learning was implemented across different classrooms. These factors highlight the complexity of educational research and the need for caution in drawing broad conclusions from this study alone.

Limitations

This study faced several limitations that may have affected the interpretation and generalizability of the findings. It was not feasible to randomize groups because the classrooms were already established. This lack of randomization can introduce selection bias, as the pre-existing classroom compositions might have inherently different characteristics that could affect the outcomes. Without random assignment, it is challenging to ensure that the groups are comparable at baseline, even with leveling results using the pre-test as a covariate.

The study included 84 participants and involved only one teacher for the treatment group and one teacher for the control group. The limited number of teachers did little to control differences in factors such as teacher quality or rapport with students. Expanding the study to include more teachers and, consequently, more participants would reduce the variability of factors between the groups beyond instructional practices during the math block.

The timing of the research presented a major limitation because it was conducted at the end of the school year rather than the beginning. This scheduling posed several challenges that could have affected the study's outcomes and the validity of its conclusions. Firstly, by the end of the school year, students had experienced consequential maturation and had become well-adjusted to the teaching styles of their respective instructors. This familiarity could have biased the results, as students might perform differently based on their comfort level and familiarity with their teacher's methods. This is in contrast to the beginning of the school year when students are still acclimating to new teaching styles and classroom routines, which might have provided a more uniform baseline for assessment.

Additionally, by the end of the academic year, the regular curriculum had concluded, and students were engaged in project-based work. This shift from standard instructional methods to project-based learning could have significantly influenced students' performance on the assessments. The nature of project-based work often emphasizes different skills and learning outcomes compared to traditional instruction, potentially affecting the comparability of the control and treatment groups. The testing did not align with the regular instructional period throughout the first three quarters of the school year, during which students were engaged in more standardized forms of learning and assessment. This misalignment likely introduced variability in students' performance that was unrelated to the types of instruction that were being measured.

The study design could have been improved by including a more detailed intervention plan for both test groups. The absence of a detailed intervention protocol meant that instructional practices were adjusted without a structured framework, which may not have been reflective of the two unique pedagogical styles on a theoretical basis. Teachers were instructed to continue teaching as they normally would between the pre- and post-tests. However, the researcher did not anticipate or account for the transition to project-based learning at the end of the year. The timing of this event meant that the researcher was unaware that both settings would shift to project-based learning, further complicating the analysis and interpretation of the results. By not providing a specific plan of intervention, the study allowed for crucial variability in instructional practices, which undermined the ability to isolate the effects of the intervention. The research design failed to control for these variations, making it difficult to determine whether observed differences in student performance were due to the types of instruction facilitated by each teacher or the variation in teaching methods at the end of the school year.

State testing had just concluded before the pre-test was administered. This timing presents the issue of test fatigue, where students may have been mentally exhausted from the state tests, potentially affecting their performance on the pre-test. The post-test was conducted during the second to last week of school. The anticipation of summer break and the completion of major academic activities could result in lower levels of effort and engagement during the post-test, potentially creating bias in the results. This may have influenced the concentration and effort students put into the post-test.

These limitations suggest that the findings should be interpreted with caution. Future research could address these issues by considering the timing of assessments and implementing randomization to control for selection bias. It is also important to ensure that testing periods do not coincide with other major assessments to mitigate test fatigue.

Recommendations for Future Research

Recommendations for future research:

- Test a variety of factors, including differences in gender, curriculum, and teacher experience. The Upper Elementary Mathematics Resilience Scale is a valid tool to measure the subscales of value and growth, and can be used to measure other variables within a mathematics classroom.
- Create interventions for the specific requirements of the control and treatment groups. A more structured study with specific interventions would reduce the possibility of teachers meandering from their expected instructional strategies implemented in their classrooms. Each teacher's general teaching style, though different, did not statistically significantly affect mathematical resilience for the growth subscale.

- Increase the number of participants by involving urban, suburban, and rural schools. Increasing the number and diversity of participants would increase the validity of the study.
- Schedule the research early in the school year before students adjust to the different teaching styles. This would also allow a researcher to extend the study beyond four weeks and allow for a mid-point assessment.

Conclusion

While constructivist theories emphasize the benefits of experiential and collaborative learning, this study shows that their application requires careful adaptation to classroom contexts. The unexpected results highlight the importance of understanding specific implementation factors. Requesting teachers to continue regular practices instead of providing specific interventions allows for the possibility of shifts in the instructional design of lessons.

In this study, conducting the research at the beginning of the school year rather than at the end provides several advantages. Starting the study early in the academic year allows for observing the initial impacts of new instructional strategies as they are implemented. This timing is crucial for understanding how early interventions can shape students' attitudes and performance in mathematics throughout the year. Early implementation also enables researchers to track long-term changes and adaptations in teaching practices, as well as the development of students' mathematical resilience and growth mindsets over a more extended period.

Continued research is needed to develop effective strategies that develop mathematical resilience and to identify which factors of a math lesson and teacher characteristics may produce a more statistically significant effect. By addressing these complexities from the beginning of the school year, a researcher can more effectively measure a positive attitude towards mathematics and growth mindsets among students. This approach ensures that interventions are integrated smoothly into the curriculum and maximizes their impacts through sustained and consistent application.

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APPENDIX A

Upper Elementary Mathematics Resilience Scale

Items on Value

- Math is important for my future.
- Math develops good thinking skills that are needed to be successful.
- Math will be useful when I grow up.
- It would be difficult to succeed in life without math.
- Math can help me with things outside of school that matter to me.
- Math class is helpful no matter what I want to be when I grow up.
- Knowing math will help me reach my goals.
- Knowing math helps me in other subjects at school.

Items on Growth Mindset

- Everyone struggles with math at some point.
- Only smart people can do math.
- Making Mistakes is necessary to get good at math.
- Math can be learned by anyone.
- People in my class struggle sometimes with math.
- Everyone makes mistakes at times when doing math.
- Struggle is a normal part of working on math.
- If someone is not good at math, there is nothing that can be done to change that.

Items on Demographics

- Are you male or female? (Options are Female, Male, Choose not to answer)

- What is your race? (Options are American Indian or Alaskan Native, Asian, Black or African American, Native Hawaiian or other Pacific Islander, White, From multiple races, Not sure)
- Are you Hispanic/Latino (Options are Yes, No, Not sure)

APPENDIX B

Instructional Strategy Screener

Thank you for taking the time to complete this 5 question screener. The purpose of this screener is to identify possible sample groups for a study on Mathematical Resilience.

Email *

Valid email

This form is collecting emails. Change settings

On average, how many minutes a day do your students receive mathematics instruction? Include core mathematics block and intervention. *

- Less than 30 minutes
- 30-44 minutes
- 45-59 minutes
- 60-74 minutes
- 75-90 minutes
- More than 90 minutes

On average, how many minutes a day do your students experience the core mathematics block? (This does NOT include intervention.) *

- Less than 30 minutes
- 30-44 minutes
- 45-59 minutes
- 60-74 minutes
- 75-90 minutes
- More than 90 minutes

During the core mathematics block, how many minutes daily, on average, do students spend working with a small group or partner? *

- Very rarely
- Less than 10 minutes
- 10-19 minutes
- 20-29 minutes
- 30-44 minutes
- 45-60 minutes
- More than 60 minutes

Select 1 or 2 instructional strategies that best match your students' experience in your classroom during the core mathematics block. *

- [ ] Small group rotations
- [ ] Direct instruction
- [ ] Center-based workshop model
- [ ] Problem-based learning
- [ ] Gradual release model (I do, We do, You do)
- [ ] Project-based learning
- [ ] Other...

Select 1 choice in the dropdown menu that best matches your students experience in your classroom.
During the core learning block for mathematics, my students spend most of their time working

1. within the whole group.
2. within a small group.
3. with a partner.
4. individually.

APPENDIX C

Instructional Strategy Questionnaire

Thank you for completing the Instructional Strategy Screener. Your students may be great candidates for an upcoming study on mathematical resilience. Please take a few moments to further describe your students' experience learning mathematics in your classroom.

How many students do you teach the core block of learning for mathematics?

Short answer text

What are the prime resources used for your planning and instruction?

Short answer text

Please list the blocks of time that the students experience mathematics in your classroom. Please indicate whether the focus is for the core math lesson, intervention, or other daily routine. *

Long answer text

Please describe your average daily math lesson during the core mathematics block. Please include the type of grouping you use throughout the different segments of your lesson, whether whole group, small group, partners, or individuals, and the approximate time for each segment.

Long answer text

APPENDIX D

LIBERTY UNIVERSITY

Child Assent to Participate in a Research Study

What is the name of the study and who is doing the study?
The name of the study is *A Quasi-Experimental Study on the Effects of Small Group Learning on Mathematical Resilience in Upper Elementary Students*, and the person doing the study is Joshua A. Costelnock.

Why is Joshua A. Costelnock doing this study?
Joshua A. Costelnock wants to know if instructional groupings affect students' thinking about math.

Why am I being asked to be in this study?
You are being asked to be in this study because you are a 4^{th} or 5^{th} grade student.

If I decide to be in the study, what will happen and how long will it take?
If you decide to be in this study, you will respond to some statements on whether you agree or disagree. You will complete the survey twice, which will take around 10 minutes each time.

Do I have to be in this study?
No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher and your teacher will not be angry. You can say yes now and change your mind later. It's up to you.

What if I have a question?
You can ask questions at any time. You can ask now. You can ask later. You can talk to the researcher or your teacher. If you do not understand something, please ask the researcher or teacher to explain it again.

Signing your name below means that you want to be in the study.

____

Signature of Child Date

Joshua A. Costelnock
jacostelnock@liberty.edu
(602) 717-6256

APPENDIX E

Title of the Project: A Quasi-Experimental Study on the Effects of Small Group Learning on Mathematical Resilience in Upper Elementary Students
Principal Investigator: Joshua A. Costelnock, Doctoral Candidate, Liberty University

Invitation to be Part of a Research Study

Your student is invited to participate in a research study. Participants must be 4th or 5th grade students in the southwest United States. Taking part in this research project is voluntary.

Please read this entire form and ask questions before deciding whether to allow your student to participate in this research project.

What is the study about and why are we doing it?

The study aims to measure the effects of different instructional grouping strategies on 4th and 5th grade students' mathematical resilience. Mathematical resilience will be measured with two categories: how students value mathematics and whether students have a fixed or growth mathematical mindset.

What will participants be asked to do in this study?

If you agree to allow your student to be in this study, I will ask him/her to do the following things:

1. Complete a 16-question survey on mathematics, which should take approximately 10 minutes. The survey will be administered as a pre-test and then repeated as a post-test 4-5 weeks after.

How could participants or others benefit from this study?

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include data analysis of students' mathematical resilience as it relates to common instructional practices by their teachers.

What risks might participants experience from being in this study?

The risks involved in this study are minimal, which means they are equal to the risks your student would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Research records will be stored securely, and only the researchers will have access to the records.

- Participant responses will be anonymous.
- Data will be stored on a password-locked computer and may be used in future presentations. After three years, all electronic records will be deleted, and paper surveys will be destroyed.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to allow your student to participate will not affect your or his/her current or future relations with Liberty University or Higley Unified School District. If you decide to allow your student to participate, he/she is free not to answer any question or withdraw at any time prior to submitting the survey without affecting those relationships.

What should be done if a participant wishes to withdraw from the study?

If you choose to withdraw your child from the study or your child chooses to withdraw, please inform the researcher that your student wishes to discontinue his/her participation, and your child should not submit the survey materials. Your student's responses will not be recorded or included in the study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Joshua A. Costelnock. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Joshua A. Costelnock at jacostelnock@liberty.edu.

Whom do you contact if you have questions about rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researchers, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University

LIBERTY UNIVERSITY

Your Consent/Opt-Out

Option 1: Parental Consent: By signing this document, you agree to allow your student to participate in this study. Make sure you understand what the study is about before you sign. You will be given a copy of this document for your records. The researchers will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to allow my student to participate in the study.

____
Printed Child's/Student's Name

____
Parent's Signature Date

____
Minor's Signature Date

Option 2: Parental Opt-Out: If you would prefer that your child NOT PARTICIPATE in this study, please sign this document and return it to your student's teacher by [date].

____
Printed Child's/Student's Name

____
Parent's Signature Date

APPENDIX F

ML

Mcbride, Laurie <Laurie.McBride@husd.org>
To: Costelnock, Joshua Adam

Fri 7/14/2023 7:32 AM

You don't often get email from laurie.mcbride@husd.org. Learn why this is important

Hi Josh,

Kaity, Sherry, and Heidi are all in agreement that you can move forward doing your study at Gateway. Please reach out if you need anything else.
Have a great weekend.
Thank you!

APPENDIX G

Teachers:
Thank you for facilitating the completion of the Mathematical Resilience Scale for Upper Elementary Students! I greatly appreciate your time and willingness to support me in completion of my study.
If you have any questions, please contact Josh Costelnock at (602) 717-6256.
Below you will find directions and a script that you can read for your students when you administer the assessment.

Josh Costelnock
Doctoral Candidate
Liberty University
jacostelnock@liberty.edu

- **PLEASE DO NOT READ ANY PART OF THE SURVEY TO THE STUDENTS.** The two requirements of the sample group are students that are in 4^{th} or 5^{th} grade, and students that can read and respond to the items independently. If a student is unable to independently complete the survey, the student does not need to participate in the study.

- **PLEASE INFORM YOUR STUDENTS NOT TO SHARE THEIR NUMBER.** Confidentiality will be maintained by not collecting identifiable information to begin with.

- **STUDENTS DO NOT HAVE TO COMPLETE THE SURVEY IF THEY CHOOSE NOT TO.** Students can choose not to respond to a question if they choose not to. If a student refuses or a parent has decided that their child should not participate, do not forward the survey to that student. If a student refuses after distributing the survey, simply exit the survey and responses will deleted before data analysis.

Please read the following script to the students:

Thank you for agreeing to complete the survey on math. The questions should take around 10 minutes of your time. The first question will require you to type a number which I will give to you. Please do not share this number with anyone. No one will know which survey is yours, so please be completely honest when responding. There will be no follow-up questions or interviews following the completion of the survey. There are no short answer responses in the survey – only bubbles to fill in!
You do not have to be in this study if you do not want to be. You do not have to answer any question that you do not want to answer for any reason. Your confidentiality will be maintained because you don't write your name!
The survey consists of 16 statements. We'd like to know if you agree or disagree with each statement. You can select if you completely agree, mostly agree, or kind of agree. The same options are available if you disagree. You can also choose "neither agree or disagree" if you are in between.
You can ask your teacher if you have any questions on how to complete the survey, but your teacher cannot read the questions or statements to you.

DISTRIBUTE THE SURVEY AND ALLOW THE STUDENTS TO BEGIN.
Upon completion of the survey, collect and place in the envelope provided. Please hand the envelope to your principal at your convenience.

APPENDIX H

Teacher:

Thank you for agreeing to participate in this study on the effects of small group learning on students' mathematical resilience. You have been selected based on your approach to mathematics instruction, which already includes the use of small group learning.
A pre-assessment will be given and a post-assessment 4-5 weeks later. During this time, it is recommended that you continue your current practices, and possibly implement other suggestions below, as appropriate.

Examples of Small Group Learning

Circles of Learning – Students work together and possibly divide tasks to accomplish a collective goal (Johnson & Johnson, 1975).

Jigsaw – Students divide tasks or learning, and then share so all group members receive the necessary information (Aronson et al, 1978).

Student Teams-Achievement Division – Students work together to prepare each other for a competition against other groups (DeVries & Slavin, 1979).

Team-Accelerated Instruction – Heterogenous groups are given appropriately leveled tasks and support each other to build an understanding of the content (Slavin, 1984).

Group Investigation – Students work together to accomplish a collective goal, while the teacher acts as a resource and asks questions to promote thinking (Sharan & Sharan, 1976).

Game-Based Learning – Students participate in high-engagement math games and puzzles, with or without a competitive element (Gocheva et at., 2022).

While students are working on given tasks within their group, this enables you as the instructor to teach small group lessons in a group rotation (Kuntz et al., 2001). Although the time may seem limited as you rotate through groups, the small groups enable an intense learning session, which can prepare students to complete their work while working as a group independent from you (Sammons, 2019).

Again, thank you for agreeing to participate. Please do not hesitate to contact me before, during, or after the study. I will be happy to support you in any way I can.

Josh Costelnock

APPENDIX I

Permission to use the Mathematical Resilience Instrument

Kooken, Janice W (Doctor of Education)
To: Costelnock, Joshua Adam

Reply Reply all Forward

Wed 2/7/2024 8:44 AM

Hello,

You have permission to use the Mathematical resilience instrument designed for upper elementary school students. This instrument has been validated via confirmatory factor analysis to measure two constructs:

Value - represented by the belief that mathematics is an important content area to the student that will help them in many areas of life.
Growth through struggle - represented by an attitude that one can grow in knowledge of mathematics but that it will involve struggles at times.

Please use the following citation for the paper:

Kooken, J., & Costelnock, J. (2024). *Mathematical Resilience in Middle School: Tools and a research agenda to support student success in mathematics*. [Conference presentation]. American Educational Research Association Conference, Philadelphia, PA.

Janice Kooken, PhD
Quantitative Research Methods Expert
School of Education

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APPENDIX J

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 10, 2024

Joshua Costelnock
Janice Kooken

Re: IRB Approval - IRB-FY23-24-243 A Quasi-Experimental Study on the Effects of Small Group Learning on Mathematical Resilience in Upper Elementary Students

Dear Joshua Costelnock, Janice Kooken,

We are pleased to inform you that your study has been approved by the Liberty University Institutional Review Board (IRB). This approval is extended to you for one year from the following date: April 10, 2024. If you need to make changes to the methodology as it pertains to human subjects, you must submit a modification to the IRB. Modifications can be completed through your Cayuse IRB account.

Your study falls under the expedited review category (45 CFR 46.110), which is applicable to specific, minimal risk studies and minor changes to approved studies for the following reason(s):

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b)(3). This listing refers only to research that is not exempt.)

For a PDF of your approval letter, click on your study number in the My Studies card on your Cayuse dashboard. Next, click the Submissions bar beside the Study Details bar on the Study Details page. Finally, click Initial under Submission Type and choose the Letters tab toward the bottom of the Submission Details page. Your stamped consent form(s) and final versions of your study documents can be found on the same page under the Attachments tab. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

G. Michele Baker, PhD, CIP
Administrative Chair
Research Ethics Office