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# The Math Workshop Model and the Effect on Students' Academic Achievement and Mindset in Sixth-Grade Mathematics

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# The Math Workshop Model and the Effect on Students' Academic Achievement and Mindset in Secondary Mathematics

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**Abstract**

Secondary mathematics classrooms of the 21st century did not appear to be much different than they were 10 or 20 years ago. The familiar structures and strategies of two or more decades ago used by modern mathematics teachers were in spite of drastic changes to the challenges students faced when leaving the classrooms. Achievement in mathematics in the United States declined and students' needs were more diverse than ever. Teachers needed a differentiation strategy to address the wide range of students' abilities within their classrooms while effectively engaging all students in rigorous mathematics. This study focused on constructivist learning theory, growth mindset, and differentiating instruction to explore a relationship between implementing the Math Workshop Model, a strategy to differentiate instruction while also providing equitable opportunities for experiencing rigorous mathematics, and students' academic achievement and mindset in sixth-grade mathematics. A quantitative study was used to measure the effects of implementing the Math Workshop Model in sixth-grade mathematics in an urban school district and collect and compare achievement data from students in classes where the Math Workshop Model was implemented to students where the Math Workshop Model was not implemented. In addition, a mindset survey was administered to determine if the equitable environment created by implementing the Math Workshop Model affected students' mindset.

*Keywords:* The Math Workshop Model, mathematics, differentiated instruction, equitable learning environment, mindset, constructivist learning theory

## Dedication

For the last three years, I have experienced challenges unlike any I have ever faced in my life. The person who was forced to experience these challenges with me, my husband, had no idea what he was in for when I signed up for the doctorate program three years ago. He has endured all the stress, the frustration, and anger-filled rants when the life of a doctoral candidate got to be a little too much. My husband encouraged me, he would not let me quit, and he brought me ice cream when things were really dire. I have completed my doctorate because he helped me keep it together. And before my husband was helping me keep it together, my parents did. I could write just as many pages about my parents as there are in this dissertation. But, in a few short lines, my parents made me believe I could do anything I wanted, and if they believed I could do something, I never doubted for a moment that I would accomplish it. They worked tirelessly to ensure all I had to do as a teen was focus on my education. I guess that was pretty successful, because here I am. So, thank you Mom and Dad for building the foundation and always believing in me, and thank you Scott for letting me get just to the brink of insanity before finding a way to pull me back.

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# Chapter 1: Introduction

## Introduction to the Problem

According to the 2015 Program for International Student Assessment (PISA) results, 29% of 15-year-old mathematics students tested in the United States failed to meet the international assessment's baseline for proficiency (Heim, 2016). While some educational leaders in the United States discounted the results of the PISA global assessment and other standardized assessments like it (Heim, 2016), the downward trend shown by mathematics students in the United States was difficult for many in the mathematics community to ignore (Boaler, 2016). When students in the United States graduate high school and college, no longer was their competition for the best opportunities limited to students from their own states or country; The competition was now on a global scale (Kerr, 2016). While other countries responded to the data presented by PISA by reforming educational practices and structures, particularly in the areas of mathematics, the United States had yet to make considerable changes to mathematics teaching, especially at the secondary level (Heim, 2016). Students in the United States were at risk of falling further behind on a global scale because of the United States' failure to respond appropriately to the data from the PISA assessment results (Heim, 2016).

## Background, Context, History, and Conceptual Framework for the Problem

Problems with equity in mathematics education produced a need for instructional strategies that addressed the academic ability and motivation of diverse groups of learners (Boaler, 2016b). The instructional choices teachers made in their classrooms had a tremendous impact on student achievement (Leinwand, 2012). In mathematics classrooms over the recent past, teachers usually chose whole group instruction due to its ease of implementation (Allen, 2012). Current research, however, suggested that students in mathematics achieve more academic success and growth when they learned collaboratively with peers, discussing rich mathematical problems, and approached learning mathematics with a growth mindset (Boaler, 2016b).

Evidence supporting student collaboration and helping students develop a growth mindset to learning mathematics created a conundrum for teachers who were rooted in traditional instructional practices that limited opportunities for students to work collaboratively (Leinwand, 2012). Mathematics educational leaders seeking reform were presenting new, more effective instructional ideas to teach mathematics (Boaler, 2016b; Hoffer, 2012). These instructional practices allowed educators to integrate traditional practices to which they were accustomed with newer strategies, such as student collaboration and small group learning (Hoffer, 2012). One such approach to mathematics teaching was the differentiated instruction tool Math Workshop Model.

Meeting the needs of all mathematics learners by evaluating instructional practices produced some positive results in learning outcomes DuFour, DuFour, Eaker, Many, & Mattos, 2016). However, education reform needed to address larger issues in mathematics instruction in the United States in order to effect meaningful change in student results (Webel, 2010). Traditional mathematics instruction did little to foster students' confidence and beliefs in their own abilities to succeed in mathematics (Sun, 2018). According to Boaler (2016), students' mathematical mindset was often predetermined by the time they reached secondary school, with many students believing that only certain people were born with a 'math brain'. Well-chosen activities in which students engaged in a respectful learning environment where they believed they were valued within the community offered students in mathematics classes opportunities to retrain their brains so students see themselves through a growth mindset, (Boaler and Staples, 2008). The extent to which students experienced mathematics in an equitable environment where they were given autonomy of and authority in learning also influenced students' academic success in mathematics (Webel, 2010).

The conceptual framework of this study reflected the current literature mathematics from mathematics education and the beliefs of the researcher that mathematics students learn best when building on their prior knowledge and experiences and collaborating with their peers (Boaler, 2016b; Leinwand, 2012; Koestler, Felton, Bieda, & Otten., 2013). The main component of the conceptual framework of this study was based on constructivist learning theory. At the center of constructivist learning theory was the idea of a student-centered learning environment where students create their own meanings through authentic learning tasks and social interactions with peers (Krahenbuhl, 2016).

The focus of this study was measuring the relationship between differentiation through implementing the Math Workshop Model and students' academic achievement and mindset in sixth-grade mathematics. A key aspect of the Math Workshop Model was providing students opportunities to learn at their current academic levels based on timely assessment dates without subjecting them to academic tracking (Hoffer, 2012). The Math Workshop Model allowed students to stay in heterogeneously grouped mathematics classes, collaborating and creating new meanings with students from a variety of different backgrounds while still giving teachers the opportunity to provide targeted interventions to specific students or groups of students based on data (Boaler, 2016b; Hoffer, 2012).

**Statement of the Problem**

In recent years, assessment data showed decreases in students' academic performance in mathematics (National Center for Education Statistics, Institute of Educational Sciences, 2016).

In response, leaders in mathematics have strengthened their plea for mathematics education reform. The National Council of Teachers of Mathematics (NCTM) has continued to publish research supporting their Principles and Standards of Mathematics, which include content standards, process standards, and six principles of high-quality mathematics instruction (Koestler et al., 2013). It is through these six principles that NCTM proposed shifts in teaching and learning mathematics to address student achievement and learning. NCTM argued that mathematics classes must evolve from teacher-centered environments, with students acting as disengaged, passive learners to student-centered, active learning environments where each student receives learning opportunities based on their needs (Koestler et al., 2013). Principles and standards such as those published by the NCTM and other groups committed to enhancing mathematics education have prompted a large body of research on the effectiveness of different approaches to mathematics education.

However, educators and policymakers have outlined no explicit plan for improving students' academic achievement in mathematics in the United States, especially at the secondary level. Various types of studies have examined the effectiveness of differentiated instruction in improving students' academic achievement in mathematics (Abbati, 2012; Allen, 2012; Ashley, 2016; Boaler & Staples, 2008; Dean & Zimmerman, 2012; DeJarnette, Doa, & Gonzalez, 2014; Dekker & Elshout-Mohr, 2004; Esmonde, 2009; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016). Some studies on differentiated instruction were quantitative studies analyzing assessment data for student growth to determine the effectiveness of differentiated instruction (Dekker & Elshout-Mohr, 2004; James, 2013; Kelly, 2013). Quantitative studies were used by researchers when the desired outcome was to provide objective, predictive results comparing tow quantities (McMillan, 2012).

Other studies were qualitative, relying on data derived from interviews, observations, or other subjective evidence to determine whether students receiving differentiated instruction experienced better quality mathematics instruction (Abbati, 2012; Ashley, 2016; Esmonde, 2009). In addition to implementing different methodologies, the qualitative studies focused on different aspects of improving student achievement in mathematics through differentiated instruction. The results of the studies highlighted effective strategies to improve mathematics education in the United States. However, most of these studies have addressed differentiated instruction in a broad sense rather than addressing specific strategies of differentiation.

In addition, some studies on differentiation strategies in education focused on the ways in which students were grouped during instruction, and results indicated that the grouping strategies may have influenced student achievement in mathematics (Ghousseini, Lord, & Cardon, 2017; Benders & Craft, 2016). Within the existing literature on improving students' academic achievement in mathematics, few studies examined the effects of a differentiation strategy with flexible grouping structures, allowing students to move from group to group as their needs changed. However, one study investigated the differentiation strategy Math Workshop Model (Ashley, 2016). One deficiency of research to date on improving student academic achievement in mathematics was that most research on differentiated instruction was conducted at the elementary level. As data from assessments such as PISA has revealed (Heim, 2016), mathematics students in the United States at the secondary level have fallen further behind in mathematics on a global scale. The results from the PISA assessment highlighted the need for further research on this data trend at the secondary level (Heim, 2016).

## Purpose of the Study

Teachers—both novice and experienced—struggled to implemented differentiated instruction in classrooms (Tomlinson, 2017). In part, this is because few differentiation plans were effective across diverse classroom settings (Tomlinson, 2017). Adding to the perplexing nature of differentiated instruction, the existing literature showed consistent increases in student achievement in response to differentiated instruction. However, few studies have provided specific guidelines for effective strategies to implement differentiation in the classroom (Abbati, 2012; Allen, 2012; Ashley, 2016; Boaler & Staples, 2008; Dean & Zimmerman, 2012; DeJarnette et al., 2014; Dekker & Elshout-Mohr, 2004; Esmonde, 2009; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016).

The purpose of this study was to examine one particular tool for differentiating instruction, the Math Workshop Model, to determine its effect on students' academic achievement and mindset in sixth-grade mathematics. Using a quasi-experimental method, the researcher collected quantitative data to determine whether students in the sample population receiving differentiated instruction through the Math Workshop Model showed a difference in academic achievement on district administered grade-level benchmark assessments and the Mindset Survey, which measured students' growth or fixed mindset attributes.

## Research Questions

1. What is the relationship between differentiated instruction through implementation of the Math Workshop Model and academic achievement of students in sixth-grade mathematics?

2. How does a learning environment based on implementing the Math Workshop Model affect students' perceptions of their own mathematical ability, or mathematical mindset, in sixth-grade?

**Rationale, Relevance, and Significance of the Study**

While existing research on differentiated instruction offered significant relevant data to the mathematics education community, specific areas were left unaddressed. The literature and research on differentiation that was reviewed did not propose any specific method of differentiating mathematics instruction, especially at the secondary level (Abbati, 2012; Allen, 2012; Dean & Zimmerman, 2012; DeJarnette et al., 2014; Dekker & Elshout-Mohr, 2004; Esmonde, 2009; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016). This study addressed the lack of differentiation strategies identified in prior research on differentiation. Additionally, the research reviewed deficient in analyzing differentiation at the secondary level. Neuroscience research highlighted important developmental differences among adolescents, particularly those in middle and high school (Armstrong, 2016; Jensen & Snider, 2013). These findings showed that student-centered strategies incorporating peer interaction were more effective than the teacher-centered approaches that have been the crux of mathematics education (Armstrong, 2016). With little existing research performed at the secondary level, a need existed to examine the effects of differentiation instruction using strategies that targeted the specific developmental stages of adolescents during this period of time (Armstrong, 2016). This study examined an instructional tool, the Math Workshop Model, that incorporates differentiation, activities especially designed for middle and high school students' developmental phases, and equitable opportunities for high quality mathematics instruction for all learners (Hoffer, 2012).

This study was designed to determine the relationship between the Math Workshop Model and students' academic achievement in sixth-grade mathematics as well as students' mathematical mindset. For this reason, the results of this study had significant implications for mathematics education. Unlike other research on differentiation, this study reviewed a specific differentiation tool, the Math Workshop Model, and gathered data on students' academic achievement. Teachers, principals, and other administrators could find the results of this study relevant as they search for instructional tools to improve the achievement of secondary mathematics students in their schools. Other researchers may use the results from this study to explore differentiation using the Math Workshop Model by expanding the sample population or incorporating more qualitative components. In this way, this study could help promote reform in mathematics education on many levels.

## Definition of Terms

**Academic achievement**. This term is defined as the accomplishment of education through higher learning principles (Nugent, 2013).

**Benchmark assessments**. This term is defined as periodic assessments given throughout the school year at predetermined times used to establish baseline achievement data and to measure student progress toward predetermined academic standards (Herman, Osmundson, & Dietel, 2010).

**Constructivism**. This term is defined as the paradigm that learning is active. Students are responsible for building new constructs using their own perceptions and meanings by linking new information with prior knowledge and experiences through social negotiations (Loyens & Gijbels, 2008).

**Differentiated instruction**. This term is defined as instruction that "provides different avenues to acquiring content, to processing or making sense of ideas, and to developing products so that each student can learn effectively" (Tomlinson, 2017, p. 1).

**Equity of opportunity**. This term is defined as teaching practices that ensure all students, regardless of gender, race, socioeconomic status, or previous experiences in mathematics are given the same opportunities to make progress toward their mathematic goals (Boaler, 2016b).

**Formative assessment**. This term is defined as "a collection of practices with a common feature: They all lead to some action that improves learning. It is the use of the information gathered, by whatever means, to adjust teaching and learning" (Chappuis. 2012, pp. 4–5).

**Galileo assessment system**. This term is defined as banks of more than 95,000 assessment items, including more than 15,000 technology enhanced items aligned to local state standards in grades K–12 math, English/Language Arts (ELA), and science, with 800 new items added monthly, used to build benchmark and formative assessments. Many types of pre-built and customized district, school, and classroom assessments can be administered offline and online supporting existing district assessments (ATI, 2002).

**Growth mindset**. This term is defined as the extent to which a person's believes that their talents, aptitude, and interests are not set at birth but can change and grow over time through experiences and effort (Dweck, 2016).

**Heterogeneous groups**. This term is defined as groups of students who have a variety of different genders, races, socioeconomic levels, and/or academic ability levels (Boaler, 2016b).

**Homogeneous groups**. This term is defined as groups of students who are put together because of similar traits such as gender, race, socioeconomic levels, and/or academic ability levels; also known as academic tracking (Boaler, 2016b).

**Learning goals/targets**. This term is defined as clearly defined statements of intended learning outcomes for teachers and students (Stiggins, 2017).

**Limbic system**. This term is defined as a collection of brain structures in the midbrain that is believed to be the center for emotional responsiveness, motivation, memory formation and integration, olfaction, and self-preservation (Jensen & Snider, 2013).

**Math Workshop Model**. This term is defined as a tool for differentiation that cultivates communities of mathematical learners engaged in classroom discourse, conferring with the teacher, small-guided group instruction, and assessment for learning which promotes equitable learning opportunities for all students (Hoffer, 2012).

**Mathematical mindset**. This term is defined as a belief that the ability to succeed in mathematics is not innate but can be cultivated through productive struggle, learning from mistakes, and engaging in rich mathematical activities (Boaler, 2016b).

**Middle school**. This term is defined as an intermediate stage of schooling between elementary school and high school, usually encompassing grades five or six through eight in which teachers employ a team concept to educate the whole child (Association for Middle Level Education, 2012).

**Pretest**. This term is defined as a preliminary test to determine a student's baseline knowledge or preparedness for an education experience (Chappuis, 2015).

**Prefrontal cortex**. This term is defined as the area of the brain that controls impulse and emotional reactions, complex planning, the ability to ignore external stimulus, and prioritize information. The prefrontal cortex is still developing during adolescence (Jensen & Snider, 2013).

**Posttest**. This term is defined as a test given after a lesson or period of instruction to determine what the student has learned (Chappuis, 2015).

**Secondary mathematics**. This term is defined as mathematics taught in middle and high schools (University of Maryland, 2017).

**Small group learning**. This term is defined as small group learning is an instructional strategy where students are placed in groups of three to five student based on pre-determined criteria for the purpose of intentional, targeted instruction (Hoffer, 2012).

**Social cognition**. This term is defined as the mental operations that play key roles in such developing one's capacity for social interactions as one's perceptions and interpretations, as well as the responses one has to the intentions, dispositions, and behaviors of other people (Pink, Penn, Green, Buck, Healey, & Harvey, 2013).

**Student-centered learning**. This term is defined as student-centered learning is an instructional strategy where students play a large role in dictating the action of learning by exploring ideas and finding their own meanings, having choices in the ways in which they will engage in learning new content. The teacher's role is to facilitate meaningful opportunities for students to engage with the subject matter (Tomlinson, 2017).

**Student discourse/collaboration**. This term is defined as a learning strategy in which two or more students work together to compare work, evaluate the worthiness of each other's claims based on evidence presented, build on existing understanding, reach consensus or come to a mutual understanding (Hattie, Fisher, Frey, Gojak, Moore, & Mellman, 2017).

**Synaptic pruning**. This term is defined as the neurological process whereby, when new information is taken in and processed by the brain, new synapses are created, and existing synapses grow stronger, causing the need for older, lower quality connections between neurons to be shed (Paolicelli, Bolasco, Pagani, Maggi, Scianni, Panzanelli, Giustetto, Ferreira, Guiducci, Dumas, Ragozzino, & Gross, 2011).

**Technology enhanced assessment items**. This term is defined as computer delivered assessment items that can include extended selected response, drag and drop, selectable text, interactive classifying, interactive ordering, dropdown editing, and performance events (Assessment Technology, Incorporated, 2002).

**Urban population**. This term is defined as all territory, population, and housing units located within and urbanized area or an urban cluster. The Missouri Census Bureau delineates urbanized area and urbanized cluster boundaries to encompass densely settled territory, which consists of core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile (Missouri Census Data Center, 2017).

**Whole group instruction/activities**. This term is defined as an instructional strategy in which the teacher delivers instruction or activities to all students in a class without significant modification due to any specific criteria; all students receive the same message or the same activity (Tomlinson, 2017).

**Zone of proximal development**. This term is defined as the area of learning where students' understanding is stretched past where they are comfortable into a place where students are challenged (Hattie et al., 2017).

## Assumptions, Delimitations, and Limitations

**Assumptions.** To assure the validity of the results of this study, certain behaviors and expectations were assumed to be true. The assumptions of this study regarded the instruments used to measure the dependents variables, as well as the implementation of the Math Workshop Model. Benchmark assessments and the Mindset Survey, both instruments used to measure the dependent variables, were assumed to valid and reliable tools to measure students' academic success. Teachers of the students in the study were assumed to implement the Math Workshop Model with fidelity. It was assumed that students randomly assigned to the study remained in the study for its entirety.

**Delimitations.** The delimitations of this study were associated with the sampling method chosen by the researcher. In an attempt to control some of the limitations posed by implementing the Math Workshop Model, a purposive sampling method was preferred over random sampling (McMillan, 2012). Curriculum and instructional complications among seventh and eighth grade students created more homogeneously grouped students. In turn, there was greater potential for the results to be altered by homogeneously grouped students. For this reason, the sample population was restricted to sixth-grade rather than conducting the study over multiple grade levels. In the participating district, sixth-grade students received the most equitable curriculum and instruction.

Another reason the researcher chose a purposive sample was to control the limitation of teachers' implementation of the Math Workshop Model. Students were selected to participate in the study based on their teachers' experience and knowledge of the Math Workshop Model. These teachers had both prior knowledge of the Math Workshop Model and participated in professional development on implementing the strategy prior to the beginning of the school year. By choosing only students whose teachers had knowledge of and training in the Math Workshop

Model, the researcher attempted to strengthen the validity of the study by ensuring students would experience the Math Workshop Model with fidelity. This purposive sampling created a delimitation, however, by not selecting students at random to generate a more representative sample (McMillan, 2012). Purposive sampling also generated a sample that was almost three times the size of the suggested sample size when a power analysis was performed to determine the necessary sample size (Statistical Solutions, Limited Liability Company, 2017).

**Limitations.** The limitations of this study involved the implementation of the Math Workshop Model and the time of the year when the study was performed. Despite using a purposive sampling method to minimize the effect of teachers' implementation of the Math Workshop Model, implementation of the Math Workshop Model was still a limitation. The teachers' understanding of the Math Workshop Model, their belief in its effectiveness to differentiate instruction, and the fidelity with which they implemented the Math Workshop Model throughout the study could have influenced the study. The researcher provided professional development on implementing the Math Workshop Model prior to the start of the school year and provided on-going support throughout the study to attempt to minimize the limitation. Another limitation of this study was the timing. The research phase officially began in January, approximately four months after students began the school year. During these four months, students were engaged in learning activities, some associated with the Math Workshop Model, that impacted their academic achievement. The researcher used archived assessment data to establish a clear baseline of what students knew before the study was initiated to ensure the benchmark data was valid for the time of the study.

## Summary

Recent data has shown secondary mathematics students in the United States falling behind academically, and without reform in mathematics education in the United States, this trend was likely to continue (Heim, 2016). However, mathematics education reform was difficult to implement. Mathematics education organizations, such as the NMCT (Koestler et al., 2013) have argued for major shifts in the way students learn mathematics, calling for students to collaborate with peers and engage in critical problem solving rather than relying on rote memorization. Instructional decisions in many secondary mathematics classrooms reflected the practices teachers know best and what they were comfortable doing, rather than what research indicated students needed and should be doing (Webel, 2010).

Research suggested that, in order to improve learning outcomes, mathematics students should engage in solving rich math problems, while collaborating with their peers to build on their existing knowledge and experiences (Boaler, 2016b; Hoffer, 2012; Hattie et al., 2017). Previous studies reviewed the practices of differentiated instruction and student grouping to address the shift from teacher-centered strategies to student-centered strategies experts say are necessary for student success in mathematics (Abbati, 2012; Allen, 2012; Ashley, 2016; Boaler & Staples, 2008; Dean & Zimmerman, 2012; DeJarnette et al., 2014; Dekker & Elshout-Mohr, 2004; Esmonde, 2009; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016). This study examined the relationship between differentiating instruction through implementation of the Math Workshop Model and students' academic achievement and mindset in sixth-grade mathematics.

This dissertation presented the rationale for, methodology of, and data associated with this study in five chapters. The first chapter included an introduction of the problem addressed in the study, an explanation of the purpose and significance of the study, and brief review of the background and context of the problem. The second chapter provided a conceptual framework for this study and reviewed the existing literature on constructivism, differentiated instruction, and mathematical mindsets. The third chapter presented the methodology used to develop and implement this study. The fourth chapter summarized the results of this study and analyzes the data. The final chapter, Chapter 5, summarized and discussed the results of this study, including conclusions based on these results.

# Chapter 2: Literature Review

Until recent decades, education theorists and practitioners believed that individuals who did not exhibit natural ability in a certain subject area or possess an innate talent to perform an activity would never be able to succeed in these areas (Dweck, 2016). Intelligence and ability were believed to be predetermined and finite. Through recent research in neuroscience, along with the work of people such as psychologist Dweck (2016), the seemingly outdated fixed ability mindset belief was challenged. Shifts in beliefs regarding the elasticity of intelligence led educators to rethink how to engage students in meaningful learning, especially in mathematics (Boaler, 2016b).

By an early age, many mathematics students developed a negative mindset regarding their ability to learn math, even when exposed to high quality teaching (Sun, 2018). Students retained this mathematical mindset for the rest of their educational career (Dweck, 2016). By middle school, many students developed deep-rooted opinions of their abilities in mathematics, and these opinions were negative for the vast majority of students (Boaler, 2016b). Students' mindset about their mathematical abilities, or lack thereof, often directly resulted from the instructional methods that were used and learning environments that were created by their math teachers (Boaler, 2016b). Understanding the effects classroom activities had on students' self-images and confidence as mathematicians helped teachers realize their roles in facilitating students' creation of their mathematical mindset (Sun, 2018).

## Study Topic

The standards to which students were held accountable in mathematics became more rigorous across the United States in the last decade due to the introduction of the Common Core State Standards for mathematical practice (National Governors Association Center and Council of Chief State School Officers, 2010). Parents and education policymakers expected more of students and mathematics teachers, but students continued to enter mathematics classrooms with different skills sets and ability levels (Boaler, 2016a). Teachers were expected to provide instruction so that all students, no matter their starting point, reach proficient levels on standardized assessments by the end of the academic year (Mattos, 2015). Differentiation was topical in education, especially in mathematics, for many years (Mattos, 2015; Tomlinson, 2017). Educators recognized the need to create multiple learning opportunities for the diverse needs of their students. Differentiated instruction, however, was challenging for teachers to implement (Tomlinson, 2017). The challenge of differentiating instruction led to inconclusive evidence for the effectiveness of the strategy (Abbati, 2012). Teachers' instructional strategies affect the degree to which differentiation is achieved in classrooms with heterogeneous students (Tomlinson, 2017).

Traditionally, most mathematics teachers opted for whole group instruction because it was the most prevalent instructional strategy in classrooms for decades (Leinwand, 2012). In addition, many teachers found whole group instruction easier to implement than other instructional strategies (Allen, 2012). However, recommendations from organizations such as the NCTM, changes to mathematics standards, and new challenges presented by a twenty-first century global economy forced mathematics teachers to identify alternative strategies to whole group instruction to increase student achievement (Au, 2011).

Recent research indicated that students learn mathematics effectively when they can engage with their peers in small groups so they can discuss problem solving and work collaboratively (Armstrong, 2016; Hattie et al., 2017). Sammons (2010) proposed guided instruction through small group learning as an alternative instructional strategy. In *Guided Math*, Sammons (2010) provided teachers with a structure that infused an environment of numeracy with an instructional plan that allowed teachers "to adapt instructional methods to accommodate all levels of learners" (p. 17).

While research indicated the benefits of a small group instructional strategy over whole group instruction, research and literature remained unclear how students should be grouped (Yee, 2013). Providing a more structured approach to small group instruction, in which teachers used data from formative assessment to create flexible groups and build an instructional plan, allowed teachers to combine small, guided instruction with independent student work time (Hoffer, 2012). A structure based on these criteria gave teachers the opportunity to work with small groups of students with similar learning needs, providing them specific feedback to promote their academic growth while the rest of the class engaged in independent activities (Lempp, 2017). With the flexibility to focus on individual students' needs and provide rigorous challenges to all students, small group learning strategies promoted equitable opportunities for all students regardless of mathematical ability (Esmonde, 2009).

Small, guided group instruction was only one piece of the instructional puzzle. Teachers' provision of targeted interventions based on formative assessments was a short-term solution that yielded some positive results, and interventions based on data driven decisions alone did not develop students' capacity for independent thinking and problem solving (Webel, 2010). To achieve transformative results in mathematics education, it was necessary to explore the effects of strategies that also attempted to create equitable and respectful learning environments in which students were autonomous and understood their value in the learning community. According to Boaler's and Staples' (2008) research, students who learned to appreciate their peers' perspectives rather than assigning labels such as smart or dumb enhanced their own ability to solve problems, deepening their conceptual understanding of mathematics.  The process in which teachers created these learning communities contributed to the success or failure of students meaningfully engaging in mathematical discourse (Webel, 2010).

**Statement of Problem**

According to standardized test results from the PISA assessment program, students from the United States ranked 18th in the world in mathematics performance in 2009 (National Center for Education Statistics; Institute for Educational Sciences, 2016).  Since 2009, achievement data of students in the United States has dropped, pushing the world rank of 15-year-old students to 38th (National Center for Education Statistics, Institute for Educational Sciences, 2016).  From 2009 to 2015, academic achievement scores for 15-year-old students in the United States in mathematics decreased by 3.5% (National Center for Education Statistics, Institute for Educational Sciences, 2016).

The PISA assessment data suggested the need to reform in mathematics education in the United States (Heim, 2016).  Recent research indicated that mathematics educators were ill-prepared to implement differentiated instruction to educate students with varying academic abilities in heterogeneously mixed classes (Boaler, 2016b).  Quantitative studies were conducted to investigate the relationship between differentiated instruction and students' academic achievement in mathematics at the elementary level.  In addition, some action research was conducted on differentiated instruction by implementating strategies like the Math Workshop Model (James, 2013; Kelly, 2013; Legnard & Austin, 2012). However, James (2013) and Kelly(2013) addressed a broad understanding of differentiation as it related to student achievement in elementary mathematics or focused on a narrow subset of students, such as low achieving students in their studies.  A need remained for quantitative research on the effect of differentiated instruction provided through the Math Workshop Model on the academic achievement of students in secondary mathematics.

The Math Workshop Model was a strategy of differentiation that offered teachers a more equitable alternative to whole group instruction (Hoffer, 2012). Many teachers felt more comfortable with whole group instruction as a strategy because that is how they learned mathematics and, for the most part, how they were trained (Leinwand, 2012). Whole group instruction was a teacher-centered instructional strategy that allows a large amount of information to be shared with the entire group of students, often minimizing the amount of preparation time on the part of the teacher (McLeod, Fisher, & Hoover, 2003).

During whole group instruction, teachers conveyed the same instructional message to all students, regardless of the students' ability level or readiness to receive the information presented (McLeod et al., 2003). However, small group learning as an alternative to whole group learning was not always been implemented in a way that led to true differentiation and the opportunity for students to learn at their own level (Boaler, 2016a). Instead, some teachers approached small group learning by placing students into heterogeneous groups in which one student was identified as the content expert (Boaler, 2016a). The literature did not show that heterogeneous grouping encouraged all students to engage in collaborative learning in small group settings (Webel, 2013).

When placed in homogeneous groups, students developed mindsets that tracked their learning paths for the future and created labels regarding their ability that followed them throughout their educational career, especially in mathematics (Boaler, 2016b). The Math Workshop Model allowed for small group strategies to be implemented along with other strategies that promote equity among students so students could receive instruction at the appropriate level (Hoffer, 2012). Differentiating instruction to meet individual students needs was designed from formative assessment data, providing targeted and timely instruction, and creating instruction using more relevant and timely evidence of students' performance (Tomlinson, 2017). Providing interventions based on timely, formative data which changed as the needs of students changed offered teachers an alternative to limiting students to a permanent track of learning (Chappuis, 2015).

## Research Questions

1. What is the relationship between differentiated instruction through implementation of the Math Workshop Model and academic achievement of students in sixth-grade mathematics?
2. How does a learning environment based on implementing the Math Workshop Model affect students' perception of their mathematical ability, or mindset, in sixth-grade?

## Significance

Mathematics education in the United States reached a critical crossroads (Leinwand, 2012). Leaders in education argued for a paradigm shift away from an era of high stakes, accountability-driven testing that kept many teachers in fear of failure, restricting their instruction to outcome-based rather than learning centered practices (Au, 2011). Teachers adopted instructional practices that were not always in the best interest of the learner's developmental, social, and learning needs, but were chosen for the sake of the assessment that teachers knew would be the measure of their quality as an educator (Au, 2011). High attrition rates in the field of education were recorded throughout the era of high-stakes testing, and one study indicated a possible relationship between these elevated rates and teachers' dissatisfaction in the moral value of the work they were asked to perform (Santoro, 2011). Santoro (2011) concluded that refocusing the attention of teachers' work from outcomes such as high-stakes testing to meeting individual need of all students addressed the moral values missing from teachers' work. Classrooms in which the Math Workshop Model was implemented create collaboration, equity, and challenging experiences for all students (Hoffer, 2012) that provided teachers with more sense of value in their work.

New research in neuroscience, as well as an increased emphasis on students being college and career ready, compelled teachers to reconsider their instructional choices (Boaler, 2008, 2016). This study sought to measure the effects on students' academic performance and mindset in sixth-grade mathematics when teachers implemented the Math Workshop Model, providing learning opportunities that were student-centered, individualized for students' specific needs, and designed to promote an equitable and collaborative learning community (Hoffer, 2012). Exploring the effect of these instructional shifts on students' academic achievement and mindset in sixth-grade mathematics had significant implications for students preparing to enter a twenty-first century, global economy (Bellanca, 2016). As adults, today's students needed the ability to think critically, creatively, and innovatively, communicate their ideas with others, collaborate to improve their own ideas and the ideas of others, and persevere in problem solving (Larson & Miller, 2011).

The results of this study on the effects of the Math Workshop Model sought to offer strategies to evaluate students on academic criteria in ways that allowed for targeted, specific interventions while providing opportunities for heterogeneously grouped students to share their individual experiences with peers, allowing all students to collaborate and extend past their previous experiences (Boaler, 2016b; Hoffer, 2012). In this way, the researcher contributed to the existing literature on mathematics education. Historically, teachers of mathematics have felt pressure to keep instructional practices within the constraints of curriculum or guidelines given to them by local or state leaders (Au, 2011). This researcher, however, sought to change the narrative for mathematics teachers by examining the relationship between differentiating instruction through implementing the Math Workshop Model and students' mathematic achievement and mindset in sixth-grade.

In addition, the results of the study of the effects of the Math Workshop Model on students' mathematical achievement could contribute to changes in mathematics education in the district in which the study took place. For several years, the participating district desired to create an effect plan at the secondary level to implement Response to Intervention (RTI). The work of Mattos (2015) was the district's foundation for its RTI plan. However, mathematics teachers at the secondary level struggled to translate Mattos' (2015) work to a working model for mathematics classes. By studying data on the relationship between differentiated instruction by implementing the Math Workshop Model and students' academic achievement and mindset in sixth-grade mathematics, the researcher hoped to provide evidence clarifying the district's attempts to establish a plan for RTI and the secondary level.

**Organization**

In this chapter, the existing literature was reviewed to illustrate the interconnectedness of instructional grouping strategies, social learning theory and constructivism, and neuroscience research and their applications to classroom instructional strategies. First, the conceptual framework upon which the study was based was outlined. The conceptual framework was created after an examination of empirical, theoretical, and experimental literature that explored the effects of different grouping strategies, social learning, and brain research on students' academic achievement, as well as students' genuine interest in mathematics. The conceptual framework was selected based on a review of the influence of constructivism and social learning theory on mathematical education at an empirical and theoretical level. Much of the existing literature focused on the effects of collaboration on students' learning and teachers' role in achieving positive student collaboration (Allen, 2012). Qualitative studies in which researchers explored topics such as establishing patterns of high quality collaboration were explored (Krahenbuhl, 2016). Quantitative studies in which researchers sought to determining the effect of collaboration on teacher and student perceptions of learning were also reviewed (Zain, Rasidi, & Abidin, 2012). Further support for the application of constructivist ideas in mathematics education was offered in the conceptual framework through empirical literature from professional journals from various disciplines. Many studies analyzed the development of group work structures, with particular attention being paid to researchers' methods to standardizing instructional practices, measuring student outcomes, and determining the level of success of the group work structures (Abbati, 2012; Ashley, 2016; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016).

Following the conceptual framework, other theories and practices were reviewed that supported the main conceptual theory of constructivism. The review of other theories and practices included research on the effects of recent neuroscience studies on mathematics education that supported conceptual theories of constructivism and social learning theory (Armstrong, 2016; Boaler, 2016b; Dweck, 2016; Jensen & Snider, 2013). For example, the physiology of the adolescent brain, especially of middle and high school-aged children, was different than scientists and educators once thought, and the differences influenced educational practices for students at these levels (Armstrong, 2016; Jensen & Snider, 2013). Notably, the discovery of the adult brain's capacity for elasticity led to Dweck's (2016) work on growth mindsets.  Dweck's (2016) work spawned a subset of theoretical literature in mathematics education, targeting the idea that students acquired new perceptions of mathematics as a subject in which everyone can learn to be successful rather than a subject one is naturally born to do (Boaler, 2016b).  Multiple studies were submitted in this chapter that connected insights from neuroscience to mathematics education, as well as research that noted the limitations of doing so.

In addition, theories of differentiated instruction were examined throughout the chapter as they supported constructivism and social learning theory.  The analysis of differentiated instruction through a constructivist and social learning theory lens revealed that the prevailing historical discussion surrounding the instructional strategies, especially in regard to mathematics, was how to group students most effectively (Yee, 2013).  Data on this topic have suggested different findings.  However, studies reviewed in this chapter supported heterogeneous grouping of students paired with targeted, relevant, and timely interventions for individual students or small groups of students (Boaler & Staples, 2008; Merritt, 2016; von Duyke & Matusov, 2016;). Theoretical literature demonstrated that students grouped heterogeneously in mathematics had opportunities to achieve at high levels (Dean & Zimmerman, 2012).

Different types of data were provided in the literature review that supported the effect of constructivist practices and social learning theory on mathematics education and students' academic achievement in math.  The empirical, theoretical, and systemic reviews were examined, compared, and synthesized to form the basis of the current study.  The research methodologies were analyzed for issues that may have impacted this study, including bias in the sampling, the methods that were chosen for the study, and the way in which the study was implemented.

The findings of the literature review were synthesized and critiqued, and the results were provided in the next sections of the chapter.  The critique examined whether the studies used the appropriate evidence, claims, and concepts to scientifically prove assumptions.  In other words, the processes researchers implemented were assessed for validity (McMillan, 2012).  The chapter concluded with a summary of the literature that was reviewed.

**Theoretical Framework**

The theoretical and practical relevance of the basis for this study was established by the conceptual framework.  Studying the effect of differentiated instruction through the implementation of the Math Work Shop Model on students' mathematical achievement implied that students had individual needs and experiences that should be reflected in teachers' instructional decisions (Hoffer, 2012).  The notion that students' experiences and understandings of concepts played a role in their learning environment aligned to a constructivist theory of learning (Krahenbuhl, 2016), making constructivism a critical component of the conceptual framework of this study.

Traditionally, mathematics was taught using strategies that were predominantly teacher-centered and involved students in a passive learning role (Allen, 2012).  In light of challenges students faced as they enter the twenty-first century global economy, as well as insights from research on instructional practices, educators came to understand the need to engage students in active classrooms (Larson & Miller, 2011).  Learning environments that provided students with equal opportunities to articulate their thinking, critique the arguments and thinking of their peers, and build knowledge in context of their previous experiences and prior knowledge maximized learning (Allen, 2012).  Implementing the Math Workshop Model created this type of equitable learning environment (Hoffer, 2012).

Constructivist learning theory emerged as one of the most influential theories in twenty-first century mathematics education (Liu & Chen, 2010). At the heart of constructivist theory was the argument that "knowledge is not discovered but is rather by constructed the human mind" (Krahenbuhl, 2016, p. 98). Students learning in classrooms in which constructivist theory influenced instruction were engaged in questioning peers, analyzed information, and synthesized ideas to develop new understandings based on previous experiences (Liu & Chen, 2010). Student-centered activities such as engaging in meaningful discourse, testing the validity of the arguments of others, and collaborating to synthesize new meaning were of particular importance in mathematics instruction because of the emphasis placed on these skills by organizations such as NCTM, the Nationals Governors Association Center for Best Practices (NGA Center), and the Council of Chief State School Officers (CCSSO) (Koestler et al., 2013).

The NCTM recommended process standards for mathematics, including problem solving, reasoning and proof, communication, connections, and representation (Koestler et al., 2013). The NGA Center and CCSSO (2010) proposed similar process standards in the Common Core State Standards and Standards for Mathematical Practice. By defining the focus of mathematical instruction on acquisition and demonstration of knowledge, these organizations transitively endorsed a constructivist approach to learning (Koestler et al., 2013). The recommendations of professional organizations to focus on activities based on collaboration and discourse supported teachers utilizing strategies that aligned with constructivist theory (Au, 2011).

Through empirical and theoretical reviews, along with experimental research studies, researchers built on the topic of constructivism in the classroom. DeJarnette et al. (2014) and Allen (2012) analyzed qualitative data to find patterns and trends in effective collaborative group work in secondary mathematics classrooms, strategies that were pillars of constructivist learning theory (Krahenbuhl, 2016). In one study performed at the middle school level, mathematics classrooms were observed, and collaborative groups were measured against the observers' ideas of what constituted a positive collaborative environment (DeJarnette et al., 2014). The study resulted in recommendation of strategies for teachers to use and model to make students' collaborative group work more effective and included excerpts of student interactions that illustrated barriers to collaboration if students were not given the proper tools (DeJarnette et al., 2014). Another empirical study reviewed the correlation between the way teachers create learning environments and the effectiveness of student collaboration (Allen, 2012). The review of empirical and informal research yielded cultural, structural, and nurturing standards that teachers can implement to build constructivist classrooms that foster collaborative learning (Allen, 2012).

Zain et al. (2012) examined evidence to support the constructivist theory that students learn most effectively through collaboration with their peers. The authors investigated the effect of student-centered learning on students' and teachers' perception of learning. The results of this quantitative study were based on questionnaires given to 128 participants. This study of student-centered learning analyzed questionnaire responses in a quantitative manner, and the researchers concluded that students and teachers felt student-centered learning increased students' confidence in the content (Zain et al., 2012). However, this study included no academic element to validate the opinions of students and teachers who participated in the survey (Zain et al., 2012). In addition, the researchers provided no scale for the questionnaire to explain their statistical analysis. The researchers indicated the study was quantitative (Zain et al., 2012), but the conclusions drawn were based on interviews conducted with the participants (a qualitative measure), as well as the quantitative results from the questionnaire. The collection of qualitative data for analysis in a study identified as a quantitative study limited the usefulness of its results (McMillan, 2012). Despite collecting the wrong type of data for the method of study indicated by the researchers, the results of the study indicated that learning in student-centered activities had greater effect on students' and teachers' attitudes towards learning than learning that put students in passive roles (Zain et al., 2012). The study performed by Zain et al. (2012) supported the benefits of constructivist learning practices in classrooms.

## Review of Research Literature and Methodological Literature

**Constructivism.** The way children acquired knowledge was the subject of much debate and research in the educational community for many decades (Armstrong, 2016). In the 1920s, Jean Piaget, Theodore Simon, and Alfred Binet set the standard in educational theory, attempting to prove a correlation between a child's age and their capacity for learning (Erneling, 2012). Piaget refined the group's research based on further analysis to hypothesize that a child's individual learning path was affected by predictable stages of development as well as personal life experiences (as cited by Ashley, 2016). More researchers and educators added to this body of work, leading to the educational theory known as constructivism (Lui & Chen, 2010). There were varying interpretations of constructivist theory as it pertained to instructional strategies. However, the prevailing definition of the theory centered on students creating meaning in new situations using their own prior knowledge and experiences to construct new knowledge or understanding (Krahenbuhl, 2016). In a constructivist classroom, students facilitated their learning under the watchful eye and guidance of a teacher who understood how to allow students to develop their own meaning and understanding (Kelly, 2013).

Through the literature reviewed for this study, a common misconception among supporters and non-supporters of constructivism was highlighted, that is, that constructivist instruction engages students in creating meaning through physical, hands-on activities (Krahenbuhl, 2016). However, studies showed that the nature of the activity needed not be physical for students to be engaged in developmentally appropriate tasks that allowed them to compose information schemas using their prior knowledge (Pilgrim, 2010). Another misconception in the relevant literature was that students could not learn in a constructivist classroom by receiving information from the teacher in a direct, passive manner (Ashley, 2016). However, research indicated that even teacher-centered instructional practices—which, by definition, are not aligned to constructivist theory—can have a strong effect size on learning in appropriate settings (Hattie et al., 2017).

Research suggested the need for mathematics teachers to recognize when students have enough understanding to facilitate their own learning and when the teacher must play a more active role in learning (Hill, 2012). Unique lesson structures that allowed for different styles of learning within the same time frame in order to accommodate multiple instructional strategies helped teachers to offer opportunities for students to work independently while also being free to facilitate learning when students needed more assistance highlighted the need for (Hoffer, 2012). Ashley (2016) demonstrated that Math Workshop Model allowed students to experience freedom to explore, construct their learning in an independent way, and receive more direct and specific instruction from the teacher. Ashley (2016) explored the effects of implementing the Math Workshop Model on students' mathematics academic achievement by presenting teachers with the Math Workshop Model for instruction and tracking the frequency and fidelity with which they implemented this model. Ashley's (2016) data showed that adult behaviors were not consistent when implementing the Math Workshop Model, nor were the teachers' strategies for grouping students.

***Constructivism and grouping strategies.*** One fundamental characteristic of constructivist theory was the idea that children's ability to construct learning and meaning depended in part on the social interactions in which they participated (Krahenbuhl, 2016). When given the opportunity to work in social situations, such as group work structures, research found students tended to accept more autonomous roles in learning (Boaler, 2016a). In mathematics classes, this autonomy translated to students learning at deeper, conceptual levels (Ghousseini et al., 2017). Students working in groups, as opposed to a whole group, lecture-based instructional model, were grouped in different ways with different results. With little to no guidance on grouping strategies, however, students ended up in groups that may not lead students to acquire deeper, conceptual learning or an autonomous role in their learning (Dean & Zimmerman, 2012). For most students, these ill-conceived grouping strategies were the equivalent of independent work with an alternative seating arrangement (Hattie et al., 2017).

Clear behavior goals were established when students were engaged in effective group work (Allen, 2012). Modeling well-defined roles was essential to establishing constructivist learning environments (Allen, 2012). For example, collaborative learning strategies utilized roles along with a common group goals or rewards to encourage equitable participation in group work. Hattie et al. (2017) indicated that the effect size for cooperative learning versus individual learning was 0.59, which is within the zone of the desired effect. However, encouraging engagement through promotion of group goals contradicted the ideals of constructivist theory (Krahenbuhl, 2016). Students who are motivated by a reward to produce a group-based product did not always develop their own true meaning (Dweck, 2016).

In the literature reviewed for this study, von Duyke and Matusov (2016) suggested ways to structure group work that aligned with constructivist theory, allowing students to make meaning of real-life scenarios and use their own experiences and understanding to communicate their solutions through discourse with peers and teachers. The results presented by von Duyke and Matusov (2016), however, indicated that adults often exerted their influences and learning constructs on students when the students' mathematical modeling did not fit within the teachers' preconceived ideas of the learning. When teachers established a culture of trust and equity in their classroom, however, students were more likely to participate in group tasks, fulfilling their individual learning needs, as well as ensuring that everyone in the group succeeded (Allen, 2012). Rather than hampering creative thinking and student collaboration by imposing a predetermined learning model on students, a constructivist model, such as the Math Workshop Model, employed strategies that encouraged students to think freely and advancement not matter what their ability (Lempp, 2017). Students who were taught to see past cultural, social, and academic differences extracted information from situations that helped them build new knowledge schema (Allen, 2012).

The role of the teacher in facilitating group work was documented throughout the literature reviewed. However, the relevant literature did not often offer evidence on the effectiveness of group work from students' perspective (Jansen, 2012). Some study results indicated that students perceived different goals during group work, even after the teacher had taught explicit behaviors and expectations (Webel, 2013). The literature reviewed for this study supported student collaboration as a constructivist-learning tool that allowed individual students the freedom to retain relevant information and create new knowledge (Blanke, 2018; Boaler & Staples, 2008; Coomes & Lee, 2017; DeJarnette et al., 2014; Ghoussenini et al., 2017;). However, the research reviewed was not as consensual when determining procedures for establishing high quality group work that ensure all students working collaborative were focused on the same learning goals.

While clearly defined behavioral norms and individual roles facilitated collaboration, the way in which teachers created groups also determined the culture generated in a classroom (Boaler, 2016a; Merritt, 2016; Stankov, Glavinic, & Krpan, 2012; Sun, 2018). The literature and research reviewed suggested that students' and teachers' involvement in creating the groups in which students collaborate affected the outcomes achieved by the group. In one action research study researchers analyzed the impact of different methods of grouping students on academic achievement (Stankov et al., 2012). In the study, teachers assigned groups based on a set of academic criteria, then teachers allowed students in a portion of the class to choose their own groups. The academic results of the two groups were compared and results showed that students choosing their own groups scored slightly higher than those who were placed in groups by the teacher, but researchers noted the grading structure of the course in the study skewed the data, preventing the researchers from determining the potential relationship between how groups were formed and academic performance (Stankov et al., 2012). However, the researchers observed that groups formed based on social preferences of the students rather than academic abilities engaged in more substantial discourse (Stankov et al., 2012). Other research reviewed supported this conclusion. Hattie et al. (2017) surmised the effect size for ability grouping, grouping students based on similar academic criteria, to be 0.12, a measure indicating the strategy had low impact on learning.

Ability grouping, however, was one of the most frequently used grouping strategies by mathematics teachers over recent decades, whether in the form of small groups within one classroom or in the form of tracking students into certain courses (Boaler, 2016b). Whichever form it took, the research reviewed shows that all students who were placed into groups based on their academic ability did not have the same opportunities to experience mathematical learning as those who were grouped heterogeneously (Boaler, 2016b; Yanisko, 2016). Grouping strategies based on social, cultural, academic, and other factors and allowed for flexibility in the grouping structures were optimal for student learning (Hattie et al., 2017). Additional research examined supported heterogeneous grouping through a structure referred to as complex instruction. In complex instruction, teachers created an atmosphere of interdependence and equity based on the idea that any student, regardless of ability level, can contribute to other students' learning process (Pescarmona, 2010). When evidence indicated students entered the classroom, particularly at the secondary level, with a preconceived mindset regarding their mathematical ability, inability, or even inferiority, opportunities were investigated for teachers to utilize their roles to build lessons and relationships to create new student mindsets (Boaler, 2016a). Previous research results from studies on complex instruction indicated that heterogeneously grouping students without regard to ability gave teachers an effective option for culturally responsive teaching, as well as a method to address math students' diverse academic needs (Sullivan, Jorgensen, Boaler, & Lerman, 2012).

**The Math Workshop Model.** According to Kranhenbuhl (2016), "Constructivist learning theory points us to deficiencies students have that directly impact their learning" (p. 102). Creating a learning environment that facilitated constructivism emancipated educators from the traditional role of the primary source of knowledge, permitting them to assess the exact learning needs of students (Hill, 2012). The Math Workshop Model was an instructional strategy that allowed for each student to learn within their zone of proximal development with the added support of a collaborative learning community (Ashley, 2016; Hoeffer, 2012).

According to empirical research by Hoeffer (2012), by focusing on elements such as engaging in challenging tasks, building a sense of community, collaborating through rich mathematical discourse, and conferring with teachers, the Math Workshop Model offered meaningful learning opportunities for all levels of students. In her research, Merritt (2016) found a lack of conclusive support for implementing one type of grouping over another on a consistent basis. Hattie et al. (2017) provided corroborating evidence that flexible grouping was most effective, whereby teachers analyzed the given instructional situation to determine students' learning needs over time. The literature implied that instructional models that provided instructional choices for teachers and students were effective for student learning (Benders & Craft, 2016).

When implemented correctly, the Math Workshop Model combines brief, whole group instruction with engaging, collaborative group tasks, all while giving students autonomy in the classroom (Ashley, 2016). By creating learning opportunities for students to engage in collaborative group work designed to activate learners in their zones of proximal development, teachers were free to work in small, guided situations or to confer with individual students, addressing specific and sometimes individual needs (Hoffer, 2012). Teachers used this collaborative group time to conduct individual conferences with students, share specific feedback regarding students' individual progress toward learning goals, engage students in self-reflection on recent learning experiences, or use other formative learning strategies (Sammons, 2010). Table 1, taken from Hoffer's (2012) empirical research, compares components of a traditional lesson and a lesson performed using the Math Workshop Model.

Table 1

*Comparison of Traditional and Math Workshop Model Lessons*

| | Traditional Lesson | Math Workshop Model Lesson |
|---|---|---|
| Opening | Students are given a task with the purpose of disengaging them from the activity, so teachers can perform the "business" of starting classes. | Students are engaged in a task with the purpose of activating their prior knowledge from previous learning goals. |
| Mini lesson | Students receive information and learning is orchestrated by the teacher so students can replicate what the teacher show them. | Teacher shares learning goal(s) with students, poses a problem and involves students in a discussion of the ways the problem could be solved. |
| Work time | Students work independently, or in groups, on the same set of problems while the teacher helps in a random way. | Students work independently or in groups on tasks that are challenging and possibly tailored to the students' own level. The teacher is active in conferring with students or working with small groups of students, which have been grouped together based on formative data, to address specific needs. |
| Reflection | Teacher assesses students' understanding with formative assessment based on a small sample problems from the set on which students worked during work time. | Teacher orchestrates a discussion led by students. During this discussion, students express what they now know about the concepts at the heart of the learning goal and how their understanding may have changed because of the work they did in class. The teacher takes notes of this discussion. |

Adapted from *Minds on Mathematics: Using Math Workshop to Develop Deep Understanding in Grades 4-8* by Hoffer, 2012, p. 8.

***Neuroscience and its relationships to the Math Workshop Model.*** Through recent neuroscience research, the benefits of social learning approaches, especially in secondary mathematics classrooms, have been emphasized (Armstrong, 2016; Jensen & Snider, 2013). As late as the 1990s, it was believed that the brain stopped developing around age 10 (Armstrong, 2016; Dweck, 2016). While the size of the brain was set by age 10, its functions and capacity continued to develop well into adulthood (Boaler, 2016b). In addition, humans had the conscious ability to change the brain's function (Jensen, 2013). Through neuroscience research on the brain function of secondary students, insights into instructional activities that engage students in meaningful learning experiences were revealed (Armstrong, 2016; Boaler, 2016b).

The limbic system, which controls the need to explore and engage in reward-seeking behaviors, was developed fully in the adolescent brain. The prefrontal cortex, which controls decision making and planning, was not developed fully in adolescent brains (Armstrong, 2016). The prefrontal lobe also helped regulate social cognition (Blakemore & Choudhury, 2006). Because these areas of the brain were still developing during adolescence, the activities in which students participated in school shaped how adolescents' brain were formed (Armstrong, 2016). In light of the research regarding the key areas of adolescent brain development occurring during secondary levels of education, attention in the literature was given to reviewing activities that engaged secondary students (Armstrong, 2016; Boaler, 2016b).

In addition, neuroscience theory authenticated the social aspect of constructivist learning theory (Armstrong, 2016). Neuroscience research confirmed that adolescents are driven by social interactions and peer acceptance (Armstrong, 2016). The source of adolescent motivation suggested that secondary students learned better in groups than individually (Armstrong, 2016). However, deeper analysis of these findings revealed more substantial extrapolations. As the prefrontal cortex continued to develop, adolescents' social and emotional behavior was affected (Blakemore & Choudhury, 2006). The social experiences students accumulated during this time influenced their neurological development (Blakemore & Choudhury, 2006). Researchers found evidence that the prefrontal cortex played a role in many cognitive abilities, including self-awareness and the ability to recognize the attitudes, wishes, and purposes of others (Blakemore & Choudhury, 2006). There was evidence that this development of self- and social awareness, known as social cognition, was processed in the prefrontal cortex, which was under development during adolescence (Armstron, 2016). Determining that adolescent students were developing their social cognition at the secondary level suggested that different instructional activities may have effects students' social cognition development (Grossmann, 2013). A teacher's choice of group work over whole group instruction or a teacher's care in choosing the tasks given to students during independent work time could shape students' social cognition (Armstrong, 2106; Grossmann, 2013).

In addition, empirical research indicated that students who engage in socialization during this critical adolescent period were potentially more likely to experience normal development of social behaviors in adulthood, exhibiting less frequent dysfunction (de Gentile & de Orue, 2012). By orchestrating learning situations that allow for positive experiences, normal development of social behaviors was promoted (Armstrong, 2016). Creating small learning communities and collaborative learning groups were ways teachers established safe, structured social experiences for students to acquire normal social interactions (Armstrong, 2016). These strategies also supported constructivist approaches to learning (Krahenbuhl, 2016).

Research on adolescent brain development helped educators understand why some structures and activities were more effective than others for middle and high school students (deGentile & de Orue, 2012; Grossman, 2013;). One area in which adolescent brains began developing new capacity, according to recent research, was the ability to control metacognitive thinking (Armstrong, 2016). During middle school, students started to recognize and monitor their own thoughts, assessing them to manage their lives and behaviors (Jenson & Snider, 2013).

Activities that incorporate open-ended tasks, and challenge students to solve problems in multiple ways promoted metacognitive development in mathematics classrooms (Armstrong, 2016). Researchers found a natural activation of students' brains in mathematics classes when students were engaged in making sense, using patterns to solve problems, discovering meaning through natural curiosity, and working at an appropriate level (Malone, 2015).

Some educators and theorists argued that very young children neither have the desire nor the capacity for deep and meaningful mathematics learning (Boaler, 2016b). However, emerging neuroscience research provided counterexamples to the belief that young students do not have the mental capacity to engage in rigorous learning (de Gentile & de Orue, 2012). De Gentile and de Orue (2012) linked the process of pruning, the natural elimination of old neural connections between brain cells, and the frequency with which students engage in activities. During pruning, the connections that are unstable because they have not been re-enforced by repetition were eliminated to make room for new connections between cells (De Gentile & de Orue 2012). Students of all ages exposed with regularity to even the most rigorous tasks such as solving and making sense of problems, collaborating and engaging in mathematics discourse, and creating deep, conceptual understanding of mathematical concepts developed the capacity to succeed at difficult tasks (de Gentile & de Orue, 2012). Early practice and repetition of these critical mathematical thinking skills solidified the connections from elimination during pruning, thus engraining the skills as the habits into adulthood (de Gentile & de Orue, 2012). The Math Workshop Model challenged teachers to incorporate these types of activities into the instructional plan for all students on a regular basis, offering opportunities, regardless of mathematical ability, for exposure to rigorous and challenging mathematics (Hoffer, 2012).

***Growth mindset and equity of opportunity*.** Evidence of the brain's capability to continue to learn throughout adolescence and into adulthood spurred important theories of learning, especially in mathematics education (Boaler, 2016b; Dweck, 2016). Dweck's (2016) research on growth mindsets was in direct response to work in neuroscience that indicated the brain could be trained, allowing people to acquire new skills in any area, even those in which they previously believed they were predisposed to be inept. Expanding on Dweck's (2016) work, Boaler (2016) studied how the application of mindset theory affected students who believed that they were simply born without the ability to excel in mathematics. Dweck (2016) found a link between the type of mindset one had and the praise one received. Students who were told they were smart built a fixed mindset and built resistance to taking chances (Dweck, 2016). In an analysis of the 2012 PISA mathematics scores, Boaler (2016) and her research team were able to compare the students' quantitative scores with results of a student questionnaire about mindset. The students with the highest scores on the PISA mathematics test also had a growth mindset as indicated by their questionnaire results, and these students outranked their peers by more than one full year of mathematics instruction (Boaler, 2016,b). The results of Boaler's (2016b) comparison of the PISA scores and mindset questionnaire underscored the need for further studies to explore the relationship between students' mathematics test scores and mindset, as well as determining instructional activities that foster growth mindsets in secondary mathematics students.

Other research indicated that students' mindsets and beliefs about their learning environment determine their motivation and academic achievement (Yanisko, 2016). Students perceptions of their own ability and the extent to which they were willing to persevere when faced with challenging problems was often shaped by teachers' preconceived notions of students’ abilities in mathematics (Yanisko, 2016). Teachers’ words, actions, and expectations created a learning environment that either led to a perception of trust or became a barrier to it. In one study, two teachers learned how their beliefs in their students’ abilities due to the tracked classes in which they were placed effected students’ actions in class (Yanisko, 2016). By reflecting on how their own beliefs effected their teaching practices, the teachers in the study were able to learn strategies that deconstructed their own preconceived notions and created more equitable and rigorous learning opportunities for all students (Yanisko, 2016). Equitable opportunities that provided exposure to rigorous mathematics was at the heart of the Math Workshop Model (Hoffer, 2012).

Paunesku (as cited by Touch & Headden, 2014) tested the effect of simple messages given to students studying fractions. Five groups of students received different messages as they completed their work on fractions. These messages ranged from “Some problems are hard, so just do your best,” to “Remember, the more you practice, the smarter you become” (as cited by Touch & Headden, 2014, p. 3). Other students received no message at all or messages of irrelevant scientific facts. Paunesku (as cited by Touch & Headden, 2014) noted that students who received a growth mindset message mastered the content on fractions at a rate of three percent faster than other students in the sample. The results documented by Paunesku (as cited by Touch & Headden, 2014) illustrated the inequity created when some students were exposed to instructional practices that promoted a growth mindset while other students were denied these equity-building practices.

Research showed that creating a growth mindset enhanced students’ learning, and a variety of strategies were illustrated throughout the research to promote growth mindset (Boaler, 2016a; Touch & Headden, 2014). In mathematics classes, grouping strategies were used to maximize each student's opportunity to succeed and contribute to the outcome of the group (Sun, 2018). Encouraging students to solve mathematics problems using multiple strategies legitimized more students' approaches to completing problems and encouraged growth mindset, (Sun, 2018). Feedback given to students promoted growth mindset when it focused on students' process and ability to solve a problem, rather than whether the student's answer was correct (Sun, 2018). Practices like grit, productive struggle, formative assessment, and celebrating mistakes were common in classrooms that promoted a growth mindset, and thus equity of opportunity (Boaler, 2016a).

**Conflicting research regarding methods of differentiation.** One difference between the classrooms of the late eighteenth century and today's classrooms was access to education (Ferguson, 2008). Educators in the United States aspired to make modern classrooms inclusive environments where all students realized their right to a high-quality education, but the practice of inclusion posed challenges for teachers, especially in mathematics (Riehl, 2017). Traditional instructional methods addressed one cognitive ability level, language, learning preference, or cultural background (Huebner, 2010). For decades, teachers, particularly mathematics teachers, attempted to combat the problem of wide ranges of ability levels within one class by separating students into homogeneous subgroups usually based on common ability levels (Yee, 2013). Ability grouping, also known as tracking, lost its popularity in the late 1980s and 1990s because some research showed the method of grouping had negative psychological effects on students, especially those in lower ability groups (Yee, 2013). Other empirical data supported this finding. When students only spent time grouped in ways that exposed them to low-level materials, they never aspired to achieve beyond that level (Boaler, 2016b). This phenomenon was termed *opportunity to learn* (Boaler, 2016b).

To complicate the debate over homogeneous grouping in mathematics further, other research indicated that some students responded positively to ability grouping as a method of differentiated instruction (Yee, 2013). In a study of Massachusetts middle schools in which mathematics student were "de-tracked" and grouped in heterogeneous classrooms, fewer students scored at the advanced levels on the Massachusetts Comprehensive Assessment System, and more students scored at the "failing" and "needs improvement levels" (Dean & Zimmerman, 2012). This data provided an example illustrating how providing instruction without regard to ability level impeded student learning, supporting the practice of ability grouping (Dean & Zimmerman, 2012). However, this study did not investigate teachers' methods of differentiating instruction for students within heterogeneous classes. When students were homogeneously grouped, placing students with the same instructional needs into groups, the teacher focused his or her instruction on a more specific set of topics, simplifying instructional planning and implementation for the teacher (Dean & Zimmerman, 2012). However, if students in homogeneous groups always experienced the same level of instruction over time, they seldom had opportunities to learn above, or stretch, their capacity (Boaler, 2016b). Due to conflicting research on grouping strategies, an instructional approach that provided opportunities for both student learning in like-minded groups and an environment with capacity for academic stretch offered some clarity to the issues facing mathematics teachers (Hoffer, 2012). This study sought to examine the use of the Math Workshop Model to address this need for flexibility and adaptability in mathematics instruction.

Other studies also examined differentiation practices and methods to achieve optimal academic and social results in response to the inconclusive research on grouping strategies. One study (Boaler & Staples, 2008) compared three high schools in California. In Boaler's and

Staples' (2008) study, they observed the results as one school placed their students into heterogeneous mathematics classrooms while the other two schools placed their students into ability groups, or tracks, for mathematics. Data points analyzed in this study included instructional strategies, student interactions and views of mathematics, and academic achievement. The researchers concluded that despite popular opinion, heterogeneously mixed classrooms and schools performed as well, or better than those that tracked students (Boaler & Staples, 2008).

Some studies on differentiated instruction and grouping students examined qualitative aspects of students' social interactions while working in groups rather than being passive learners in a lecture-style classroom (Commes & Lee, 2017; Webel, 2013;Jansen, 2012; Esmonde, 2009). Other studies investigated the correlation between students' social interactions and academic performance by engaging in mixed method studies, analyzing both qualitative and quantitative data (Boaler & Staples, 2008; Benders & Craft, 2016; Dekker & Elshout-Mohr, 2004; Hanson & Wolfskill, 2000; Hattie et al., 2017; Kelly, 2013; Stankov et al., 2012; Zain et al., 2012;). Studies that grouped students heterogeneously and homogeneously have offered valuable insights for mathematics educators. To help students meet the demands of changes in the global economy when they graduate, effective instructional strategies incorporated more than academic standards (Larson & Miller, 2011). For this reason, neither method's results were excluded as tertiary. Both qualitative and quantitative analyses of students' participation in collaborative learning needed to be examined from various perspectives to ensure that the results provided an effective framework for this type of instruction in the classroom.

**Differentiation begins with identifying learning goals**. Developing systemically effective differentiated instruction in secondary mathematics required a definition of the term. Tomlinson's (2017) defined differentiated instruction as

> an alternate approach—a classroom that honors and adapts to learners' variations while building a 'team of learners' who work together to benefit outcomes for the group and each of its members and around a curriculum that is designed to be relevant and engaging to young people. (p. 13)

Chappuis (2015) showed that quality assessment plans needed for effective differentiate instruction began with teachers identifying the learning targets of the unit and communicating them to students in clear, student-friendly language. These learning targets provided diagnostic information to help teachers make decisions regarding differentiation (Tomlinson, 2017). The goal of a differentiated classroom was for each student to achieve a level of proficiency that is within his or her zone of proximal development (Tomlinson, 2017). As such, assessments should be created with student learning targets in mind (Chappuis, 2015; Stiggins, 2017;). Stiggins (2017) suggested that learning targets should represent a high standard with scaffolds for differing ability levels among students, define a clear progression of learning, consider the students' background and interests, and be thoroughly understood by teachers so that all students can achieve proficiency.

The social nature of differentiation made sharing learning targets with students an important feature of differentiated classrooms (Chappuis, 2015; Tomlinson, 2017;). Tomlinson (2017) highlighted collaboration between teachers and students as one characteristic of differentiated classrooms. Providing students with a clear learning target gave them a tool to become more autonomous and active in their own learning (Konrad, Keesey, Ressa, Alexeeff, Chan, & Petes, 2014). When students understood intended learning goals and targets, they could predict their teacher's expectations of them, and they were more likely to engage in classroom activities, as well as collaborate with their peers (Stiggins, 2017). In studies, learning targets led to other assessment practices that helped students' attain academic proficiency (Hattie et al., 2017). An effect size of 1.44 was found for the strategy of communicating learning expectations to students in combination with student self-reflection on their own performance of these learning target (Hattie et al., 2017). This effect size was among the highest of any individual practice measured by Hattie et al. (2017).

**Instructional decisions through assessment.** When research on the effects of grouping strategies on academic achievement and mindset proved inconclusive, further research to explore differentiated instruction and the strategies used within was required. Assessment practices and uses of the data generated from assessment was a topic that occurred frequently when reviewing differentiating instruction (Stiggins, 2017; Tomlinson, 2017). Quality assessments provided teachers with specific information regarding what students knew and did not know to facilitate effective differentiated instruction (Tomlinson, 2017). While the idea of assessment often was synonymous with testing, quality assessment strategies included more than administering testing. Chappuis (2015) found quality assessment strategies that were intended to drive instruction began with an understanding of learning targets. In addition, effective strategies incorporated formal and informal activities to inform teachers and students of what was known and still to be learned in reference to the learning targets. James (2013) argued that teachers need this type of formal and informal data to make quality decisions regarding differentiated instruction.

Teachers did not need to generate assessment data from formal assessments to create differentiated structures in their classrooms (Tomlinson, 2017). Tomlinson (2017) observed that teachers generated high quality formative data on what students knew and did not know by watching students interact with one another. These observations included paying attention to the questions students asked the teacher and their peers, looking at the ways students chose to solve a problem, and listening to student discourse. In respect to teacher observations of students, studies have found the Math Workshop Model allowed teachers to assume the role of classroom facilitator, freeing them to collect formative data (Ashley, 2016; Hoffer, 2012).

Working as a facilitator, teachers could analyze data from formative assessments to determine students' level of understanding and identify patterns in the level of work of the entire class (Hoffer, 2012). Formative data collected helped teachers make proper instructional decisions for individual students, as well as for the class. In addition, teachers gave students feedback based on this data to engage students in their own learning journey (Accardo & Kuder, 2017; Coomes & Lee, 2017; Chappuis, 2015; Tomlinson, 2017;). Given repeated references to formal and informal assessment data in the literature reviewed for this research, this study utilized both types of data to determine the effectiveness of the Math Workshop Model as a method of differentiation.

**Methodological Issues**

Further research was needed to confirm the results of some studies reviewed for this research due to inconsistencies with the studies' methodology or execution. When comparing cooperative groups of students, for example, Esmonde (2009) and Dekker and Elshout-Mohr (2004) studied students who all were familiar with working in collaborative groups. In addition, Esmonde's (2009) study included a curriculum that supported open-ended tasks and cooperative learning. By excluding students unfamiliar with the cooperative group framework, these studies (Dekker & Elshout-Mohr, 2004; Esmonde, 2009) contained an element of bias. As such, their results may not apply to settings in which cooperative learning was not being used. While these studies were not designed to test the effectiveness of cooperative learning, the fact that all students involved in the study were familiar with cooperative learning was an example of research bias (McMillan, 2012).

Conversely, studies that disregarded qualitative data completely presented data without context. The authors of these studies described their research, including the participants, the environment, and the implementation. However, the pretest and posttest results lacked support and development without qualitative data (Dekker & Elshout-Mohr, 2004; James, 2013; Kelly, 2013). In some instances, the authors did not explain the intervention studied (James, 2013). Without qualitative data, the reader was left to wonder what took place in the classroom to produce the test results presented by the research (McMillan, 2012). In addition, some studies reviewed for this research used questionable assessments to determine the effectiveness of the variable being tested. In addition, few details were provided to describe the assessments used in the studies. For researchers to draw valid conclusions from the outcome of assessment interventions, their measurements must be sound, reliable, and valid (McMillan 2012).

**Synthesis of Research Findings**

The review of the existing literature on best practice in mathematics instruction through differentiation and group learning provided evidence that a structure like the Math Workshop Model could enhance students' academic achievement (Hoffer, 2012). Increasingly, policymakers and educators expected mathematics teachers to ensure that students master rigorous mathematical content and develop social and emotional skills to function in a global society (Koestler et al., 2013; National Governors Association Center and Council of Chief State School Officers, 2010). The emphasis on student mastery of content, as well as development of social and emotional skills underscored the importance of the instructional choices teachers make in the classroom (Boaler, 2016a; ; Koestler et al., 2013; Larson & Miller, 2011). The review of the existing literature suggested that factors with the greatest scope to influence student learning involved drawing from constructivist learning theory to incorporate collaboration in secondary mathematics classrooms, as well as the use of quality assessments and data to provide effective differentiation (Kranhenbuhl, 2016). Multiple studies suggested students in secondary mathematics classes had more opportunities to learn in social settings (Armstrong, 2016; Boaler, 2016b; Hattie et al., 2017). Paired with social aspects of constructivist learning theory, using data to inform instructional decisions regarding grouping students and differentiating their learning created learning environments that facilitated individual achievement among heterogeneous groups of mathematics students (Chappuis, 2015; Hattie et al., 2017; Hoffer, 2012; Stiggins, 2017; Tomlinson, 2015).

Traditional strategies used to teach mathematics in the United States have come under scrutiny amid steady declines in students' achievement, especially in PISA global standardized assessments (Boaler, 2016b). The downward trend in students' PISA scores indicated to educators, policymakers and parents the need to reform mathematics education in the United States (Heim, 2016). The review of the existing literature suggested that implementing components of constructivist learning theory promoted mathematics instruction reform (Boaler, 2016b; Krahenbuhl, 2016). In addition, research in neuroscience suggested that instructional activities in secondary mathematics that were collaborative and social in nature facilitated learning in ways that traditional learning strategies have not (Armstrong, 2016, Boaler, 2016b). Studies found an effect size of 0.59 for students learning collaboratively compared to individually (Hattie et al., 2017). Boaler and Staples (2008) studied the effects of students working collaboratively in heterogeneous groups. Their research supported the idea that student collaboration increased academic achievement in mathematics, as well as changing students' mindset about their mathematical ability (Boaler & Staples, 2008). By becoming facilitators of learning, and cooperative partners with students rather than centers and deliverers of knowledge, research suggested teachers could improve student learning in mathematics (Ashley, 2016; Hoffer, 2012; Tomlinson, 2017).

Research on the development of the brain further verified social structures as an effective instructional strategy, especially collaboration in secondary mathematics classrooms (Armstrong, 2016). Results of studies on adolescent brain development suggested activities to enhance learning for students at the secondary level (Armstrong, 2016; Jensen & Snider, 2013). The prefrontal cortex was developing during adolescence, and during this period of development, adolescent students were acquiring their social cognition (Blakemore & Choudhury, 2006). Adolescent students were shaping their abilities to form self-awareness as well as acquiring their capacity to detect the perspectives, beliefs, and opinions of others (Blakemore & Choudhury, 2006). Research regarding adolescent brain development recommended instructional activities for secondary students that promoted positive interactions between students, allowed students to explore each other's differences in safe ways, and learned from their peers to expand their meaning schemas and created growth mindsets (Boaler, 2016b; Dweck, 2016).

Structuring mathematics learning based on social and collaborative experiences for students was not traditional practice (Allen, 2012). However, recent neuroscience research has suggested collaborative experiences improved learning outcomes (Malone, 2015). Differentiation experts offered evidence that most effective classrooms for heterogeneously grouped students incorporated multiple strategies such as whole group, small group collaboration, cooperative learning, and individual learning, many of which are collaborative in nature (Tomlinson, 2017). With so many ways to structure a heterogeneously grouped class, teachers have struggled to determine the best instructional strategies for students in a heterogeneous class (Tomlinson, 2017). Often, teachers have made these decisions on a broad scale for the entire class or without sufficient data to support their decisions (Hattie et al., 2017). Timely and relevant formative assessment data that demonstrates what students know and do not know were used to make informed instructional decisions for individual students as well as the whole group (Chappuis, 2015). Quality assessment plans designed for learning were critical in order to make decisions regarding instruction and differentiation that were appropriate, timely, and targeted (Chappuis, 2015; Stiggins, 2017; Tomlinson, 2017). In quality assessment plans, teachers created learning targets that define the content to be learned throughout a unit and communicated the learning targets to students (Chappuis, 2015). Through this strategy, teachers can increase the effectiveness of instruction, collaboration, feedback, and self-assessment (Chappuis, 2015; Hattie et al., 2017).

Different types of assessments were used in quality assessment plans to gather evaluative information, especially when attempting to differentiate instruction (Tomlinson, 2017). In turn, teachers used this data to create authentic, differentiated classrooms that provided clear understanding of what students know and what instructional strategies will best serve students' needs (Ashley, 2016; Chappuis, 2015; Tomlinson, 2017). Differentiated instruction depended on informal, formative assessment as well as formal activities. Teachers gathered data on their students' knowledge by listening to students' questions and conversations during collaboration with their peers, observing their work, and engaging them in conversation (Tomlinson, 2017). The frequency by which teacher performed informal, formative assessments decreased when utilizing a whole group structure because whole group structures did not give teachers the same flexibility as small group strategies did (Hoffer, 2012). However, instructional models such as the Math Workshop Model position teachers as facilitator of learning, allows teachers to complete formative assessments more frequently and more effectively (Ashley, 2016; Hoffer, 2012).

**Critique of Previous Research**

Researchers who relied on qualitative data to support their research questions used a variety of data collection tools to establish patterns in the behavior of students working collaboratively. These researchers attempted to draw conclusions about equity of opportunity among students in collaborative situations, as well as the best ways to facilitate collaborative work (Esmonde, 2009; Jansen, 2012). Esmonde (2009) created a comparative study that tested students working in collaborative groups by relating the products of their work. Analyzing qualitative data, such as student interviews, videos of classroom observations, surveys, and student work gave researchers the opportunity to capture a true picture of what really happened in the study environment on a day-to-day basis, rather than just a snapshot (McMillan, 2012). Esmonde (2009) included detailed scripts of different conversations that were observed between students in the study working in groups. These scripts included the words students used as well as their non-verbal gestures in interacting with their peers, providing further support for the study's conclusions (Esmonde, 2009). Researchers' perspectives, experiences, and backgrounds influenced their analysis of data, and qualitative data helped readers understand how the researcher arrived at his or her conclusions (McMillan, 2012). However, the qualitative studies reviewed for this research lacked measurable results to indicate whether collaborative group led to an increase in academic achievement (Esmonde, 2009).

Other studies reviewed for this research focused on objective quantitative data. Quantitative data were favored in most educational research because many education practitioners and theorists believed that objective data delivers the truest verdict within a given set of conditions (McMillan, 2012). Most quantitative studies reviewed for this research used pretest and posttests to determine the conclusion to the hypothesis of the study. Quantitative studies reviewed for this research focused on differentiation (Dekker & Elshout-Mohr, 2004; James, 2013; Kelly, 2013). The instructional strategies used to provide differentiation were not emphasized in the development of the methodologies, and qualitative data was not collected to examine the students' interactions. By not specifically defining the parameters of the methods of differentiation, the reader was left to questions the application of the strategy and how it affected the results of the studies (Dekker & Elshout-Mohr, 2004; James, 2013; Kelly, 2013). Opportunities for further research were also left by the lack of specificity.

Other studies reviewed for this research used mixed method approaches. Through the use of quantitative and qualitative methodologies, these studies presented well-rounded pictures of their arguments and supporting evidence (Boaler & Staples, 2008; Stankov et al., 2012). These studies explored interactions between students, allowing researchers to make conclusions regarding the effects of students' social interactions on individual students' perceptions of their abilities in mathematics. Boaler and Staples (2008) compared three high schools over five years, looking at academic achievement data as well as patterns of behavior, using a mixed methods design to study the effect of students' desire to learn under different conditions of equity of opportunity.

Much of the research reviewed for this study used small sample sizes, limiting the relevance of the results to other groups of students. Most studies reviewed were conducted at the elementary level, or among specific groups of students at the secondary level (Abbati, 2012; Allen, 2012; Ashley, 2016; Boaler & Staples, 2008; Dean & Zimmerman, 2012; DeJarnette et al., 2014; Dekker & Elshout-Mohr, 2004; Esmonde, 2009; Hill, 2012; James, 2013; Kelly, 2013; Merritt, 2016). To determine best practices for secondary mathematics education, there was a need for studies of large sample sizes of secondary students (McMillan, 2012). Due to significant developmental differences between elementary and secondary students (Armstrong, 2016), more studies were needed to test the validity of differentiated instruction, particularly using the Math Workshop model with secondary students.

**Summary**

In this chapter, a conceptual framework for this research was presented, along with a review and critique of the relevant literature, including methodological issues in previous studies, and a synthesis of research pertaining on group work and collaboration in mathematics classrooms. The conceptual framework for this study was selected based on the constructivist theory of learning and the idea that teachers can utilize students' ability to create their own meaning and understanding to affect change in mathematics instruction at the secondary level (Boaler, 2016b). Through this literature review, the idea of constructivism, particularly its implication for instructional strategies in mathematics classrooms was investigated (Krahenbuhl, 2016). This analysis was validated by research from fields including neuroscience and psychology (Armstrong, 2016; Boaler, 2016b; Dweck, 2016). This literature review examined differentiation, including offering a working definition of differentiated instruction (Tomlinson, 2017). In addition, this chapter examined the role of a quality assessment plan, as well as the need for teachers to use data to determine what students know in order to make instructional decisions in a differentiated classroom (Chappuis, 2015; Stiggins, 2017; Tomlinson, 2017).

Next, the methodologies, biases and limitations of studies reviewed for this research were analyzed in the chapter. Then, the studies' methodologies were evaluated to determine their effect on research findings. After the methodologies were evaluated, the research was synthesized to identify common themes and topics in the existing literature. Two main points emerged in the relevant literature regarding best practices for secondary mathematics education. First, students should learn collaboratively so that they have opportunities to create and discover their own meaning and understanding (Boaler, 2016a). Second, assessment of learning, which generates data depicting what students know and do not know, should be the basis of instructional decisions for an effective differentiated classroom (Chappuis, 2015). Finally, a critique of the existing literature was presented, including the theoretical reasoning for using certain research methods and types of data. The limitations, potential biases, and gaps in the existing research were presented to provide the rationale for this study.

Global trends have shown the United States falling behind in mathematical achievement (National Center for Education Statistics, Institute for Educational Sciences, 2016), warranting an inspection of mathematics teaching in the United States. In this research, questions were posed regarding the relationship between differentiated instruction and student achievement, including the effects of equity of opportunity on students' mathematical mindset in response to data indicating a decline in mathematics performance in the United States (Boaler, 2016a; Tomlinson, 2017). Findings from this research that attempted to answer these questions regarding differentiation, student achievement, and mindset sought to add to existing research on the topics. Through examination of the research questions and literature presented, the need was shown for a study examining the effect of differentiated instruction implemented through the

Math Workshop Model. In particular, the review of the existing literature supported the need for research to answer the following questions:

1. What is the relationship between differentiated instruction through implementation of the Math Workshop Model and academic achievement of students in sixth-grade mathematics?
2. How does a learning environment based on implementing the Math Workshop Model affect students' perception of their own mathematical ability, or mindset, at the secondary level?

# Chapter 3: Methodology

Data has shown widening gaps between the academic achievement of students in the United States and their peers in other countries, especially in mathematics (Heim, 2016). Many education theorists and practitioners have argued that tracking students into like-minded classes or groups did not close this gap (Boaler, 2016b). Strategies that were statistically proven to address the needs of mathematics students with a wide variety of abilities, and capable of producing academic growth and achievement for all students allowed students to be grouped heterogeneously rather than be tracked into ability groups. Some studies reviewed relied on qualitative data to test the validity and effectiveness of instructional strategies and structures that offered opportunities for differentiation (Esmonde, 2009; Jansen, 2012). Qualitative studies linked student and teacher behaviors to certain instructional strategies and structures, however, research that gathered quantitative data through an experimental method established stronger correlation between differentiation methods and student achievement (McMillan, 2012).

## Purpose of the Study

Many educational experts agreed on the value of differentiated instruction (Hoffer, 2012; Lempp, 2017; Tomlinson, 2017). Even so, teachers of all levels of experience struggled to master the art of differentiation (Tomlinson, 2017). When implemented properly, the Math Workshop Model allowed teachers to differentiate instruction and offered students individualized learning choices based on data (Hoffer, 2012). This study was designed to determine the effect of the Math Workshop Model on the academic achievement and mindset of sixth-grade mathematics students. Implemented as a quasi-experimental experiment, the goal of this study was to determine whether a relationship existed between the application of constructivist learning theories through the implementation of the Math Workshop Model and academic achievement and mindset in sixth-grade mathematics students. In addition, the study was designed to determine if creating equity of opportunity by implementing the Math Workshop Model in mathematics classroom had an effect on academic achievement and mindset in sixrth-grade mathematics classrooms.

**Research questions**

1. What is the relationship between differentiated instruction through implementation of Math Workshop Model and the academic achievement of students in sixth-grade mathematics?
2. How does a learning environment based on implementing the Math Workshop Model affect students' perception of their own mathematical ability, or mindset, in sixth-grade?

Some studies showed a positive correlation between the Math Workshop Model and student performance. However, those studies did not use the same assessment data as this study, so it was not assumed that this study would find the same positive correlation. Therefore, the null hypotheses for this study stated:

1. There is no relationship between instruction that is differentiated through implementing the Math Workshop Model and students' academic achievement in mathematics in sixth-grade.
2. A learning environment based on implementing the Math Workshop Model does not affect students' perception of their own mathematical ability, or mindset, in sixth-grade.

**Research Design**

The research design selected for this study was a quasi-experimental research model. Quasi-experimental studies allowed researchers to analysis data collected from two groups that were purposely and not randomly selected (i.e., quasi) (McMillan, 2012). The groups were then compared to determine if a relationship existed that was greater than one based on chance (i.e., experimental) (McMillan, 2012) . This design is common in educational research(McMillan, 2012). A limitation of using a quasi-experimental model, however, was not being able to determine cause and effect relationships between the variables studied (Starnes, Tabor, Yates, & Moore, 2015). In some instances, studies that produced evidence for a cause-effect conclusion statement provided greater benefit to the mathematics education community because of their direct, predictive nature (McMillan, 2012). To establish a true cause and effect relationship through experimental research, evidence must definitely show that there were no other possible explanations for the relationship assumed between the independent and dependent variables (Starnes, Tabor, Yates & Moore, 2015). In an educational setting with numerous variables that are out of the control of the researcher, establishing a controlled environment that eliminated all other possible explanations was extremely difficult, making a quasi-experimental design the best choice.

The research questions for this study allowed the researcher to determine if relationships existed between the implementation of the Math Workshop Model and the academic achievement of students in sixth-grade mathematics class, as well as their perceptions of their mathematical ability. After reviewing other studies of the Math Workshop Model and analyzing the methodology used to draw conclusions in those studies, the researcher concluded that a quantitative method that allowed for comparisons was the most appropriate method for this study.  Specifically, a quasi-experimental method provided opportunities to draw direct connections between the strategies and structures of the Math Workshop Model and the resulting academic data and Mindset Survey results (McMillan, 2012).  Teachers implemented the Math Workshop Model as a differentiation strategy in response to formative data, which was collected in class in various forms.  Instructional decisions were made, and activities planned to implement the Math Workshop Model based on formative assessment data that teachers generated using various assessment strategies (Chappuis, 2016; Hoffer, 2012).  Follow up formative assessments were performed to determine the effectiveness of the instruction and to continue to make instructional decisions to implement the Math Workshop Model.

An experimental model was not considered because of the random assignment feature of an experimental research model (McMillan, 2012).  Given the intricacies of implementing the Math Workshop Model, the researcher recognized the importance of proper implementation to the validity and reliability of the study.  To minimize the limitation presented by the implementation of the Math Workshop Model, selection criteria for students were established to ensure that students selected for the study were assigned to teachers who had prior knowledge of and training in the Math Workshop Model.  The purposive sampling method used to select the sample was not an acceptable sampling method in a true experimental model (McMillan, 2012). The data analyzed to perform the appropriate statistical analysis was obtained by comparing the data of students who learned in classrooms where the Math Workshop Model was implemented to the data of students who did not learn in classrooms where the Math Workshop Model (independent variable). The data analyzed was collected from two instruments used to measure students' academic achievement (dependent variable) assessed by benchmark assessments given through the Galileo assessment system, as well as students' mindset (dependent variable) assessed by a mindset survey.

**Target Population, Sampling Method, and Related Procedures**

Most research on the Math Workshop Model and mathematics education interventions in general were implemented at the elementary level. This specific and targeted research left a void for secondary teachers in search of strategies to address the needs of their students. To address this void, the target population of this study was sixth-grade mathematics students. The school district from which the population was selected was a large urban district in Missouri with a total enrollment of approximately 18,000 (Missouri Department of Elementary and Secondary Elementary Education, 2017a). The district student enrollment was predominantly white, with approximately 82% of the population falling into that subgroup. Other sub-categories of students were so minimal that they did not register on the department of education's reports. At the secondary level, student enrollment was divided among four middle schools, each with its population attending corresponding high schools. There was also one alternative high school. An analysis of the district's mathematical data trends and demographic issues was considered when determining the sample for this study.

Trends in the school district's data indicated a growing achievement gap at the secondary level, particularly in mathematics, that was dividing the district geographically in half. One half of the district had a significantly lower percentage of students on the free and reduced lunch program (average of 17% for two middle schools and two high school). The other half of the district had an average of 25% of their students on the program. Data trends showed lower academic performance on the state standardized test, especially in mathematics, for the schools in the district with higher percentage of students in the free and reduced lunch program (Missouri Department of Elementary and Secondary Education, 2017b).

The purpose of this research study was to determine if the Math Workshop Model had an effect on academic achievement in mathematics, but also to understand the mathematical mindset of students in the district. For these reasons, the researcher wanted to ensure that the sample included students from the portion of the district experiencing lower academic achievement. Choosing a study population with purpose or intent could introduce the elements of bias and limits (McMillan, 2012). To control for bias, the researcher included participants from another portion of the district to vary the sample and to provide a more representative sample. Once these district characteristics were considered, the sample size was determined so that teachers could be assigned to the study.

A purposive sampling method was used to select the population for this study. The design was not random in nature and specific criteria were used to select the students for the study (McMillan, 2012). One group of students was selected to participate based on their teachers' experience and knowledge of the Math Workshop Model. These teachers had both prior knowledge of the Math Workshop Model and participated in professional development on implementing the strategy prior to the beginning of the school year. This group of students is here after referred to as *MWM students*. The second group of students was selected based on the criteria that teachers taught the same grade level and at the same school as the teachers in the *MWM students* group, but had not received professional development on implementing the Math Workshop Model. This group was chosen to create a group with as many of the same characteristics as the *MWM students* group based on district and school demographic data. This group of students is here after referred to as *traditional students*. A third group of students was selected based on the criteria that teachers taught the same grade level and in the same district as the *MWM students* groups, but had not received professional development on implementing the Math Workshop Model. This group of students is here after referred to as *district students*. The total number of participants studied in the *MWM students* group was approximately 180.

After an initial population was identified based on the criteria, a power analysis was performed to determine whether this sample was the appropriate size for a quantitative analysis. The statistical power analysis included three key data parameters: the alpha value, beta value, and effect size (Hunt, 2015). First, the alpha value was determined. The alpha refers to the likelihood of the sample yielding statistically significant data as a false positive result. It represents the probability of Type I errors appearing in the data (Hunt, 2015). The value of 0.05 was used in the power analysis to determine the sample size for this study. Second, the beta value was determined. This represented the likelihood of statistically significant data that was actually significant, or of not finding it when it was there (Hunt, 2015). The beta value used to calculate the sample size in this study was 0.85. Third, effect size was calculated using the Power and Sample Size Calculator (Statistical Solutions, Limited Liability Company, 2017). This was accomplished by calculating the known mean, the expected mean of the population, and the standard deviation of the population. To calculate this data, the researcher used summative grade level state standardized assessment scores from the 2016–2017 school year. Using these data, the online calculator determined the sample size should be 66 participants (Statistical Solutions, Limited Liability Company, 2017).

The approximate number of participants was significantly larger than the sample size required by the power analysis performed by the online calculator (Statistical Solutions, Limited Liability Company, 2017). However, for ethical and organizational reasons, the researcher decided to include all students assigned to the teachers who met the criteria to be in the *MWM students* group participate in the study rather than randomly select some of them. This allowed all students in the 10 sections of classes to receive instruction based on the Math Workshop Model. The 10 sections each averaged 15 to 18 students per section, and some sections were identified as advanced sixth-grade mathematics and others as regular sixth-grade mathematics. The *MWM students* group contained some students with Individualized Education Plans (IEPs) who received special education services in an inclusive setting.

**Instrumentation**

The main purpose of this study was to determine whether a relationship existed between the implementation of Math Workshop Model and academic achievement and students' self-perception of ability in sixth-grade mathematics. Other studies on the Math Workshop Model used various types of assessments to determine student achievement. One study used instruments provided by textbook companies (Kelly, 2013), while another used nationally-based, norm-referenced assessments to measure achievement (James, 2013). However, neither study stated the reliability or validity of these assessments.

McMillan (2012) stated that the criteria for evaluating the instrumentation of a study should include evidence to justify the validity and reliability of the instrument, clear descriptions of the implementation of the instrumentation, and explanation of the norms and interpretation of the scores if the test is not norm-referenced. McMillan (2012) has also emphasized that researchers, if playing a role through observation, should minimize their influence on study results. For these reasons and for the purposes of this study, two main instruments were used to collect quantitative data: benchmark assessments created and implemented through a platform provided by Assessment Technology Incorporated (ATI) and a mindset survey (Smithtown Central School District, 2014) adapted from the work of Dweck (2016).

The benchmark assessments used were created by ATI in cooperating with the participating district. The items that were used to build the benchmark assessments, which were used as the pretest and posttest to analyze research question 1, came from ATI's secure bank of items that have been vetted for validity and reliability. "ATI conducts psychometric analyses of items and multiple types of district-wide assessments using Item Response Theory (IRT) techniques" (Assessment Technology Incorporated, 2017, n.p.). IRT allowed for item difficulty, grade level, and the ability of students to guess the correct answer to be identified for items on the benchmarks. Identifying these characteristics and keeping them uniform from the pretest to the posttest ensured that the results generated were both valid and reliable measures of the effectiveness of the Math Workshop Model intervention given to students participating in the study. ATI used Multilog to conduct IRT analysis and marginal reliability estimations (Bergan, Burnham, Bergan, &Bergan, 2011). "Marginal reliability coefficients combine measurement error estimated at different point on the ability continuum into an overall reliability coefficient, which corresponds quite closely to other widely used coefficients such as coefficient alpha" (Bergan, Burnham, Bergan, &Bergan, 2011, p. 21). Due to its ongoing research and continuing work in IRT and psychometric analysis with each new year's data, ATI's benchmark assessments routinely demonstrate high reliability (Assessment Technology Incorporated, 2017).

The validity of the benchmarks used as instruments in the study was confirmed by the evaluation processes of ATI. To be valid, ATI's benchmark assessments required four criteria to be true:

1. The assessment provides mastery of the standards targeted for instruction during the specific time period.
2. The assessment provides guidance as to which standard should be targeted next to promote further learning.
3. The assessment can be used to estimate the probability of standard mastery on state-wide assessments.
4. The assessment can be used to measure progress towards standard mastery (Bergan, Burnham, Bergan, &Bergan, 2011).

ATI established procedures to facilitate meeting the four criteria listed, ensure the validity of their benchmarks. One procedure was a benchmark review process, allowing district officials to review benchmark items prior to finalizing assessments to guarantee content alignment (Bergan, Burnham, Bergan, &Bergan, 2011). The researcher did participate in the review process with the all three benchmarks. During the review process, the psychometric performance of the items was reviewed to confirm that items from test to test included an acceptable range of difficulty for students with varying abilities. Reviewing the psychometric profile of items from their IRT process was also another procedure recommended by ATI to assure validity (Bergan, Burnham, Bergan, &Bergan, 2011). The IRT process performed by ATI on the items used on its benchmarks were pivotal to the validation of the benchmarks. Each year, student data from the benchmarks given in Galileo were compared to the results of the subsequent state assessments to determine the predictive nature of the Galileo benchmark assessments, and, through the IRT process, items used on the benchmark assessment were reevaluated to provide the most accurate information to consumers (Bergan, Burnham, Bergan, &Bergan, 2011).

**Benchmark assessments.** Benchmark assessments were used to track student achievement and growth over time in classes where the Math Workshop Model was implemented, as well as in classes where the Math Workshop Model was not implemented. Mathematics benchmark assessments were a district requirement for Grades Six, Seven and Eight, as well as Algebra 1 taught in Eighth Grade. Benchmark assessments provided checkpoint data and allowed teachers to assess their instruction over a given period of time, determine what students knew and did not know, provide feedback to students, support learning through interventions where necessary, and identify best practices among their peers (William, 2011). Benchmark assessments for each grade level were created at the district level using a data platform and questions provided by ATI through an assessment system called Galileo.

ATI has been proving schools with assessment and intervention services since 1986, and the questions used to create the benchmark assessments in the Galileo system have been vetted and validated to ensure reliability of data (Assessment Technology Incorporated, 2002). Assessment planners were created by assessment experts at ATI using the specifications regarding standards to be assessed provided by district leaders. The assessment planner ensured the appropriated number of items were included on the benchmark assessments to provide valid and reliable results (Bergan, Burnham, Bergan, &Bergan, 2011). Items were chosen for the benchmark assessments based on psychometric data calculated by ATI identifying the difficulty level of the content, the likelihood students could guess correct answers, and the difficulty of the item type (Assessment Technology Incorporated, 2018).

These assessments were aligned to the Missouri Learning Expectations (MLEs) and to the district course level curriculum (Missouri Department of Elementary and Secondary Education, 2017c). They were implemented three times per year. In addition, the content of each assessment aligned with the curriculum being implementing in the timeframe of the window in which the assessment was given. The alignment made the assessments timely and more relevant, so teachers could use the data to inform their instructional practices, which was one of the criterion for ensuring validity of benchmark assessments outlined by ATI.

Assessment were administered online, with item types ranging from traditional multiple choice to matching, drag and drop, multi-select tables, and other technology enhanced items. Galileo's online assessment platform provided English language learners and students with reading disabilities accommodations that met their needs using the text-to-speech feature of the online assessment platform (Assessment Technology Incorporated, 2002). The Galileo Assessment platform was chosen by the district specifically because of the data it provided teachers and administrators on student achievement and growth. The benchmark assessment data were tracked individually by student to show exactly what was learned in the instructional time frame between assessments. In addition, data were analyzed by teachers to identify patterns of growth for entire classes (Assessment Technology Incorporated, 2002). The data from the students in the *MWM students* group were compared to data from other students to determine which strategies had the greatest effect on student growth and achievement.

**Mathematical mindset survey.** The other instrument used to collect the quantitative data in this study was a survey designed to assess the mathematical mindset of students (see Appendix A). The Mindset Survey (Smithtown Central School District, 2014) was adapted from the work of Dweck (2016) to quantitatively measure students' mindset, and permission to use this survey was given to the research by person at School on Wheels responsible for creating the survey. This survey helped teachers and students identify whether students had fixed or growth mindsets. In addition, the survey provided insight into fostering growth mindsets in students

(Dweck, 2016). The survey contained 15 statements regarding learning and intelligence. Students indicated the strength with whether they agreed or disagreed with each statement by choosing either “agree strongly,” “agree,” “disagree,” or “disagree strongly” as the indicator of their agreement with each statement. The questions were designed especially for students, written in student-friendly language, and intended to determine the students’ mindset regarding mathematics (Smithtown Central School District, 2014). Some statements reflected a growth mindset while others reflect a fixed mindset, and the scoring guide was created with this distinction in mind. A scoring sheet, which was identical to the initial survey, indicated the number of points a student’s response earned for each question, with the cumulative total indicating the student’s overall mindset. Students self-scored the survey or teachers scored the survey, and the class engaged in a discussion of the difference between growth and fixed mindset and how mindset affected learning.

The growth mindset survey was used as the instrument to collect data to analyze research question 2. Permission to use the survey was obtained from School on Wheels and was adapted from the work of Dweck (2016). The adaptations to the Mindset Survey involved ensuring the language was grade-level appropriated and student friendly without changing the intention of the questions from the original survey questions on the Mindset Works website (founded by Dweck). The short surveys developed by the Mindset Works group “have not been used in rigorous research by itself, but contain a sampling of questions from several research-validated scales measuring mindsets about intelligence, learning goals, and beliefs about efforts” (E. Perez, personal communication, Aug. 17, 2018). The majority of the questions in the Mindset Survey used in the study were fundamentally the same questions as the surveys included on the Mindset Works website, using the same scoring scale to place students into either a growth or fixed mindset category (Mindset Works, 2018). Other researched showed that the scoring and interpretation of surveys similar to those found on the Mindset Works site (which were also extremely similar to those used by the Mindset Survey in this study) had high internal reliability and predictive value with respect to one another and achievement outcomes. Blackwell, Trzesniewski, and Dweck (2007) were able to validate mindset statements regarding intelligence and effort and develop a reliable and predicable scoring scale that consistently produced an accurate measure of one's mindset. In addition, the research of Blackwell, Trzesniewski, and Dweck (2007) indicated that due to Dweck's (as cited in Blackwell, Trzesniewski, & Dweck, 2007) Theory of Intelligence, certain statements within the survey measuring mindset should be reverse-coded so that a high score truly indicated a growth mindset. Some of the survey questions found in the Mindset Survey used in this study were reverse coded to ensure a valid measure of students' mindset in relation to the scale used.

Because of the similarity between the Mindset Survey used (with permission from School on Wheels) in the study and those on the Mindset Works website, any studies regarding validity and reliability of surveys found on the Mindset Works resource could also provide support for the validity and reliability of the Mindset Survey used in the researcher's study. A study of the reliability and validity of a growth mindset survey from the Mindset Works website was performed by Hanson, Bangert, and Ruff (2016), and they concluded the tool "to be a reliable and valid construct that demonstrated convergent validity…[e]ach individual subfactor was highly correlated with the overall school mindset construct (correlations from .81-.94)" (p.260). In addition to the results of the study from Hanson, Bangery, and Ruff (2016), the adapted questions of the Mindset Survey were written in both positive and negative language so as to accurately assess students' true mindset and avoid outlier data from student survey manipulation.

## Data Collection

**Academic data.** The questions the study sought to address were whether a relationship existed between the implementation of the Math Workshop Model in sixth-grade mathematics and academic achievement, and whether implementing the Math Workshop Model affected secondary students' mathematical mindset. Therefore, the data collection processes were designed to generate data to align with these goals. Generating appropriate data was necessary for quality analyses of the research questions to be performed. For the researcher to draw valid conclusions about the research questions regarding the Math Workshop Model, the data needed to address both academic achievement and mindset. Previous studies that focused on academic data without supporting evidence to describe the instructional strategies had limited practical application in mathematics education (James, 2013).

Data to measure students' academic performance were collected using the online benchmark assessment platform provided by ATI-Galileo. A grade-level appropriate benchmark assessment was given to every student in the sixth, seventh, and eighth grade throughout the district three times during the school year. The district assessment coordinator and the mathematics curriculum coordinator created a testing calendar prior to the start of the school year, and these assessment windows were shared with the mathematics teachers. The teachers did not have access to the assessment prior to administering the assessment. Students took the benchmark assessments online through ATI-Galileo's benchmark platform according to the district assessment calendar. Using an interactive dashboard, teachers monitored students' progress as assessments were taken. Teachers viewed students' progress as each question was completed. Once students finished the entire assessment, results were available to teachers immediately. Teachers of the students in the *MWM students* group used this formative data on an individual level or class level to make instructional decisions and implement the Math Workshop Model.

The researcher had access to benchmark assessment data for the entire district, not just that of the students in the *MWM students* group. The ATI-Galileo data system analyzed data by classroom teacher for each class period of his or her instruction. The data from the benchmark assessment was collected both as a raw score and as a score indicating overall achievement. The data of the *MWM student* group was analyzed during the study by the teachers of the students to make instructional decisions when implemented the Math Workshop Model. As a raw score, the data was recorded as the number of correct answers. Then, using Item Response Theory, ATI analyzed the data from the benchmark assessments to compile a Developmental Level (DL) score to create a common scale to track student general growth over time (Assessment Technology Incorporated, 2002).

The raw data and DL scores were available to teachers and the researcher upon students' completion of each benchmark assessment (growth data was available only after at least two benchmark assessments had been given). Because the benchmarking system was chosen primarily as a formative tool rather than a summative tool, each assessment focused on content aligned to the most important state and district standards to determine what students understood and to make instructional decisions (DuFour et al., 2016). Each assessment tracked students' academic achievement and growth on four standards from the MLEs. The academic data collected for each benchmark, therefore, was separated into the following categories: raw score for entire assessment, raw score for each standard, and growth.

**Mindset survey.** To address Research Question 2 associated with mindset, a survey designed to measure students' mindset was used. Students in the *MWM students* group were given learning opportunities in the Math Workshop Model that included activities which were targeted and focused on their own individual needs with opportunities to collaborate. (Hoffer, 2012). In similar situations, students' confidence and perception of their value in the community increased, reflecting their approach to learning and their mindset (Boaler, 2016b). The Mindset Survey generated a quantitative measure from students' responses to statements that reflected a growth or fixed mindset (Smithtown Central School District, 2014). This score correlated to a predetermined scale that placed students on a mindset continuum from strong fixed mindset to strong growth mindset (Smithtown Central School District, 2014). This was adapted from the work of Dweck (2016).

The survey was given to students at the beginning of the study. The mindset survey pretest scores of the students in the *MWM students* group were recorded in TylerSIS K12, the district's secure data base in which teachers reported attendance and grades. These scores were stored as an assignment with zero weight, so they did not affect students' grade in the course. At the conclusion of the study, the students took the Mindset Survey again as a posttest. Teachers recorded the posttest scores in TylerSIS K12. The researcher uploaded these pretest and posttest scores using the students' district identification numbers to protect their privacy.

**Demographic Data**

To determine potential biases or influences on students' academic performance unrelated to the application of the Math Workshop Model, the researcher collected demographic data for the *MWM students* group. Despite characteristics that indicated the sample population was a purposive sample, data such as gender, age, ethnicity, and socioeconomic status was gathered to show similarities between the sample and population demographics (McMillan, 2012). The researcher, having gained permission from the superintendent of the school district, gathered demographic data from the district's student database, Tyler SISK12. In addition to this demographic data, the students' previous academic data were recorded from state standardized test scores. Previous academic assessment data were recorded to determine prior patterns of achievement for comparison in the study. To protect the students' privacy, demographic and assessment data were recorded using students' district-issued identification number to ensure confidentiality.

**Operationalization of Variables**

The purpose of this study was to determine if a relationship existed between the implementation of the Math Workshop Model in mathematics classes in sixth-grade and students' academic achievement, as well as the way students perceive their own abilities in mathematics class. To evaluate these relationships, the independent variable was whether or not students learned in an environment where the Math Workshop Model was implemented. The students participating in the study were assigned to the *MWM students* group based on the criteria that teachers were familiar with the Math Workshop Model prior to the beginning of the study and participated in professional development on implementing the Math Workshop Model with the researcher prior to the beginning of the school year. The professional development provided to teachers consisted of three days of training exposing teachers to the structure of the Math Workshop Model and instructional strategies used to successfully implement the differentiation strategy (Hoffer, 2012). Establishing these criteria helped ensure the fidelity of implementation of the Math Workshop Model defining the independent variable.

There were two dependent variables in the study. One dependent variable was the academic achievement of students participating in the study. This dependent variable was used to help address the research questions regarding the relationship between differentiated instruction using the Math Workshop Model and academic achievement.  The variable associated with academic achievement was measured using assessment data gathered from the benchmark scores administered through the Galileo testing platform.  The assessments were aligned to the MLEs and the district's sixth-grade curriculum (Missouri Department of Elementary and Secondary Education, 2017c, and growth was calculated using scores from Galileo's norm referenced database.  The second dependent variable was students' scores measuring mathematical mindset.  Data to measure mindset were collected using the Mindset Survey (Smithtown Central School District, 2014).  The Mindset Survey provided scores indicating the level to which students agreed or disagreed with statements that reflected a growth or fixed mindset.  The survey results were totaled to indicate the students' general mindset toward learning and intelligence using a scale based on Dweck's (1999) Theory of Intelligence (as cited by Blackwell, Trzesniewski, &Dweck, 2007).  The scores from this instrument were compared and analyzed to determine what, if any, relationship existed between implementing the Math Workshop Model and students' mathematical mindset.

**Data Analysis Procedures**

All quantitative data collected during the study were generated from assessments that were given to participants as pretests at the beginning of the study and posttest at the conclusion of the study. The data from the academic assessments that occur within the timeframe of this study were used as the pretest and posttestof the study to measure achievement of participants and any data from assessments that were given prior to the beginning of the study were used as archive data in the analysis process.  The pretest and posttest data were saved in Excel files and stored on the researcher's district-issued computer, which did not travel from the researcher's office.  The Excel files were saved on the district server, which was password protected.  The results of the assessments were compared to determine statistical significance. If statistical significance existed, the data were analyzed further to quantify in various ways the effect of implementing the Math Workshop Model on students' academic achievement.

A similar process was used to collect data from the mindset survey. A pretest and posttest were used when administering the mindset survey to determine if implementing the Math Workshop Model affected students' mindset in sixth-grade mathematics. Teachers of students in the *MWM students* group collected the pretest and posttest results. The data were entered into TylerSISK12, the district's grading database. The mindset survey data were uploaded from TylerSISK12 by the researcher and saved as Excel files. The Excel files were saved on the district server, which was password protected. The results of the pretest and posttest surveys were compared to determine statistical significance. If statistical significance existed, the data were analyzed further to quantify in various ways the effect of implementing the Math Workshop Model on students' mathematical mindset.

To determine statistical significance, within case and across case analyses were conducted. Across case analysis was conducted to determine whether there were significant achievement differences for students whose teachers had professional development on implementing the Math Workshop Model versus students whose teachers did not receive any training on implementing the Math Workshop Model. A two-tailed *t*-test was used to determine whether any differences in the data were statistically significant. The within case analysis was interested in exploring whether shifts occurred in students' mindset in sixth-grade mathematics. A paired two-tailed *t*-test was employed to determine whether any differences were significant. Both *t*-tests used the $p$ value of $\alpha \leq 0.05$ to determine whether the influence of the Math

Workshop Model was greater than expected by chance. An alpha value less than 0.05 was commonly used in social science research to determine statistical significance (McMillan, 2012).

**Limitations and Delimitations of the Research Design**

The ability of teachers to implement Math Workshop Model was a major factor in the research design of this study. If the teachers struggled implementing the Math Workshop Model, the research design was limited greatly. Limitations were conditions or parameters effecting the methodology and conclusions of a study that were out of the control of the researcher (Simon, 2011). In addition to a lack of understanding of implementing the Math Workshop Model, a lack of commitment to implementation of the Math Workshop Model had a tremendous impact on the study's outcome. Providing professional development on the Math Workshop Model before and during the study and providing instructional support to teachers reduced the limitations presented by teachers' understanding of the Math Workshop Model. Some sixth-grade teachers in the district already had prior knowledge of the Math Workshop Model and previous experiences with similar instructional models. The researcher considered these teachers when students were chosen for the study because their knowledge and experiences with the Model supported the research design.

Time created a limiting factor in this study. The research phase officially began in. January, approximately four months after sixth-grade students began the school year. This meant that students were engaged in approximately four months of learning prior to the beginning of the study. A wide range of academic progress was achieved by students before the study began, and the achievement of students prior to the implementation of the Math Workshop Model posed a threat to the validity and reliability of the study. The researcher used archived assessment data from the beginning of the year to establish a clear baseline of what students knew before the study began to ensure the benchmark data was valid for the time of the study.

When analyzing other research studies of differentiation strategies in mathematics classrooms, researchers claimed that a delimiting factor present was a lack of diversity in the study participants (James, 2012; Kelly, 2012). Delimitations were the characteristics of a study that the researcher can control that limit the study (Simon, 2011). Initially, the researcher considered including multiple grade levels from sixth-grade to twelfth-grade to make the study results more applicable to all grade levels in secondary mathematics. After completing the power analysis and determining a relatively small valid sample size of 66 participants was needed, the researcher chose to include only students from the sixth-grade in the study, based on the criteria established for the purposive sampling method used. The researcher's choice to include only students from sixth-grade introduced delimitations into the study's design. The delimitation created by the sampling method was avoidable by choosing students from other grade levels, but the researcher created a sample consisting of all sixth-grade students to easily and consistently compare the instructional strategies, classroom activities, and implementation of the Math Workshop Model of the teachers of the *MWM students* group. Even focusing the study on just sixth-grade students still yielded a sample of approximately 180 students, nearly three times the size of the power analysis recommendation size of 66. Including all students from the *MWM student* group rather than just random students chosen from the group increased the validity of the. Studying all students in the *MWM students* group also gave the student sample academic variety because sections of both advanced math classes and regular math classes were contained within the group.

The sampling method was also delimitation of the study. Students were not chosen for participation at random. Rather, the research chose students within a predetermined set of parameters: understanding of the Math Workshop Model and attended professional development on implementing the Math Workshop Model. By attempting to control the limitation of implementation, a delimitation of the sample was created. While the researcher deliberately manipulated the student sample of the study, the student participants were still assigned to teachers before school started in a random manner. Students were enrolled in all classes throughout the district randomly, so students were not purposively selected to be in the classes of teachers who attended the professional development on implementing the Math Workshop Model. This random assignment of students to sixth-grade teachers minimized the delimitation of the sampling. Given the nature of the treatment being studied (Math Workshop Model), the researcher felt it was more appropriate to establish criteria placing students in the study purposively, ensuring they be exposed to quality implementation of the Math Workshop Model.

**Internal and External Validity**

In order for the results of any study to be accepted by others in the field, the experiment must prove to be high in both internal and external reliability (Druckman, Green, Kuklinski, Lupia, 2011). Internal validity referred to the quality with which the experiment is executed, and there were several areas that posed threats to the internal and external validity of a study (Druckman et al., 2011). While the areas that posed threats to both the internal and external validity could not be completely eliminated, those that posed the greatest threat to internal validity were carefully considered by the researcher and addressed through the design of the study.

**Maturation.** According to Druckman et al. (2011), changes in the dependent variable due to natural development rather than the application of the treatment in the independent variable caused the internal validity harm. In the case of this study, it was reasonable to believe that all students grew academically from the beginning of the study to the end simply from experiencing a certain period of time in a new grade level of instruction, and there was a reasonable amount of academic growth experienced by students prior to the beginning of the study due to the approximately four months of instruction students experienced from the beginning of school in mid-August until the beginning of the study in January. To ensure the students participating in the study had a different educational experience than all other students in their grade level, the independent variable was implementation of the Math Workshop Model in the classes in which the *MWM students* were enrolled. The *MWM students* were selected using a purposive sample based on the criteria that the teachers had prior knowledge of the Math Workshop Model and attended professional development on implementing the Math Workshop Model. Being in the *MWM students* group ensured the students would be exposed to the Math Workshop Model while students in other groups should not.

**Selection.** Druckman et al. (2011) indicated that groups selected to participate in a study should be relatively equivalent in the beginning of the study and selection should not pose a threat to the group selected or those not selected. Everyone should have an equal chance of being selected in order to ensure high internal validity (Druckman et al., 2011). In this study, all students participating were equivalent in that they all were in the sixth-grade. Students did not start at the same mathematical ability level according to the results of their state standardized tests; However, the number of advanced sections of sixth-grade math course in the *MWM students* group were proportional to those in the *traditional students* and *district* groups. The students were distributed randomly into the appropriate sections by their own administrators due to the equity among their sixth-grade mathematics teams within their buildings.

**Design contamination and compensatory rivalry.** Internal validity was affected by design contamination. Design contamination was a phenomenon whereby study participants in one group became aware they were part of a study, affecting their behaviors (Druckman et al., 2011). In this study, the chance of design contamination was minimal because each student in the *MWM student* group was learning in the same way as his or her classmate. Students in the *traditional students* group who attended the same schools as the students in the *MWM students* group were learning in different classrooms taught by different teachers. The likelihood of contamination or compensatory rivalry between different groups was minimal (Druckman et al., 2011).

**External validity.** External validity, the degree to which study results can be applied from the small sample of the experiment to a larger, more generalized population (Druckman et al., 2011), was addressed by the way in which the sample was chosen. First, the researcher ensured that the sample represented the entire sixth-grade population of the district so that the findings of the study could be generalized for the teachers across the whole district. By choosing a sample that reflected the population of the district, the results from this study could be applied to other large populations similar to the district from which the sample was drawn, thus strengthening the external validity (Druckman et al., 2011). Despite the purposive sampling method described earlier in this chapter, the researcher believed the sample proved to be representative of the population, providing external validity to the study (McMillan, 2012).

## Expected Findings

Through the literature reviewed, the researcher believed that student-centered instructional models that offered teachers multiple opportunities to provide specific feedback to students and differentiate instruction would improve students' academic achievement in mathematics and their perception of their own ability, or mindset, in mathematics. Additionally, it was anticipated that this study would show students in mathematics classrooms in which the Math Workshop Model was implemented achieved higher academic growth on benchmark assessments as compared to students in mathematics classrooms where traditional instructional methods were used.

It was also expected that implementing the Math Workshop Model would have an impact on the mathematical mindset of students. When students learned in an environment in which they receive instruction that was specifically designed to meet their individual needs, even a portion of the time, and they received personal feedback regarding their work and informing their learning, they would acquire a more positive mindset about their own ability in mathematics. A positive change in mindset was expected to manifest itself in the survey data collected at the beginning and end of the study.

**Ethical Issues in the Study**

This study required teachers to implement a certain structure of differentiation, the Math Workshop Model. Because the entire district was focusing on providing focused and targeted instruction for all students based on timely, formative assessment, the students in this study were not exposed to strategies or data collection that was outside the normal district expectations. Since the students in the study were learning in an environment consistent with the district learning expectations, consent for student participation was given by the district superintendent rather than each individual student's parent or guardian. The participating students experienced similar instructional, assessment, and data collection practices as other students in the district did, so consent was given by district leadership. When the researcher used data specifically for the study's purpose, students' district identification numbers were used instead of names to protect students' privacy.

Educational negligence was an issue the researcher felt introduced the potential of an ethical concern in this study. To avoid any possibility of educational negligence by the participating teachers, all students in the *MWM students* group were included in the study rather than choosing a portion of the *MWM students* group at random to meet the recommended sample size of 66 (Statistical Solutions, Limited Liability Company, 2017). Choosing all students from the *MWM student* group allowed the teachers to make instructional decisions that were in the best interest of their students, and they did not have to be concerned whether any students' educational needs were not being met simply for the sake of the study. As for students in the other groups not exposed to the Math Workshop Model, the short nature of the study allowed for other teachers to begin implementing the Math Workshop Model if the data proved the structure was beneficial for students.

The researcher had no vested interest in the outcome of this study other than attempting to determine best practices for student achievement in mathematic. The researcher was the secondary mathematics curriculum coordinator of the district in which the study was conducted and worked with all middle and high school teachers and students to implement mathematics curriculum and assessment and to identify instructional practices that helped students in the district achieve success in mathematics. The researcher's role was one at the administrative level in the district in which the study was conducted, however, the researcher did not have any authority over or influence in the teachers' yearly evaluations or hiring status. Thus, conducting the study in the district and the subsequent data generated did not affect teachers' status with the district as a teacher. Being a mathematics curriculum coordinator, the researcher sought to determine the most effective strategies for teaching mathematics to all students at the secondary level. It was intended that the results of this study would help determine if the Math Workshop Model was an instructional tool that could benefit the teachers and students in the district.

**Summary**

This chapter outlined the development of and rationale for the research methodology that was used to explore the study's research questions and provide data to support a conclusion. A quantitative study focused on collecting data from two instruments was used to answer the research questions posed, primarily focused on identifying the relationship between differentiated instruction through implementing the Math Workshop Model and students' academic achievement and mindset in sixth-grade mathematics. Sample populations were chosen using a purposive sampling method (McMillan, 2012) to provide high internal and external validity (Druckman et al., 2011). To generate and collect data appropriate for analyzing the research questions which were the foundation of the study, two instruments were developed and implemented. The data collected from these instruments were analyzed for statistical significance using applicable test (McMillan, 2012). When statistical significance existed, the data was reviewed through multiple lenses to determine if adequate evidence existed for conclusions regarding the research questions to be drawn. These extensive measures provided a solid statistical foundation described in great detail in Chapter 4.

## Chapter 4: Data Analysis and Results

The purpose of this study was to determine if a relationship existed between implementing the Math Workshop Model and mathematical academic achievement and mindset in sixth-grade classrooms. To exam the effectiveness of the Math Workshop Model on both students' academic achievement and mindset, quantitative data was collected to measure academic achievement and students' mathematical mindset. The *MWM students* group consisted of students in 10 sixth-grade classrooms from two of the four middle schools in the participating district; A purposive sampling method was used to choose these students based on the teachers' experience with the Math Workshop Model. Academic achievement data was also collected from the *traditional students* and *district* groups, groups of students whose teachers had no prior understanding of or professional development in the Math Workshop Model prior to the beginning of this study. The curriculum that was taught to the students in the *MWM students, traditional students,* and *district* groups was identical as were the assessments given to students. Academic achievement data collected from the *MWM students* group was compared to the achievement data of students from the *traditional students*, and *district* groups to determine whether a relationship existed between implementing the Math Workshop Model and academic achievement data. Having comparable data from students who were exposed to the Math Workshop Model and students who were not exposed allowed for the execution of an ex-post experimental method for the study. By comparing this data, conclusions about the research questions could be drawn. The following research questions guided this study:

1. What is the relationship between differentiated instruction through implementation of the Math Workshop Model and academic achievement of students in sixth-grade mathematics?

2. How does a learning environment based on implementing the Math Workshop Model effect students' perception of their mathematical ability, or mindset, in sixth-grade?

In order to determine if a relationship existed between implementing the Math Workshop Model and mathematical academic achievement and mindset, quasi experimental method was used. A true experimental method was not used to avoid potential ethical issues of denying a treatment to all students believed to be beneficial (McMillan, 2012). If implementing the Math Workshop Model proved successful during the course of the study and other teachers wanted to implement the strategy, they were free to do so.

**Summary of Methods**

Two instruments were used to collect data to measure the dependent variables utilized to address the research questions in this study. The benchmark assessments used to generate the achievement data were given to all sixth-grade students in the district in September, December, and March. The official pretest and posttest for this study correlated to the December and March assessments. The data analyzed for this study aligned to four standards from the MLEs and the district's sixth-grade curriculum (Missouri Department of Elementary and Secondary Education, 2017c). The four standards assessed and measured in this study were:

6.NS.A.1a: Compute and interpret quotients of positive fractions. Solve problems involving division of fractions by fractions.

6.NS.B.3: Demonstrate fluency with addition, subtraction, multiplication and division of decimals.

6.NS.B.4a: Find the greatest common factor (GCF) and least common multiple (LCM).

6.NS.B.4b: Use the distributive property to express a sum of two numbers with a common factor as a multiple of a sum of two whole numbers.

The first benchmark assessment results were also used as achieved data in the analysis of achievement data as these results proved to be relevant in an ex-post facto review of the data and establish a baseline for student achievement for student learning that occurred prior to the beginning of the study (McMillan, 2012). The benchmark assessments were created using a benchmarking platform provided by ATI-Galileo (Assessment Technology Incorporated, 2002). The questions chosen were aligned to the district's sixth-grade curriculum, as well as the MLEs for sixth-grade (Missouri Department of Elementary and Secondary Education, 2017c). While the questions on the three benchmarks were not identical, the item types and difficulty levels remained constant.

The survey used to measure students' mindset in mathematics contained a variety of questions designed to determine whether students had a growth or a fixed mindset (Smithtown Central School District, 2014). Students indicated the level to which they agreed or disagreed with a series of 15 statements, and a scoring guide was used to determine a total score for each student. The totals of these responses placed students in a range of scores that indicated whether they had a growth or a fixed mindset and also indicated the strength of their particular mindset (Smithtown Central School District, 2014). All students in the *MWM students* group took the survey as a pretest and as a posttest at the end of the study. The questions on the pretest and posttest surveys were identical. The total scores from the pretest and posttests were analyzed to address the second research question in the study.

A delimitation that was not intended at the beginning of the study involved the implementation of the Mindset Survey. The original intention was for all students in *district* group to also take the survey as a pretest and posttest so that the data from the students in the *MWM student* group could be compared to that of the students in the *district* groups. Given the timing of the study's conclusion, the posttest needed to be given in by the end of March, but the students in the *district* group were scheduled to take it in May. Rather than change the plan for the *district* group for the sake of generating data, it was determined that the only students who would take the survey by the end of March would be those in the *MWM students* group. Therefore, the only Mindset Survey data available for analysis was that of the *MWM students*. There was not a comparison of the survey data from the *MWM students* group and any other group because the survey was not given to any other group, creating a delimitation that had not been anticipated.

**Description of the Sample**

When determining the optimal sample size by performing a power analysis calculation, it was found that the sample size for this study should be 66 (Statistical Solutions, Limited Liability Company, 2017). To ensure that the teachers with students in the study did not encounter any ethical dilemmas, however, the researcher decided to include all students from the classes of the teachers that met the criteria of the *MWM students* group for an estimated 180 participants. The total of students participating in the study was almost three times the needed sample size according to the power analysis calculation. Taking into consideration given factors, such as the criteria of teachers' prior understanding of the Math Workshop Model and participation in professional develop on the topic and educational ethics, however, it was right to include all students from teachers meeting the criteria of the *MWM students* group even though it caused a delimitation for this study.

The study's data was possibly affected by pre-identified delimitations associated with the sampling methods chosen for the study. To implement the Math Workshop Model effectively, teachers needed prior understanding and training, therefore a purposive sampling method was used instead of a random sampling method to determine which sixth-grade students would participate in the study (McMillan, 2012). The results of the study may have been negatively skewed if a random sample method was applied and students of teachers without knowledge of the Math Workshop Model would have been chosen to participate in the study. Similarly, if students would have been chosen randomly, and their teachers did not implement the Math Workshop Model with fidelity because of the teachers' own person beliefs or preconceived notions about the strategy, the results of the study could have been impacted. To attempt to control the impact of implementation fidelity, a purposive sampling method was preferred, leading to a delimitation of the study.

This study focused on a portion of the sixth-grade in a school district, classified as urban by the state of Missouri, which is located in central eastern Missouri. The district's and schools' names were omitted from the data analysis of this study to protect the rights and privacy of the students. The researcher expected 180 students in the study. There were 187 students who participated in the study (*MWM students*, $N = 187$). The difference in expected sample and actual sample was attributed to actual class enrollments not meeting the projected enrollment calculated from previous years' data which were used to arrive at the expected number of 180 participants. The district was comprised of approximately 80% white students with about 11% of its students identified as African American. The largest other ethnic groups large enough to register in the population were Hispanic (3%) and Asian (6%). To gain a better understanding of the demographic distribution of the students in the *district* group, as well as the *traditional students* and *MWM students* groups, the data was examined within each of these groups. Additionally, the *traditional students* and *MWM students* groups were subdivided to determine if any abnormal patterns existed in the distribution of students in the groups between the different schools (School A and School B).  *$MWM_B$ Students* group had demographic distributions, which were very similar to that of the *district* group, with 81% of students identifying as white and 10% African American.  *$MWM_B$ students* group had a slight difference in the percentages of Hispanic students (6%) and Asian students (1%) than the district.  *$MWM_A$ students* group showed somewhat different distribution in the percentage of white (75%) and African American (18%) students when compared to the *district* group. Hispanic (4%) and Asian (3%) student distribution was almost even.  The demographic data for these groups were obtained from the district data base system, Tyler SISK12.  In Table 2, the population totals and distribution by race for the *district, traditional students* group (disaggregated by subset *$traditional_A$ students* and *$traditional_B$ students*) and *MWM students* group (disaggregated by *$MWM_A$ students* and *$MWM_B$ students)* groups were given.

Table 2

*Demographic Data of Various Groups in District*

| Group | Total Population | White | African American | Hispanic | Asian | Other |
|---|---|---|---|---|---|---|
| *district* | $N$ = 1202 | 80% ($n$ =9 62) | 10% ($n$ = 120) | 3% ($n$ = 36) | 6% ($n$ = 72) | 1% ($n$ = 12) |
| *traditional students* | $N$ = 635 | 79% ($n$ = 499) | 13% ($n$ = 85) | 3% ($n$ = 22) | 4% ($n$ = 27) | <1% ($n$ < 1) |
| *traditional$_A$ students* | $N$ = 298 | 77% ($n$ = 229) | 15% ($n$ = 45) | 4% ($n$ = 12) | 4% ($n$ = 12) | <1% ($n$ < 1) |
| *tradtional$_B$ students* | $N$ = 337 | 80% ($n$ = 270) | 12% ($n$ = 40) | 3% ($n$ = 10) | 5% ($n$ = 17) | <1% ($n$ < 1) |
| *MWM students* | $N$ = 187 | 79% ($n$ = 147) | 14% ($n$ = 26) | 5% ($n$ = 9) | 2% ($n$ = 3) | 1% ($n$ = 2) |
| *MWM$_A$ students* | $N$ = 82 | 75% ($n$ = 62) | 18% ($n$ = 15) | 4% ($n$ = 3) | 3% ($n$ = 2) | 0% ($n$ = 0) |
| *MWM$_B$ students* | $N$ = 105 | 81% ($n$ = 85) | 10% ($n$ = 11) | 6% ($n$ = 6) | 1% ($n$ = 1) | 2% ($n$ = 2) |

*Note*. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups containing students enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups containing students enrolled in School B

In Table 3, the gender distribution for the *district* group, *traditional students* (disaggregated by *traditional$_A$ students* and *traditional$_B$ students* groups) and MWM students (disaggregated by *MWM$_A$ students* and *MWM$_B$ students* groups) were presented. The gender distribution showed generally more males in the *district* group (52%) than females (48%). Conversely, the *MWM students* group contained more females (57%) than males (43%). With considerable more males (59%) than females (41%), the *traditional$_A$ students* group had a gender distribution that was unique from any other group compared.

Table 3

*Gender distribution in Sixth-Grade throughout the District*

| Group | Total Population | Female | Male |
|---|---|---|---|
| *district* | $N = 1202$ | 48% ($n = 577$) | 52% ($n = 625$) |
| *traditional students* | $N = 635$ | 47% (n = 301) | 53% ($n = 334$) |
| *traditional$_A$ students* | $N = 298$ | 41% ($n = 122$) | 59% ($n = 176$) |
| *tradtional$_B$ students* | $N = 337$ | 53% ($n = 179$) | 47% ($n = 158$) |
| *MWM students* | $N = 187$ | 57% ($n = 106$) | 43% ($n = 81$) |
| *MWM$_A$ students* | $N = 82$ | 54% ($n = 44$) | 46% ($n = 38$) |
| *MWM$_B$ students* | $N = 105$ | 59% ($n = 62$) | 41% ($n = 43$) |

*Note*. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

The research questions in the study addressed both academic achievement and mathematical mindset of students in sixth-grade students, so analyzing the academic success of the students both in the *MWM students* group and in the other groups could lead to evidence to answer the research questions. In the participating district, sixth-grade students could either take a course which provided mathematics instruction at a regular pace and on the material from the district's sixth-grade curriculum, or they could take an advanced course which provided mathematics instruction at an accelerated pace on material from both the sixth-grade and seventh-grade district curriculum. In Table 4, data were provided detailing the distribution of students in the *MWM students, traditional students*, and *district* groups in of the sixth-grade math course. The sixth-grade students in the *district* group ($N = 1084$) were evenly distributed between the regular sixth-grade mathematics course and the advanced sixth-grade course as illustrated by the 50% enrollment in each course.  When looking at the other enrollment distributions, however, even distribution was not found.  The outlier of the data appeared to be the students in the *traditional*$_A$ *students* group ($N$ = 176), in which 64% of students were enrolled in the advanced course.  Conversely, the students in the *MWM*$_A$ *students* group ($N$ = 82), who were enrolled in the same school, only had 49% of students enrolled in the advanced math course.  The variance found between the enrollment of students in the *traditional*$_B$ *students* ($N$ = 305) and *MWM*$_B$ *students* ($N$ = 105) groups, all students enrolled in the same school, was not as great.  Students in the *traditional*$_B$ *students* group were enrolled in the advanced math course at a rate of 44% while the students in the *MWM*$_B$ *students* group were enrolled in the same course at a rate of 48%.

Table 4

*Sixth-Grade Course Enrollment Distribution of Different Groups of Students throughout the District*

| Group | Total Population | Enrollment | |
|---|---|---|---|
| | | Advanced Course | Regular Course |
| *district* | *N* = 1084 | 50% (*n* = 542) | 50% (*n* = 542) |
| *traditional students* | *N* = 481 | 51% (*n* = 246) | 49% (*n* = 235) |
| *traditional$_A$ students* | *N* = 176 | 64% (*n* = 112) | 36% (*n* =64) |
| *tradtional*$_B$ *students* | *N* = 305 | 44% (*n* = 134) | 56% (*n* = 171) |
| *MWM students* | *N* = 187 | 48% (*n* = 90) | 52% (*n* = 97) |
| *MWM*A *students* | *N* = 82 | 49% (*n* = 40) | 51% (*n* = 42) |
| *MWM*B *students* | *N* = 105 | 48% (*n* = 50) | 52% (*n* = 55) |

*Note*. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

The teachers of the students participating in the study had considerable teaching experience. The teacher of the students of the *MWM$_A$ students* group had seven years' experience teaching middle school mathematics. However, this year was her first teaching sixth-grade, and her first teaching in the participating district. The teacher of the students of the *MWM$_A$ students* group had spent the previous six years teaching seventh grade mathematics in a different urban Missouri school district. The teachers of the students of the *MWM$_B$ students* group had 25 years' experience in elementary and middle school mathematics, with multiple years teaching sixth-grade mathematics. Both teachers had multiple degrees and had engaged in extensive professional development besides the professional development on implementing the Math Workshop Model.

In combination, the two teachers held two bachelor's degrees, three master's degrees, and five teaching certificates in the state of Missouri. One teacher was working toward a doctorate degree. Both teachers had held leadership positions at different points in their careers and had mentored other teachers.

**Summary of the Results**

The study began at a point in the school year when the participating district was scheduled to give the second of three benchmark assessments. The second district benchmark was proposed as the pretest for the study, providing baseline data for the study for academic achievement for the *MWM students, district,* and *traditional students* groups. Students in the *MWM students, district,* and *traditional students* groups had been exposed to approximately three and a half months of mathematics instruction before the study received approval from Concordia University-Portland IRB. The participating district's assessment plan included a benchmark given at the beginning of the year in September before any significant instruction was provided to any of the groups in the study. In order to minimize the possibility of invalid data and to provide an adequate examination of the effect of the Math Workshop Model on students' academic achievement in sixth-grade mathematics, the archived district benchmark data from the beginning of the year was also reviewed. This review provided an appropriate sense and scale of the learning trends of all sixth-grade students.

As the teachers of the *MWM students* group implemented the Math Workshop Model in their classrooms, weekly observations were made, and feedback was given by the researcher. The fidelity with which the participating teachers implemented the Math Workshop Model was also a possible delimitation of the study. Participating teachers needed working knowledge of the Math Workshop Model, and they needed to be monitored to ensure the Math Workshop

Model was being implemented. The teachers of the students of the *MWM students* group met the criteria of the purposive sample because the teachers had prior understanding of implementing the Math Workshop Model and attended professional development prior to the beginning of the school year. Students were assigned to sixth-grade teachers for the academic school year randomly, and then the students assigned to the teachers who met the criteria were chosen to participate in the study based on the design of a purposive sample rather than using a random sampling method (McMillan, 2012). Feedback given by the researcher to the teacher was qualitative, and the intent of the weekly feedback was to provide on-going support as the teachers continued to build on their knowledge of the Math Workshop Model. This feedback was not used to address the research questions of the study, but rather to support the teachers' implementation of the Math Workshop Model.

At the conclusion of the study, students in the *MWM students group*, as well as the *district* and *traditional students* groups, completed the third district benchmark assessment in March. The assessment was included in the participating district's assessment plan, but was scheduled to be given at the end of the year. Due to the state standardized testing window coinciding with the end of the school year, the district decided to give the third benchmark in early spring rather than at the end of the school year. The timing of the third benchmark assessment posed an issue for the district assessment plan, as well as the implementation of the study. This scheduling delimitation was not anticipated when the study was proposed. The third benchmark was created to assess content sixth-grade students would have learned at a deeper conceptual level. For the purpose of this study, the delimitation of assessment scheduling conflict was addressed in part by each standard being assessed with multiple items, each having varying degrees of difficulty. Offering students multiple items, each with different degrees of difficulty, provided a statistical process to more accurately determine students actual level of understanding (Assessment Technology Incorporated, 2002).

One of the main goals of the study was to determine if implementing the Math Workshop Model affected student achievement in sixth-grade math. The proposed analysis to determine effectiveness included comparing the growth data of the *MWM students* group to that of the *district* group, and this comparison was one component of the data analysis used to address Research Question 1. However, given the added delimitation of the change in district assessment schedule, as well as some of the interesting patterns in the demographic data distribution throughout the *district*, *traditional students*, and *MWM students* groups, the researcher also analyzed the academic achievement data using different comparisons than originally planned. Since the design model of the study was a quasi-experimental, ex-post facto model, the research studied the effect of factors such as race, gender, birthdates, and course enrollment on achievement data to determine if any of these factors may have affected the dependent variable along with the implementation of the Math Workshop Model (Mc Millan, 2012). In some cases, the population to which the *MWM students* group data was compared also changed. As anomalies in the demographic data or course enrollment data gave cause the researcher to question whether these factors might have influence the outcome of the dependent variable(s), further data analysis was preformed to provide support for future conclusions.

In addition to the academic achievement data collected through the benchmark assessments, students in the *MWM students* group took the Mindset Survey pretest and posttest to provide data to address Research Question 2. Permission and consent to give the survey was granted by the participating district's administration since the survey was a normal instructional tool for the district teachers. Since the survey was used by the district, teachers in the *district* group also gave it as a pretest. The study's proposal called for all teachers to give the survey as a pretest and posttest to allow for comparison between the *MWM students* group and *district* group. However, the instructional plan for the district called for the regular administration of the posttest of the Mindset Survey in May, well past the end date of the study.

Therefore, only the *MWM students* took the Mindset Survey at the conclusion of the study, in March. Another delimitation in regards to implementing the mindset survey that was not anticipated was a greater emphasis on mindset lessons at the beginning of the year by the teacher of the $MWM_B$ *students* group. In the first two weeks of the school year, the students in the $MWM_B$ *students* group were exposed to activities devoted to developing growth mindsets. Because of the different levels of emphasis placed on developing growth mindsets in the $MWM_A$ *students* and $MWM_B$ *students* groups and lack of data from the *district* group, the data from the $MWM_A$ *students* and $MWM_B$ *students* groups were only compared within case.

**Detailed Analysis**

**Research Question 1.** The first research question of the study sought to determine whether a relationship existed between implementing the Math Workshop Model and academic achievement in secondary mathematics. Determining whether a relationship existed required a comparison of the academic achievement data of students who learned in classes where the Math Workshop Model was implemented (*MWM students*) to students in who learned in classes where the Math Workshop Model was not implemented (*district*). A Statistical significances test was performed on the academic data from the benchmark assessments, and if the results proved to be significant, they could be used to address Research Question 1:

What is the relationship between differentiated instruction through the implementation of the Math Workshop Model and academic achievement of students in secondary mathematics?

To determine if the academic achievement data measured by the benchmark assessments were statistically significant, students' results for the benchmark assessments were uploaded from ATI-Galileo's data base to be analyzed.

District benchmark assessments were given in September (Assessment one), December (Assessment two), and March (Assessment three). Only the data of students who took all three benchmark assessments was analyzed. Each question answered correctly was assigned a value of one in an Excel spreadsheet, and a total for each benchmark was generated for every student. Then, using formulas in Excel, the growth from benchmark two (pretest) to benchmark three (posttest) was calculated for every student. Another set of growth scores from benchmark 1 to benchmark three was also calculated for every student. These growth scores for the *MWM students* group and the *district* group were used to perform a two-tailed *t*-test for each set of growth scores. The results of these analyses produced one set of statistically significant results, and one set of data that was not statistically significant. In Table 5, the analysis of the growth data from Benchmark two to Benchmark three showed the data not to be statistically significant.

Table 5

*Statistical Significance Summary of Achievement Growth Comparing Students Who Did and Did Not Experience the Math Workshop Model*

| Statistical measure | Observed |
|---|---|
| mean | 0.01 |
| SD | 2.49 |
| n | 160 |
| SE | 0.20 |
| Mean SD | 0.02 |
| Variance | 6.19 |
| Hypothesized Mean Diff. | 0 |
| t-Test | -0.66 |
| P(T,<=t) two-tail | 0.54 |
| DF | 160 |
| t Critical | 1.97 |

A two-tailed *t*-test of the growth data from Benchmark two and Benchmark three rendered a *p* value of approximately 0.54, much larger than the assumed alpha value of 0.05 needed to make this set of data statistically significant. This analysis led to the acceptance of the null hypothesis of Research Question 1: there is no relationship between differentiating instruction through implementing the Math Workshop Model and the academic achievement of students. However, given the internal reliability factors of maturation and previous instruction provided to students prior to the beginning of the study and administration of Benchmark two, consideration was given to the archived Benchmark one data. The decision was made to compare the growth data generated from the first benchmark assessment that was archived by the district and the third benchmark data of the *MWM students* group and the *district* group.

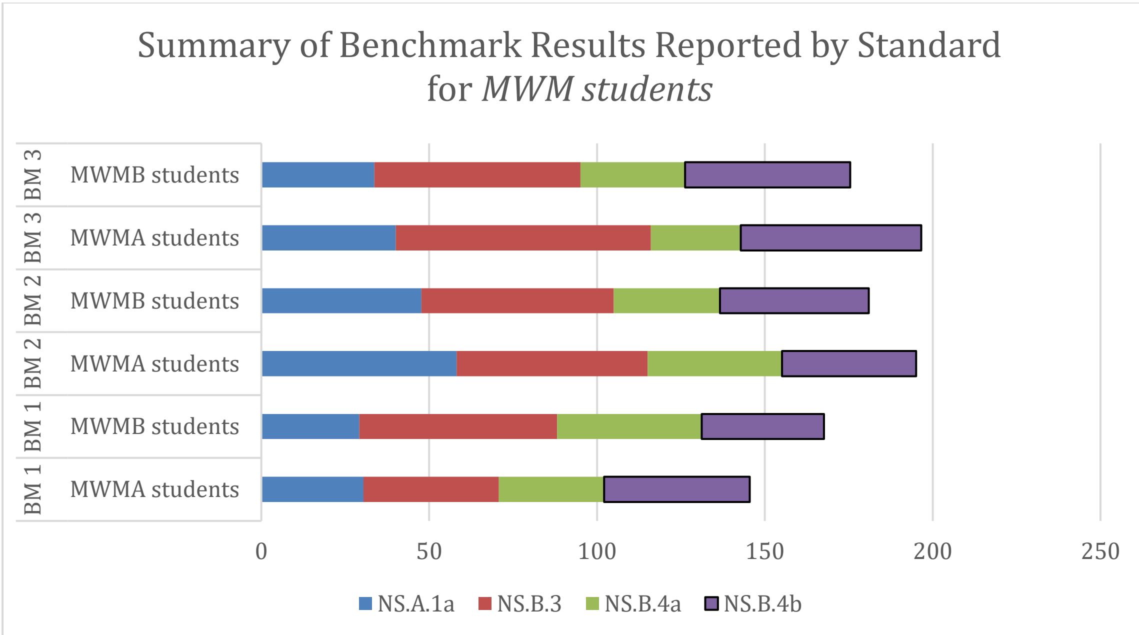
A two-tailed *t*-test comparing student growth from Benchmark one to Benchmark three of the *MWM students* group and the *district* group was statistically significant. The *p* value determined in the two-tailed *t*-test of growth data from Benchmark one to Benchmark three was approximately $p$=0.00001, well below the required, pre-determined alpha value $p$ = 0.05.The academic growth over this 24-week period between September and March yielded an average growth of 0.27 points out of a total of 12. The results of this analysis were shown in Table 6.

Table 6

*Statistical Significance Summary of Academic Data Comparing Students Who Did and Did Not Experience the Math Workshop Model*

| Statistical measure | Observed values |
|---|---|
| mean | 0.27 |
| SD | 2.36 |
| n | 147 |
| SE | 0.19 |
| Mean SD | 0.02 |
| Variance | 5.57 |
| Hypothesized Mean Diff. | 0 |
| t-Test | -5.84 |
| P(T,<=t) two-tail | 0.0002 |
| DF | 147 |
| t Critical | 1.98 |

***Achievement data by standard.*** While the achievement data proved statistically significant from Benchmark one to Benchmark three, determining what this significance meant in terms of the impact of implementing the Math Workshop Model on achievement required a much deeper analysis of the data. To establish how the achievement of the students in the *MWM students* group may have been effected by the implementation of the structure, looking at the achievement data results next to those of the *distric*t group was necessary. For this comparison, actual performance rather than growth was used. For each of the four standards assessed on the three benchmark assessments, average performance scores for the different groups were calculated. The average scores for each standard were tracked across the three benchmark assessments and shown for the *MWM students* group (disaggregated by $MWM_A$ *students* and $MWM_B$ *students* groups) and the *district* group. The results of this analysis were shown in Figure 1. The averages for each standard across the three benchmarks were provided in Table 7.



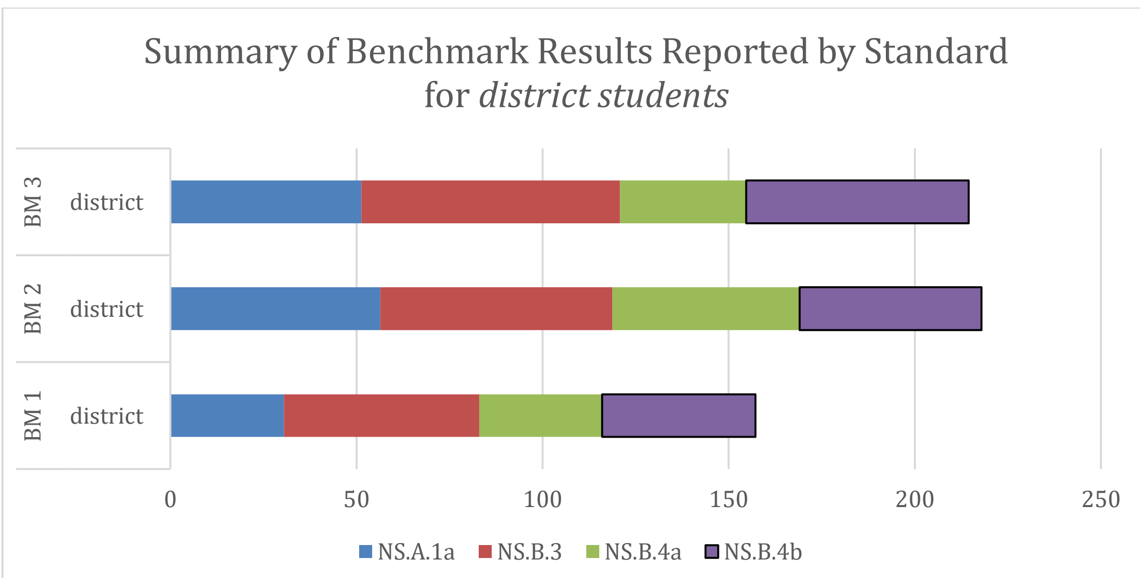




*Figure 1*. Summary of Benchmark results reported by standard for students who did and did not experience the Math Workshop Model

Table 7

*Summary of Benchmark Results Reported by Standard for Students Who Did and Did Not Experience the Math Workshop Model*

| Benchmark | Group | NS.A.1a | NS.B.3 | NS.B.4a | NS.B.4b |
|---|---|---|---|---|---|
| BM 1 | *$MWM_A$ students* | 30.42% | 40.36% | 31.33% | 43.37% |
| | *$MWM_B$ students* | 29.21% | 58.91% | 43.07% | 36.39% |
| | *District* | 30.5% | 52.43% | 33.09% | 41.2% |
| BM 2 | *$MWM_A$ students* | 58.22% | 56.89% | 40% | 40% |
| | *$MWM_B$ students* | 47.67% | 57.33% | 31.67% | 44.33% |
| | *District* | 56.38% | 62.38% | 50.29% | 48.9% |
| BM 3 | *$MWM_A$ students* | 40.06% | 76.03% | 26.7% | 53.82% |
| | *$MWM_B$ students* | 33.66% | 61.39% | 31.19% | 49.17% |
| | *district* | 51.33% | 69.46% | 33.89% | 59.81% |

*Note.* BM stands for benchmark. *$traditional_A$ students* and *$MWM_A$ students* are subsets of their larger groups enrolled in School A. *$traditional_B$ students* and *$MWM_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

In general, the students in the *MWM students* group improved from benchmark one to benchmark three. The overall average achievement on benchmark three was greater than that on benchmark one for both the students in *$MWM_A$ students* and *$MWM_B$ students* groups. The average final scores increased for students in both these groups from 36.37% to 49.2% (*$MWM_A$ students* group) and from 41.9% to 43.9% (*$MWM_B$ students* group). The students in the *district* group also exhibited growth, however. From benchmark one to benchmark three, the students in the *district* group increased their average scores from 39.3% to 53.6%. Such substantial growth by the district group compelled the researcher to query as to what other factors might have impacted the achievement of the students in the *MWM students* group, and further analysis was warranted.

To provide more extensive support for the analysis of Research Question 1, a basic examination was performed of the final achievement levels for the *$MWM_A$ students and $MWM_B$ students* groups and the *district* group for each of the four standards assessed. Looking at achievement by standard rather than by overall average provided a more detailed account of exactly where the students in the *MWM student* group were and were not outperforming the students in the *district* group. By comparing the *$MWM_A$ students* and *$MWM_B$ students* groups, extended comparisons could be made based on the documented differences in the teachers to whom the students in the *MWM students* group were assigned. Academic achievement data gathered from the benchmark assessments for both *$MWM_A$ students* and *$MWM_B$ students* groups showed growth on standards NS.A.1a (9.64% and 4.45% respectively), NS.B.3 (35.67% and 2.48% respectively), and NS.B.4b (10.45% and 12.78% respectively) from Benchmark one to Benchmark three (Table 8). On standard NS.B.3, the *$MWM_A$ students* group outscored the *district* group 76.03% to 69.46%. The students in the *$MWM_A$ students* groups had higher final achievement levels than the students in the *$MWM_B$ students* group on three of the four standards (NS.A.1a, NS.B.3, and NS.B.4b) 40.06% to 33.66%, 76.03% to 61.39%, and 53.82% to 49.17% (Table 8).

***Ancillary findings within research question 1.*** In an ex-post facto review of the demographic data from the study, one demographic that stood out was the difference in the distribution of male and female students in the *MWM students* and *traditional students* groups. There was an unusually high distribution of male students in the *$traditional_A$ students* group ($N$ = 176, 59%) while there was a high percentage of female students in *$MWM_B$ students* group ($N$ = 38, 54%). Abnormal distribution of gender prompted the researcher to investigate this data further. To analyze this data, the academic achievement data from the *MWM students* group ($N$

= 187) was compared to the academic achievement data of the *traditional students* group ($N$ = 635). The data was sorted by gender.

The academic achievement data was collected from ATI-Galileo's database. Growth scores were again calculated for both the male students and the female students for each of the three benchmark assessments. A two-tailed $t$-test was performed on the academic achievement data from male students, as well as the female students. The results of the tests for significance yielded two different outcomes. The data comparing the male students in the *MWM students* and *traditional students* groups proved statistically insignificant. This indicated the null hypothesis of the Research Question 1 should be accepted. In Table 8, statistical significance testing results showed that the $p$ value calculated from the two-tailed $t$-test was approximately $p$=0.0895, larger than the required alpha value of $p \leq 0.05$.

Table 8

*Statistical Significance Test Results for Males' Achievement Data*

| *Statistical measure* | *traditional students* | *MWM students* |
|---|---|---|
| Mean | 0.41 | 0.09 |
| Variance | 1.73 | 1.65 |
| Observations | 233 | 65 |
| Pooled Variance | 1.71 | |
| Hypothesized Mean Difference | 0 | |
| df | 296 | |
| t Stat | 1.70 | |
| P(T<=t) one-tail | 0.04 | |
| t Critical one-tail | 1.65 | |
| P(T<=t) two-tail | 0.09 | |
| t Critical two-tail | 1.97 | |

When the data from the female students in the *traditional students* and *MWM students* groups was analyzed, however, statistical testing verified significance. After collecting achievement data from ATI-Galileo for Benchmark one and Benchmark three and determining a growth score for each student, a two-tailed *t*-test was completed comparing the females in the *MWM students* and *traditional students* groups. Table 9 illustrated the results of the statistical testing performed on the achievement data from the female students from the *MWM students* and *traditional students* groups.

Table 9

*Statistical Significance Test Results for Females' Achievement Data*

| *Statistical Measure* | *traditional students* | *MWM students* |
|---|---|---|
| Mean | 1.07 | 0.19 |
| Variance | 8.55 | 6.99 |
| Observations | 212 | 80 |
| Pooled Variance | 8.12 | |
| Hypothesized Mean Difference | 0 | |
| df | 290 | |
| t Stat | 2.35 | |
| P(T<=t) one-tail | 0.01 | |
| t Critical one-tail | 1.65 | |
| P(T<=t) two-tail | 0.02 | |
| t Critical two-tail | 1.97 | |

In the results of the two-tailed *t*-test of the data for achievement of female students, the *p* value calculated was approximately $p = 0.0195$, much less than the accepted $p \leq 0.05$ alpha value. These results indicated that the null hypothesis of Research Question 1 was rejected.

Once the null hypothesis of Research Question 1 could be rejected, the researcher examined the female data of the *MWM student* group for evidence of the relationship of implementing the Math Workshop Model and academic growth. Unlike the previous analysis, this data was not examined by dissecting the *MWM students* group into the same subgroups of $MWM_A$ *students* and $MWM_B$ *students*. Reducing the size of the population by focusing only on the female students reduced the subgroups to sizes that could deem them statistically insignificant (McMillan, 2012). The size of the $MWM_A$ *students* group changed from $N = 82$ to *n*

= 42, and the *MWM$_B$ students* group size changed from $N$ =105 to $n$ = 62. Based on the sizes of these subgroups, the researcher decided to examine the female data of the *MWM student* group. Figure 2 shows a comparison of the academic achievement of the MWM students and traditional students groups for the three benchmark assessments reported by standard. Table 10 provides the data that corresponds to the data displayed in the graph.

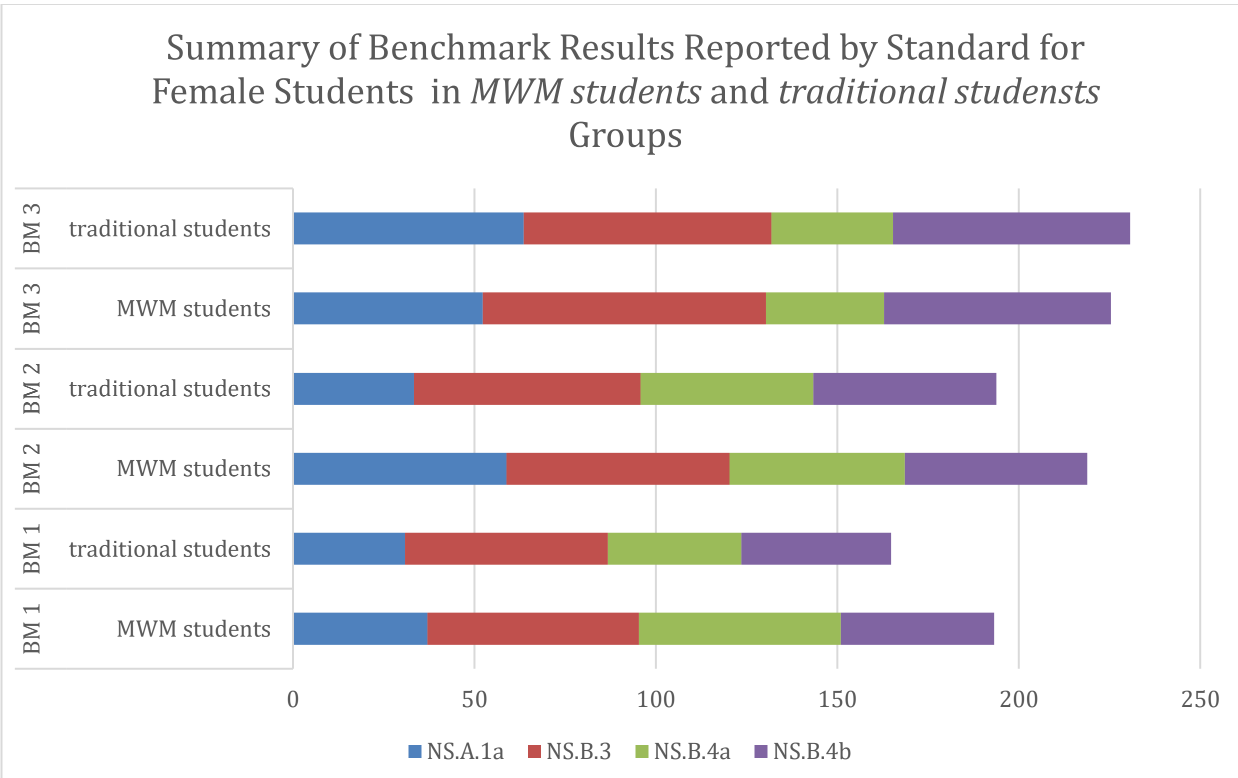



*Figure 2.* Summary of benchmark results reported by standard for female students who did and did not experience the Math Workshop Model

Table 10

*Summary of Benchmark Results Reported by Standard for Female Students Who Did and Did Not Experience the Math Workshop Model*

| Benchmark | Group | NS.A.1a | NS.B.3 | NS.B.4a | NS.B.4b |
|---|---|---|---|---|---|
| BM 1 | *MWM students* | 37.04% | 58.33% | 55.56% | 42.28% |
| | *traditional students* | 30.91% | 55.91% | 36.7% | 41.26% |
| BM 2 | *MWM students* | 58.85% | 61.46% | 48.31% | 50.26% |
| | *traditional students* | 33.33% | 62.46% | 47.6% | 50.45% |
| BM 3 | *MWM students* | 52.26% | 78.1% | 32.51% | 62.55% |
| | *traditional students* | 63.55% | 68.31% | 33.5% | 65.35% |

*Note*. BM represents benchmark. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

When separated by standard, the academic achievement data for female students in the *MWM students* group generally showed growth from Benchmark one to Benchmark three. The overall average achievement of students in the *MWM students* group change from 48.3% on benchmark one to 56.4% on benchmark 3 (Table 11). This compared to the students in the *traditional students* group which demonstrated an overall achievement difference of 47.6% on benchmark one to 57.8% on benchmark 3 (Table 11)). Academic achievement growth did not occur in all four standards in the *MWM students* group or at the same rate as the *traditional students* group. Nonetheless, academic achievement changed positively in the *MWM students group* with sustained regularity. The variance of growth displayed by the females in the *MWM students* and *traditional students* group was much smaller than that illustrated in the comparison of the *MWM students* and *district* groups.

*Achievement by ability group.* Another anomaly in the proportions of students in the *MWM students* and the *traditional students* groups was the distribution of students in the two different courses available for sixth-graders in the participating district. At the district level (*N*

=1084), there was an even split of students taking the advanced sixth-grade mathematics class and the regular sixth-grade mathematics class in sixth-grade, with 50% of students enrolled in each course. This data offered no potential influence on the academic data, and subsequently the distribution of the student enrollment in the *district* group was not considered in further analysis. In the *MWM students* group ($N$ =187), however, the percentages were not evenly distributed, with 48% of students enrolled in the advanced math course and 52% of student enrolled in the regular math course). Additionally, the enrollment of students in the $traditional_B$ *students* group was so unbalanced towards the advanced sixth-grade class (64%), the researcher decided to use the $traditional_A$ *students* and $traditional_B$ *students* group as the comparison group for the analysis of the course enrollment data.

A growth score for each student was calculated from benchmark one to benchmark three. The growth data from the students' enrolled in the advanced sixth-grade math course in the $MWM_A$ *students* and $traditional_A$ *students* groups, as well as the $MWM_B$ *students* and $traditional_B$ *students* groups was analyzed using a two-tailed $t$-test. The $p$ values generated from these tests for statistical significance were approximately $p = 0.08$ and $p = 0.52$. As such, the academic data from students in advanced mathematics was not significant, and the null hypothesis of Research Question 1 was accepted for this data. No relationship could be assumed to exist between the implementation of the Math Workshop Model and academic achievement in the advanced sixth-grade courses. Tables 11 and 12 provided the results of these statistical significance tests.

Table 11

*Statistical Significance Test Results of Academic Data for Students in Advanced Math in School A*

| *Statistical measure* | *tradtional$_A$ students group* | *MWM$_A$ students group* |
|---|---|---|
| Mean | 0.60 | 0.22 |
| Variance | 1.33 | 1.40 |
| Observations | 106 | 37 |
| Pooled Variance | 1.34 | |
| Hypothesized Mean Difference | 0 | |
| df | 141 | |
| t Stat | 1.75 | |
| P(T<=t) one-tail | 0.04 | |
| t Critical one-tail | 1.66 | |
| P(T<=t) two-tail | 0.08 | |
| t Critical two-tail | 1.98 | |

*Note.* *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A.

Table 12

*Statistical Significance Test Results of Academic Achievement Data for Students in Advanced Math in School B*

| *Statistical measure* | *traditional$_B$ students group* | *MWM$_B$ students group* |
|---|---|---|
| Mean | 0.69 | 0.53 |
| Variance | 1.82 | 1.35 |
| Observations | 109 | 34 |
| Pooled Variance | 1.71 | |
| Hypothesized Mean Difference | 0 | |
| df | 141 | |
| t Stat | 0.64 | |
| P(T<=t) one-tail | 0.26 | |
| t Critical one-tail | 1.66 | |
| P(T<=t) two-tail | 0.52 | |
| t Critical two-tail | 1.98 | |

Note. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

Analyzing the academic achievement data generated by students taking the regular sixth-grade mathematics class produced a different outcome. Using growth scores of the student enrolled in the regular sixth-grade math courses from Benchmark one to Benchmark three, a two-tailed *t*-test was completed with the *$MWM_A$ students* and *$traditional_A$ students* groups and with the *$MWM_B$ students* and *$traditional_B$ students* groups. The outcomes of the two-tailed *t*-test for this data proved it was statistically significant, rejecting the null hypothesis. Tables 13 and 14 indicated the *p* values of approximately $p$ = 0.00605 and $p$ = 0.0404 respectively. Both were less than the alpha value of $p \leq 0.05$ needed to prove significance.

Table 13

*Statistical Significance Test Results of Academic Data for Students in Regular Math in School A*

| *Statistical measure* | *$traditional_A$ students group* | *$MWM_A$ students group* |
|---|---|---|
| Mean | 0.17 | -0.6 |
| Variance | 1.95 | 1.58 |
| Observations | 54 | 40 |
| Hypothesized Mean Difference | 0 | |
| df | 89 | |
| t Stat | 2.79 | |
| P(T<=t) one-tail | 0.003 | |
| t Critical one-tail | 1.66 | |
| P(T<=t) two-tail | 0.01 | |
| t Critical two-tail | 1.99 | |

Note. *$Traditional_A$ students* and *$MWM_A$ students* are subsets of their larger groups enrolled in School A. Names of schools were omitted for confidentiality.

Table 14

*Statistical Significance Test Results of Academic Achievement Data for Students in Regular Math in School B*

| *Statistical measure* | *traditional$_B$ student group* | *MWM$_B$ student group* |
|---|---|---|
| Mean | 0.01 | 0.5 |
| Variance | 1.84 | 1.44 |
| Observations | 150 | 40 |
| Pooled Variance | 1.76 | |
| Hypothesized Mean Difference | 0 | |
| df | 188 | |
| t Stat | -2.06 | |
| P(T<=t) one-tail | 0.02 | |
| t Critical one-tail | 1.65 | |
| P(T<=t) two-tail | 0.04 | |
| t Critical two-tail | 1.97 | |

Note. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

In Figure 3, the academic achievement data from Benchmark one to three for students enrolled in regular sixth-grade mathematics in the *MWM students* group (*N* = 187) and the *traditional students* group (*N* = 481) is illustrated. The average performances for each of these groups on the four standards assessed on each benchmark is provided in Table 16. A discernable difference is visible in the achievement of students enrolled in the regular sixth-grade math course in the *MWM students* group when compared to that of the students enrolled in the same course in the *traditional students* group. The average performance of the students in the *MWM students* group rose from 40.2% on Benchmark one to 47.4% while the students in the *traditional students* group increased from 33.1% only to 44.7% (Table 15). Students enrolled in the regular sixth-grade math course were the only subgroup of students in the *MWM students* group whose academic achievement increased more significantly than that of their peers in the group to which their data was compared.

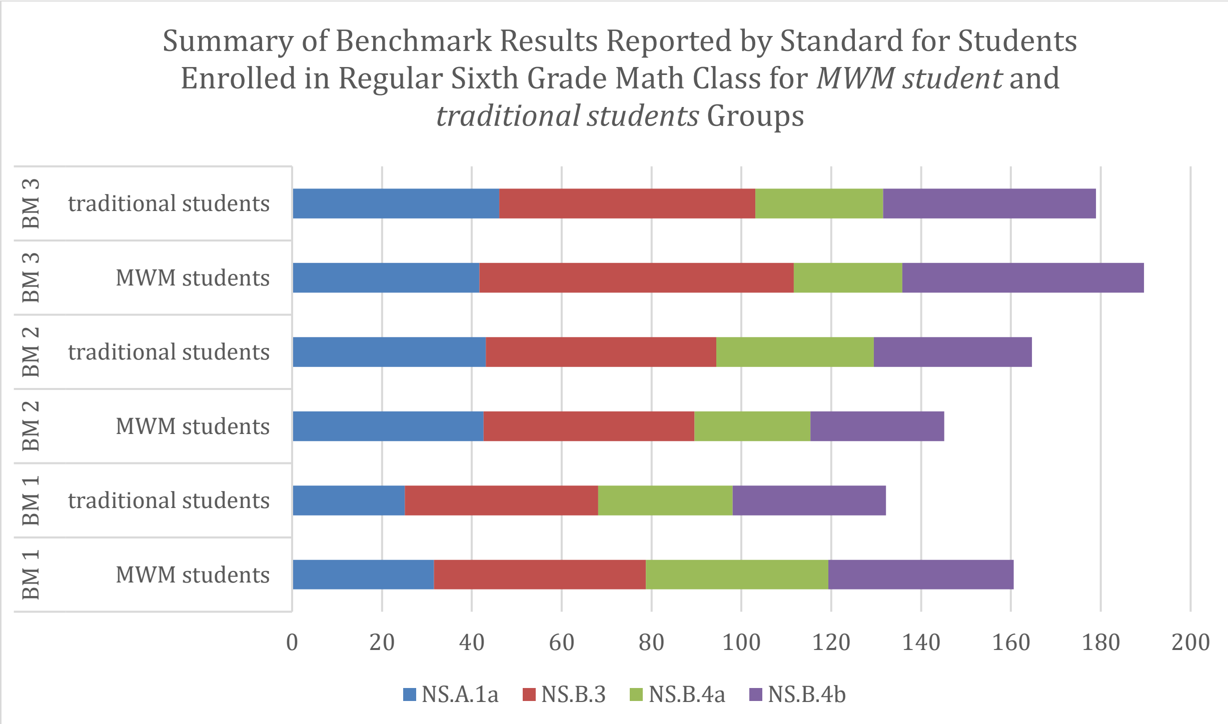



*Figure 3.* Summary of benchmark results reported by standard for students in regular sixth-grade math course who did and did not experience the Math Workshop Model

Table 15

*Summary of Benchmark Results Reported by Standard for Students in Regular Sixth-Grade Math Course Who Did and Did Not Experience the Math Workshop Model*

| Benchmark | Groups | NS.A.1a | NS.B.3 | NS.B.4a | NS.B.4b |
|---|---|---|---|---|---|
| BM 1 | *MWM students* | 31.56% | 47.19% | 40.63% | 41.25% |
| | *traditional students* | 25.12% | 43.01% | 29.9% | 34.19% |
| BM 2 | *MWM students* | 42.65% | 46.95% | 25.8% | 29.75% |
| | *traditional students* | 43.1% | 51.29% | 35.06% | 35.2% |
| BM 3 | *MWM students* | 41.67% | 70% | 24.17% | 53.75% |
| | *traditional students* | 46.08% | 57.03% | 28.46% | 47.39% |

*Note*. BM represents benchmark. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

**Research Question 2.** The second research question in this study was intended to address the relationship between implementing the Math Workshop Model as a tool for differentiating instruction and students' mindset in mathematics:

> How does a learning environment based on implementing the Math Workshop Model impact students' perception of their mathematical ability, or mindset, in sixth-grade?

The Math Workshop Model is designed to provide students of all ability levels equal opportunities to perform and learn in mathematics classes (Hoffer, 2012). To determine if the null hypothesis of the second research question could be rejected (that is, that a learning environment based implementing the Math Workshop Model does not have an impact of students' perception of their mathematical ability, or mindset), pretest and posttest data was collected from surveys to measure students' mindsets. The survey consisted of 15 questions regarding mindset, with students indicating the level to which they agreed or disagreed.

Using the scoring guide that accompanied the survey, a score (0-3) was assigned to each student response. Responses were totaled, and the maximum score a student could earn was 45. The final score placed each student into a predetermined category developed by the creators of the survey (Smithtown Central School District, 2014) indicating a strong fixed mindset (0–14 points), a fixed mindset with some elements of a growth mindset (15–23 points), a growth mindset with some elements of a fixed mindset (24–32 points), or a strong growth mindset (33–45 points). Because of the delimitation of students in the $MWM_B$ *students* group being exposed to instructional activities on mindset during the first two weeks of school, the pretest and posttest survey data of the $MWM_A$ *students* and $MWM_B$ *students* groups were tested for statistical significance separated. A two-tailed, paired *t*-test was performed using the pretest and posttest scores to determine whether each groups' data was statistically significant. The results of the two-tailed, paired *t*-test are provided in Table 16 and 17.

Table 16

*Statistical Significance Test Results for $MWM_A$ students'Mindset Survey Data*

| *Statistical measure* | *Mindset Posttest* | *Mindset Pretest* |
|---|---|---|
| Mean | 28.97 | 26.61 |
| Variance | 26.51 | 16.69 |
| Observations | 77 | 77 |
| Pearson Correlation | 0.81 | |
| Hypothesized Mean Difference | 0 | |
| df | 76 | |
| t Stat | 6.85 | |
| P(T<=t) one-tail | 8.24E-10 | |
| t Critical one-tail | 1.67 | |
| P(T<=t) two-tail | 1.65E-09 | |
| t Critical two-tail | 1.99 | |

Note. *$MWM_A$ students* is a subset of the larger group School A. Names of the school was omitted for confidentiality.

Table 17

*Statistical Significance Test Results for $MWM_B$ students' Mindset Survey Data*

| *Statistical measure* | *Mindset Pretest* | *Mindset Posttest* |
|---|---|---|
| Mean | 31.90 | 29.63 |
| Variance | 35.01 | 22.07 |
| Observations | 97 | 97 |
| Pearson Correlation | 0.30 | |
| Hypothesized Mean Difference | 0 | |
| df | 96 | |
| t Stat | 3.53 | |
| P(T<=t) one-tail | 0.0003 | |
| t Critical one-tail | 1.66 | |
| P(T<=t) two-tail | 0.001 | |
| t Critical two-tail | 1.98 | |

Note. *$MWM_B$ students* is a subset of the larger group School B. Names of the school was omitted for confidentiality.

As the *p* values from both two-tailed, paired t-tests ($p = 0.0001$ and $p = 0.001$) were smaller than the predetermined alpha value of $p \leq 0.05$, both sets of data proved to be statistically significant, leading to the rejection of the null hypothesis (a learning environment based implementing the Math Workshop Model does not have an impact of students' perception of their mathematical ability, or mindset). It was concluded that a relationship could exist between implementing the Math Workshop Model and students' mathematical mindset in a secondary setting.

Since the Mindset Survey data proved statistically significant, the data was explored further to draw conclusions about the relationship between the implementation of the Math Workshop Model and students' mindset in secondary mathematics. Because the survey results put students into categories, the data was analyzed in categories. Based on the survey data, students from *the $MWM_A$ students* and *$MWM_B$ students* groups were classified into each of the four categories provided with the survey. The number of students in each category after the pretest was compared to the number in each category after the posttest to determine how students' mindset changed. These comparisons were illustrated in Figures 4 and 5.

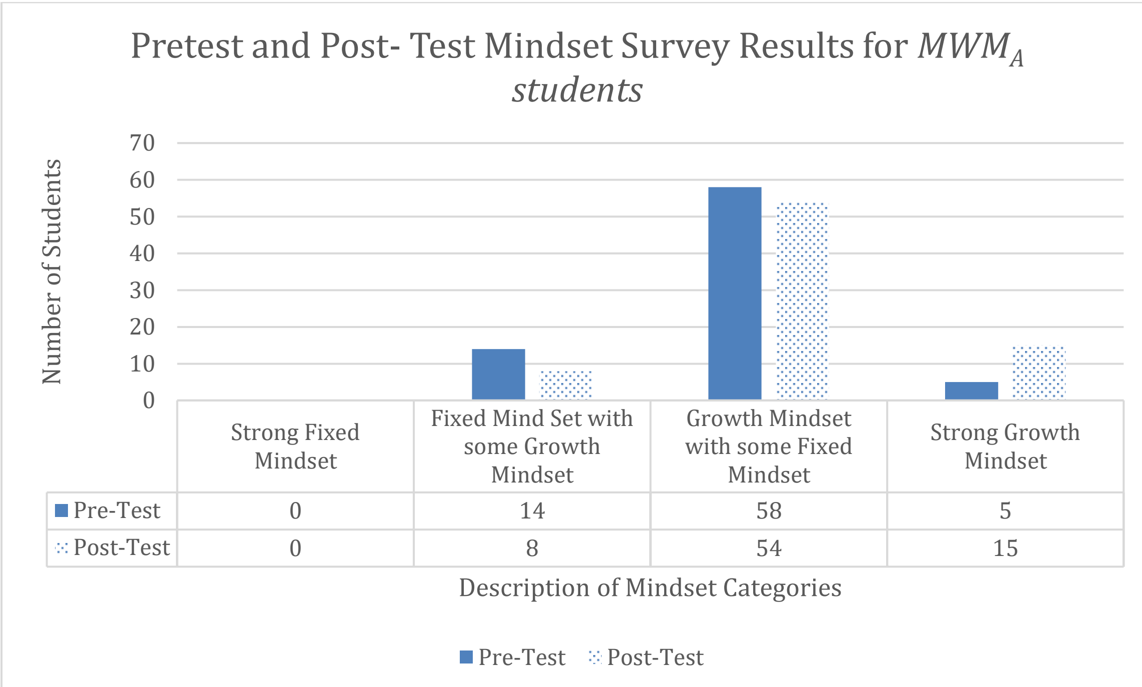



*Figure 4*. Distribution of pretest and posttest mindset survey results for $MWM_A$ *students*

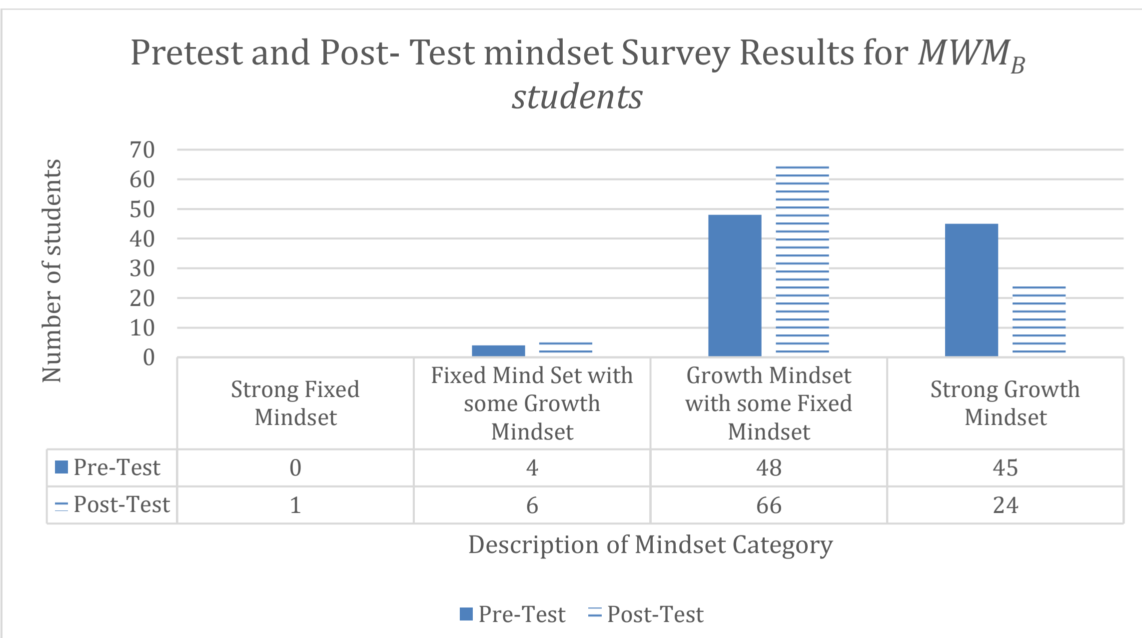



*Figure 5*. Distribution of pretest and posttest mindset survey results for $MM_B$ *students*

According to the pretest Mindset Survey data from the $MWM_A$ *students* group ($N$ = 77), many students began the study with elements of a growth mindset, with 63 scoring in the "strong growth mindset" and "growth mindset with some elements of fixed mindset" categories. These 63 students represent 82% of the group. When the posttest was administered, the number of students whose scored in the "fixed mindset with some elements of growth mindset" category shrank from 14 to eight students. The number of students in the strong growth mindset category rose from five to 15 students. After the posttest, the percentage of students in the "strong growth mindset" and "growth mindset with some elements of fixed mindset" was 90%, an increase of eight percent from the pretest.

Similar to the mindset pretest survey data generated by the students in the $MWM_A$ *students* group (Figure 4), the pretest Mindset Survey data showed that students in the $MWM_B$ *students* group ($N$ = 97) also began the study with strong elements of growth mindset. According to the Mindset Survey pretest data, displayed in Figure 5, 96% of students in the $MWM_B$ *students* group started the study with either a strong growth mindset (45) or a growth mindset with some elements of fixed mindset (48). However, by the end of the study, students in the $MWM_B$ *students* group had acquired more fixed mindset attributes, according to the scores of their posttest Mindset Survey. One student's posttest survey score indicated a strong fixed mindset. In addition, the number of students whose score placed them into the category of fixed mindset with some elements of growth mindset grew by two to six from the pretest to posttest survey. Overall, 90% of the students in the $MWM_B$ *students* group remained in the categories dominated by growth mindset (growth with some fixed: 66; strong growth: 24), indicating that only 6% of the total group fell out of a category that was growth mindset oriented.

**Summary**

This study was to designed to determine if a relationship existed between differentiating instruction by implementing the Math Workshop Model and academic achievement in sixth-grade mathematics, as well as students' mindset regarding their abilities in mathematics. After 187 students learned in classes in which the Math Workshop Model was implemented, quantitative data was collected to conclude if the null hypotheses of the research questions of this study could be rejected.

Students' academic achievement data was collected from the participating district's benchmarking database, ATI-Galileo, and converted into Excel files. The data was then analyzed using SQL, a standard programming language for accessing and manipulating databases, and Analysis ToolPak, an AddIn statistical analysis tool for Microsoft Excel. Students' district-administered benchmark data was used to calculate a growth score from one benchmark to another and from the first benchmark to the last. These growth scores were tested, using a two-tailed *t*-test, for statistical significance.

As the data was explored, the final demographic data and other student distribution data within the *MWM students*, *traditional students*, and *district* groups presented opportunities to explore the data for unanticipated relationships. The unusual and unbalanced distribution of male and female students in the *MWM students* groups when compared to the *traditional students* groups led to analysis of achievement data between male student and female students. Similarly, the unbalanced distribution of students into the regular sixth-grade mathematics and advanced mathematics courses led to examination of the academic data of students enrolled in each of these courses. The general data analysis for this study showed that the *MWM students* group usually exhibited growth when the data proved to be statistically significant. However, deeper analysis of this data led to more meaningful conclusions. In Chapter 5, the researcher analyzed results that were different than expected, as well as the differences that occurred from different courses and genders groups.

# Chapter 5: Discussion and Conclusion

Educators disagreed about what constituted high quality differentiated instruction in mathematics (Huebner, 2010). However, many mathematics teachers agreed that "when students are productively engaged, learning is an almost certain byproduct." (Leinwand, 2018 as cited in Blanke, 2018, p. 5). Finding instructional strategies that promoted engagement in mathematics, especially at the secondary level, due to the expansive range of ability levels found within a single classroom was challenging (Huebner, 2010). Instruction strategies focused on one specific group or ability engaged students with higher academic ability but left students at lower academic levels struggling to find entry points into the activities (Boaler, 2016).

Through recent neuroscience research, connections were made between students' cognitive development during the secondary years and the need for student interaction with peers and validation from individuals their own age rather than adults (Armstrong, 2016). These insights into the neurological motivations of adolescents added another layer to the challenge of engaging students in mathematics (Jensen & Snider, 2013). This study explored the potential relationship between implementing the Math Workshop Model, an instructional tool that promotes student engagement and equity through a variety of strategies, and students' academic achievement and self-perception, or mindset, in sixth-grade mathematics.

In this chapter, results of the quantitative, ex-post facto study of the impact of 187 students learning in classrooms where the Math Workshop Model was implemented were discussed. In addition, data from this study were synthesized with recent research to enhance understanding of strategies designed to engage secondary mathematics students to promote academic achievement and growth mindsets. Potential opportunities for future research to further develop the data from this study were also considered in this chapter.

## Summary of the Results

Research in the last decade indicated that students, especially in mathematics, learned more effectively when they collaborated with their peers to solve problems, rather than working in isolation (Armstrong, 2016; Boaler, 2016a; Jensen & Snider, 2013). North American students' scores in mathematics on standardized assessments continued to decline compared to scores of students in other countries (National Center for Education Statistic; Institute for Educational Sciences, 2016). The conflict between research on best practices to engage students in high quality mathematics learning environments and steady declines in mathematics scores on academic achievement tests prompted the research questions that framed this study:

1. What is the relationship between differentiated instruction through implementation of the Math Workshop Model and academic achievement of students in sixth-grade mathematics?
2. How does a learning environment based on implementing the Math Workshop Model affect students' perception of their own mathematical ability, or mindset, in sixth-grade?

A quasi-experimental research model was used for this study. A true experimental method was not used because participants were not chosen in a random order to be in certain groups that were studied during the research (McMillan, 2010). Student were chosen to participate in the study based on the criteria that teachers had prior understanding of the Math Workshop Model and participated in district professional development on the Math Workshop Model, where the teachers learned about the structure of the Math Workshop Model and strategies used within the structure to engage all students equitably in learning. The teachers were expected to utilize the strategies highlighted in the professional development as they implemented the Math Workshop Model.

Additionally, a purposive sample was used to select students for the study. A purposive sampling method was applied by selecting students for the *MWM student* group according to criteria defining teachers' experience with and professional development in the Math Workshop Model. This limited, purposive sampling method effected the study's internal validity and reliability. Students in the *district* and *traditional students* groups learned in math classrooms in which the Math Workshop Model was not implemented. Therefore, the independent variable in this study was whether or not students learned in an environment where the Math Workshop Model was implemented. The dependent variables were the students' academic achievement scores on the benchmark assessments given throughout the study and the students' pretest and posttest scores from the Mindset Survey given at the beginning and the end of the study.

**Research question 1.** Students' academic data was collected and analyzed from three benchmark assessments to determine if the null hypothesis of Research Question 1 (there is no relationship between differentiating instruction through implementation of the Math Workshop Model and students' academic achievement in mathematics in sixth-grade mathematics) could be rejected. The first benchmark assessment was given prior to the start of the study, at the beginning of the school term in September. These academic assessment scores were archived to be used for comparative purposes. Even though the scores were collected from an assessment given before the study began, the data from this assessment provided internal validity and reliability to the academic data collected throughout the study (McMillan, 2012). In addition, students' results on the district's first benchmark assessment represented a true pretest data of students' academic ability.

The academic achievement scores from the three benchmarks were analyzed for growth on an individual student level. The growth per student was used in the *MWM students* group as well as the growth per student of the *district* and *traditional students* groups to conduct two-tailed *t*-tests. The results of the two-tailed *t*-tests were used to determine if the academic achievement data was statistically significant. When the academic growth data from Benchmark two and Benchmark three were compared in this manner, the results were not statistically significant. Instead, results of the test for statistical significance yielded a *p* value of approximately $p = 0.5409$, well above the acceptable alpha value of $p \leq 0.05$. When the academic growth data from Benchmark one and Benchmark three were compared using a two-tailed *t*-test, however, the results were statistically significant, yielding a *p* value of approximately $p = 0.00001$.

**Academic achievement data.** Once students' academic achievement was determined to be statistically significant when comparing growth from Benchmark one to Benchmark three, the data was analyzed in depth to establish patterns in the *MWM students* group that could be used to respond to Research Question 1. First, the data was considered based on the four standards that were assessed over the course of the three benchmark assessments. These standards were outlined in Chapter 4. The average achievement score was calculated for the $MWM_A$ *students*, $MWM_B$ *students*, and *district* groups. These scores of these groups were compared to infer if implementing the Math Workshop Model affected the academic achievement of students in the *MWM students* groups significantly enough to attribute the growth to the Math Workshop Model. These scores are illustrated in Table 18.

Table18

*Summary of  Benchmark Results by Standard for Students Who Did and Did Not Experience the Math Workshop Model*

| Benchmark | Group | NS.A.1a | NS.B.3 | NS.B.4a | NS.B.4b |
|---|---|---|---|---|---|
| BM1 | *$MWM_A$ students* | 30.42% | 40.36% | 31.33% | 43.37% |
| | *$MWM_B$ students* | 29.21% | 58.91% | 43.07% | 36.39% |
| | *district* | 30.5% | 52.43% | 33.09% | 41.2% |
| BM2 | *$MWM_A$ students* | 58.22% | 56.89% | 40% | 40% |
| | *$MWM_B$ students* | 47.67% | 57.33% | 31.67% | 44.33% |
| | *district* | 56.38% | 62.38% | 50.29% | 48.9% |
| BM 3 | *$MWM_A$ students* | 40.06% | 76.03% | 26.7% | 53.82% |
| | *$MWM_B$ students* | 33.66% | 61.39% | 31.19% | 49.17% |
| | *district* | 51.33% | 69.46% | 33.89% | 59.81% |

Note.  BM represents benchmark.  *$traditional_A$ students* and *$MWM_A$ students* are subsets of their larger groups enrolled in School A.  *$traditional_B$ students* and *$MWM_B$ students* are subsets of their larger groups enrolled in School B.  Names of schools were omitted for confidentiality.

This data analysis showed some positive effects of implementing the Math Workshop Model in the *$MWM_A$ students* and *$MWM_B$ students* groups in some circumstances, but not for every standard and not always at the same rate as the *district* group.  The students in *$MWM_A$ students* group, for instance, showed positive growth at a higher rate for standard NS.B.3 than the other groups being compared, but illustrated inconsistent growth (both negative and positive) on other standards.  The students in *$MWM_B$ students* group had inconsistent growth patterns over the all four standards.  With no consistent pattern emerging, it was difficult to use the results of the data analysis comparing *$MWM_A$ students*, *$MWM_B$ students*, and *district* groups to draw any solid conclusions regarding the relationship between implementing the Math Workshop Model and students' academic achievement.

One consistent trend for the students in the *$MWM_A$ students* and *$MWM_B$ students* group was a higher average academic achievement level on Benchmark three than Benchmark one. On three out of four standards, the students in the *$MWM_A$ students* and *$MWM_B$ students* group posted higher average academic achievement scores at the end of the study than each group did respectively at the beginning of the study. For the standard on which higher average academic achievement scores were not posted, NS.B.4a, the *district* group showed only minimal growth on Benchmark three at less than one percent (0.8%). Despite the inconsistent growth patterns illustrated by the academic achievement data across all three data points, the final results from September to March showed the *$MWM_A$ students* and *$MWM_B$ students* group had positive growth on three out of four standards measured, even if this growth was not more substantial than that recorded by the students in the *district* group.

*Academic data analyzed by subgroups.* When considering the unusual distribution of the student demographics within the *MWM students* and *traditional students* groups and the size variance of the *MWM students* and *district* group, analyzing the data through different lens after students finished taking the benchmarks was appropriated (McMillan, 2012). By changing the subgroups according to which the data was organized and analyzed after the assessments were completed, the researcher gained the opportunity to exam how different factors might have effected implementation of the Math Workshop Model and the academic achievement of the students in the *MWM students* and other groups. For instance, the distribution of male and female students in the *$MWM_A$ students and $MWM_B$ students* groups was disproportionate to the distribution of male and female students in the *$traditional_A$ students* and *$tradtional_B$ students* groups, as shown in Table 19. The population of the *$traditional_A$ students* group (*N*=298) consisted of significantly more male students by percentage (59%) than the *$traditional_B$ students* group (47%) or the *$MWM_A$ students and $MWM_B$ students* groups (46% and 41% respectively). These unusual patterns in gender distribution indicated a factor that could have potentially affected the data, and thus warranted further analysis (McMillan, 2012).

Table 19

*Gender distribution in Sixth-grade throughout the District*

| Group | Total Population | Female | Male |
|---|---|---|---|
| *district* | *N* =1202 | 48% (*n* = 577) | 52% (*n* = 625) |
| *traditional students* | *N* = 635 | 47% (*n* = 301) | 53% (*n* = 334) |
| *$traditional_A$ students* | *N* = 298 | 41% (*n* =122) | 59% (*n* = 176) |
| *$tradtional_B$ students* | *N* = 337 | 53% (*n* 179) | 47% (*n* = 158) |
| *MWM students* | *N* =187 | 57% (*n* = 106) | 43% (*n* = 81) |
| *$MWM_A$ students* | *N* = 82 | 54% (*n* = 44) | 46% (*n* = 38) |
| *$MWM_B$ students* | *N* =105 | 59% (*n* = 62) | 41% ( = 43) |

*Note*. *$traditional_A$ students* and *$MWM_A$ students* are subsets of their larger groups enrolled in School A. *$traditional_B$ students* and *$MWM_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

To determine the statistical significance of the academic achievement data for gender groups, the achievement data for each gender group from the *MWM students* and *traditional students* group were compared. A two-tailed *t*-test of the data comparing the academic achievement data of the male students in the *MWM students* group and the male students in the *traditional students* group produced a *p* value of approximately $p$=0.0895. This exceeded the acceptable alpha value of $p \leq 0.05$, indicating the male achievement data was not significant. The conclusion drawn from this statistical test was that the null hypothesis of Research Question

1 must be accepted and there was no relationship between implementing the Math Workshop Model and the academic achievement of male students in sixth-grade mathematics.

The two-tailed *t*-test of the data comparing the academic achievement data of the females in the *MWM students* group and the females in the *traditional students* group generated a *p* value of approximately *p*=0.0195. This was less than the acceptable alpha value of $p \leq 0.05$, indicating the female achievement data to be significant. These results meant that the null hypothesis of Research Question 1 could be rejected, and a relationship between implementing the Math Workshop Model and academic achievement of female students in sixth-grade was possible. When the data was analyzed to determine what that relationship might be, it was observed that in most cases, female students in the *MWM students* group exhibited positive academic achievement growth from Benchmark one to Benchmark three on three of the four academic standards assessed. Generally, when positive growth was not present in the female *MWM students* group, a similar lack of positive growth existed in the female *traditional students* group. Despite showing growth on 75% of the standards assessed, as well as overall growth from Benchmark one to three (48.3 % to 56.4%), the final performance of the females in the MWM students group did not surpass that of the females in the *traditional students* group. Females in the *traditional students* group started with an average score on Benchmark one of 47.6% and finished with an average score of 57.8% on Benchmark three. While the scores of the females in the *MWM students* and *traditional students* groups were extremely similar, the females in the *MWM students* group did not outscore the other females.

In addition to gender, the data was analyzed according to the course in which students were enrolled. The distribution of students enrolled in the regular sixth-grade and advanced sixth-grade courses indicated a possible disparity between the data of students in the $MWM_A$

*students*, *$MWM_B$ students, traditional$_A$ students*, and *traditional$_B$ students* groups. As shown in Table 20, the district sixth-grade enrollment (*N*=1084) between the two different course offerings was split evenly. However, course enrollments in other populations did not reflect this even split. In *traditional$_A$ students* group (*N*=176), a majority of students (64%) were enrolled in the advanced sixth-grade course, which was a unique trend. Enrollments in the *$MWM_A$ students* (*N*=82) and *$MWM_B$ students* (*N*=187) group showed percentages that were closer to the district one-to-one ratio, with 49% and 48% of their students respectively enrolled in the advanced sixth-grade course. Due to the drastic difference in the percentage of students in the *traditional$_A$ students* group enrolled in the advanced sixth-grade course than all other groups, the researcher was concerned with the effects of this factor on achievement data and performed additional analysis on the achievement data.

Table 20

*Sixth-Grade Course Enrollment Distribution of Different Groups of Students throughout the District*

| Group | Total Population | Enrollment | |
|---|---|---|---|
| | | Advanced Course | Regular Course |
| *district* | *N*=1084 | 50% (*n*=542) | 50% (*n*=542) |
| *traditional students* | *N*=481 | 51% (*n*=246) | 49% (*n*=235) |
| *traditional$_A$ students* | *N*=176 | 64% (*n*=112) | 36% (*n*=64) |
| *tradtional$_B$ students* | *N*=305 | 44% (*n*=134) | 56% (*n*=171) |
| *MWM students* | *N*=187 | 48% (*n*=90) | 52% (*n*=97) |
| *MWM$_A$ students* | *N*=82 | 49% (*n*=40) | 51% (*n*=42) |
| *MWM$_B$ students* | *N*=105 | 48% (*n*=50) | 52% (*n*=55) |

*Note*. *traditional$_A$ students* and *MWM$_A$ students* are subsets of their larger groups enrolled in School A. *traditional$_B$ students* and *MWM$_B$ students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

Two-tailed *t*-tests were performed to compare the academic achievement data of students enrolled in the advanced mathematics courses of the *MWM$_A$ students* and *traditional$_A$ students* groups as well as the *MWM$_B$ students* and *traditional$_B$ students* groups. The groups of students from School A and School B were analyzed separated due to the drastic difference in enrollment in the advanced math course in the *traditional$_A$ students* group at School A. The analysis produced *p* values of approximately $p = 0.0823$ and $p = 0.52184$, respectively. Neither of these *p* values were less than the acceptable alpha value of $p \leq 0.05$. As such, neither group of data was statistically significant, and the null hypothesis of Research Question 1 was accepted, and no relationship was assumed to exist between implementing the Math Workshop Model and academic achievement of students enrolled in the advanced math course in sixth-grade.

To determine if the null hypothesis of Research Question 1 could be rejected for the students in the *MWM students* group enrolled in the regular math course, a two tailed *t*-tests was performed on the academic achievement growth data of students in the $MWM_A$ *students* and $traditional_A$ *students* groups, as well as the $MWM_B$ *students* and $traditional_B$ *students* groups enrolled in regular sixth-grade mathematics. This test of significance produced *p* values of approximately $p = 0.0065$ and $p = 0.0404$, respectively. These were less than the acceptable alpha value of $p \leq 0.05$, proving the data significant. Therefore, the null hypothesis of Research Question was rejected, and it was assumed a relationship could exist between implementing the Math Workshop Model and the academic achievement of students enrolled in the regular sixth-grade math course. The data of the students enrolled in the regular sixth-grade math course in the *MWM students* and *traditional students* groups were explored, and the researcher noticed a different result than any other comparison revealed. For the first time, the students in the *MWM students* group finished with a higher achievement level than did the students in the *traditional students* group. Students in the *MWM students* group started with an average score of 40.2% on Benchmark one and ended with an average score of 47.4% on Benchmark three. The students in the *traditional students* group, however, began with an average score of 33.1% on Benchmark one and ended with an average score of 44.7% on Benchmark three.

**Research question 2.** To draw conclusions about Research Question 2, how implementing the Math Workshop Model affected students' mathematical mindset, students' results from the Mindset Survey were analyzed. Due to a conflict with the predetermined district schedule for administering the pretest and posttest of the Mindset survey to all sixth-grade student in the district and the schedule of the study, only the students in the *MWM students* group were given both the pretest and posttest Mindset Survey.  To determine the statistical significance of this survey data, separate two-tailed, paired *t*-test was performed for the students in the *$MWM_A$ students* and *$MWM_B$ students* groups.  The data from the two groups was analyzed separately due to a previously identified delimitation in the *$MWM_B$ students* group regarding mindset contend presented to students in this group in the first two weeks of school.  Both statistical tests produced *p* values, $p = 0.0000001$ and $p = 0.001$ respectively, smaller than the acceptable alpha value of $p \leq 0.05$.  These *p* values smaller than 0.05 made both sets of data statistically significant.

To analyze the mindset data for the students in the *$MWM_A$ students* and *$MWM_B$ students* groups, the change in distribution of data into each of the four defined categories (strong fixed mindset, fixed mindset with some elements of growth mindset, growth mindset with some elements of fixed mindset, and strong fixed mindset) was analyzed (Smithtown Central School District, 2014).  The pretest and posttest data from the *$MWM_A$ students* ($N = 77$) group indicated a shift from fixed toward growth mindsets.  On the pretest, 18.2% of students' scores placed them in the fixed mindset category, but on the posttest, this percentage dropped to 10.4%.  The data from the students in the *$MWM_B$ students* group ($N = 97$) did not suggest the same positive shift, however.  The pretest data from the *$MWM_B$ students* group ($N = 97$) indicated, through their pretest scores, 96% of students possess either a growth mindset or strong growth mindset, while 4% of students had a fixed mindset.  The posttest scores of the students in the *$MWM_B$ students* group ($N = 97$) demonstrated a shift towards more fixed mindsets.  Based on the posttest results, only 93% of students had a growth or strong growth mindset while 7% of students had a fixed or strong fixed mindset.

**Discussion of Results**

The results generated in this study were not always consistent within the scope of the study, nor were they always consistent with existing literature on learning environments influenced by constructivism, the Math Workshop Model, or growth mindsets. Some data analysis indicated that implementing the Math Workshop Model and focusing on growth mindsets created equity of opportunities for students, with positive effects on academic achievement data. However, students in the *MWM students* group did not consistently outperform students in the *traditional students* or *district* groups. Previous research on differentiated instruction found consistent positive growth on measured achievement, regardless of the differentiation strategy used (Abbati, 2012; Ashley, 2016; Boaler & Staples, 2008; Hattie et al., 2017; James, 2013; Kelly, 2013; Merritt, 2016).

When significant growth did occur in the *MWM students* group, strategies utilized by teachers implementing the Math Workshop Model seemed to be most effective in classes where students were grouped heterogeneously and ability levels varied. The strategies used by teachers implementing the Math Workshop Model included small, guided group instruction, conferencing with students, collaborative groups, and learning centers. Learning activities that promote peer collaboration in which the teacher's main role is the facilitator allowed for more equitable opportunities for all students (Hoffer, 2012), and research showed that specific components of adolescent brain development can be enhanced by these engaging, social activities (Armstrong, 2016; Jensen & Snider, 2013). When significant achievement and/or shifts toward growth mindset were not present, implementation of other district initiatives, benchmark assessment scheduling issues, and pre-existing student mindsets may have affected the outcome of the data.

**Positive effects of implementing the Math Workshop Model.** While the academic achievement growth of students in the study was not as significant as in other research, growth was observed. Students in the *MWM students* group learned mathematics in classrooms in which the Math Workshop Model was implemented. Students were chosen to be in the *MWM students* group based on the criteria that teachers of their classes had prior understanding of the Math Workshop Model and attended professional development on implementing the Math Workshop Model prior to the start of school. During the professional develop attendee by teachers, the researcher presented training on research-based instructional strategies to be used while implementing the Math Workshop Model (Hoffer, 2012) The four strategies taught to the teachers were small, guided group instruction, conferencing with students, collaborative student group work, and learning centers. Hattie et al. (2017) indicated that feedback, when timely and individualized for students' specific needs, had an effect size of 0.75. Given that the four strategies taught to teachers and utilized during the implementation of the Math Workshop Model were designed to provide students with feedback, the Math Workshop Model itself, when implemented with fidelity, was in the high zone of desired effects (Hattie et al. 2017).

Studies have found that small, guided groups and conferencing with students allowed teachers to provide students with more specific and timely feedback than in whole group settings (Hoffer, 2012). By implementing the Math Workshop Model, the students in the *MWM students* group were exposed to researched-based strategies that provided them with more detailed information about their individual learning progress and needs (Lempp, 2017). Teachers of these students also gained specific knowledge of each student's individual needs, leading to more targeted, data-driven interventions (Hoffer, 2012). When teachers know their students' needs, can communicate to students what students know and do not know, and plan instruction based on this timely data, student achievement increases (Chappuis, 2015). Despite overwhelming literature and research that supported implementing the Math Workshop Model and the strategies used within is, inconsistent and smaller than expected growth was recorded in this study. The unexpected results could be attributed to implementation of the Math Workshop Model. A purposive sample was used to select students whose teachers had knowledge of the Math Workshop Model to limit the effects of teacher implementation on the results of the study (McMillan, 2012), but teachers were still relatively inexperienced with the implementation of Math Workshop Model during the study. This inexperience could have affected the results, causing the unexpected differences.

***Reversing gender bias in secondary mathematics classrooms***. In and outside classrooms, students are exposed to educational influences of gender bias, especially in mathematics (Boaler, 2016b). Female students saw and heard messages that they were not equipped to handle the complex tasks of advanced mathematics (Boaler, 2016b). Some mathematics teachers had classroom routines and preconceived notions that reinforced these gender biases (McKibben, 2018). The results of this study implied that female students could benefit from learning in classrooms where the Math Workshop Model was implemented.

Gender bias often accompanied female students from elementary school (McKibben, 2018). Female students' frequently entered middle school unaware they possessed unconscious perceptions of inadequacies regarding their abilities in mathematics, making it difficult for teachers to recognize female students' feelings of self-doubt in mathematics (Boaler, 2016b). The instructional practices teachers chose could either reinforce these feelings of failure and insufficiency or begin to change the way female students view themselves (Baoler, 2016a). Without the appropriate structures in place, male students easily overtook whole group classroom discussions while female students became passive and disengaged (McKibben, 2018). Implementing the Math Workshop Model allowed for students who lack confidence in their own abilities in mathematics to experience mathematics learning in smaller groups by working in properly constructed collaborative settings and under the closer guidance of the teacher (Hoffer, 2012). Students who learned in small, guided groups instead of large whole group settings reported more confidence and were more comfortable to participate in discussion and answer questions (Lempp, 2017). In this study, the female students in the *MWM students* group exhibited similar academic achievement as the female students in the *traditional students* group. While similar achievement between the groups did not provide conclusive support to Research Question 1, the researcher found promise within the results of the analysis of the data from the females in the *MWM students* group. The researcher would have liked to continue studying the *MWM students* and *traditional students* group to see what patterns might evolve over time.

***Changing mindset.*** Students' perception of their own abilities in mathematics class, especially at the secondary level, often depended on their interaction with peers throughout the learning process (Armstrong, 2016; Dweck, 2016). Constructivist theory was built on the foundation that understanding was a synthesis of previous experiences and new knowledge gained from social interactions with peers (Krahenbuhl, 2016). Neuroscience research indicated that students at the secondary level were influenced by their peers' opinions and feedback more than adults' (Armstrong, 2016). Consistent with this research, the results of the pretest and posttest Mindset Survey data suggested that students exposed to the Math Workshop Model, learning in a more collaborative environment, experienced positive shifts toward growth mindsets.

Most students in this study possessed some growth mindset traits at the outset of the study, as indicated by the pretest survey results from the students in the *$MWM_A$ students* and *$MWM_B$ students* groups. However, the posttest survey results showed that many students developed more growth mindset traits, especially in the *$MWM_A$ students* group. This positive shift in data indicated students in the *MWM students* group acquired stronger growth mindset attributes after learning through the Math Workshop Model, a more equitable and collaborative learning environment (Hoffer, 2012). By collaborating with peers, working in small groups, and becoming part of a learning community, students gained confidence in their own abilities (Boaler & Staples, 2008). The purpose of Research Question 2 was to establish if implementing the Math Workshop Model effected students' mathematical mindsets in sixth grade. As supported by the data from the study, the environment created by implementing the Math Workshop Model allowed students in the *MWM students* group to participate in activities that promoted growth mindsets.

**Inconsistencies in the data.** The original research methodology in this study was to collect pretest and posttest academic achievement data that would be analyzed to determine what, if any, relationship existed between implementing the Math Workshop Model to differentiate instruction and students' academic achievement in sixth-grade mathematics. The complexity of distributions of different subgroups within the students being compared led to the possibility that the data was influenced by more than just implementing the Math Workshop Model (independent variable). Multiple analyses of the data into several different groups and subgroups within the sample and the population were needed to achieve more accurate results. Other factors, such as curriculum design, sampling method, and assessment design may have also impacted the results, causing some of the inconsistencies revealed in the results.

***More growth in the first half of the year***. Prior to the beginning of the study, the participating district created an assessment plan for the school year that included a schedule for administering its district grade-level benchmark assessments. The sixth-grade benchmark assessments were also used as the instrument to collect academic achievement data in this study. The district assessment plan called for Benchmark one to be given in September, Benchmark two in December, and Benchmark three in May. Due to the timing of the approval process for the study, Benchmark two was used as the pretest for the study, and Benchmark three was used as the posttest. When looking at the complete data profile for the sixth-grade students in the *MWM students*, *traditional students*, and *district* groups, however, the data generated by students prior to Benchmark two could not be ignored. There were four standards from the sixth-grade MLEs (Missouri Department of Elementary and Secondary Education, 2017c) and the participating district's curriculum that were measured over the course of the assessment cycle. These four standards were:

6.NS.A.1a: Compute and interpret quotients of positive fractions. Solve problems involving division of fractions by fractions.

6.NS.B.3: Demonstrate fluency with addition, subtraction, multiplication and division of decimals.

6.NS.B.4a: Find the greatest common factor (GCF) and least common multiple (LCM).6.NS.B.4b: Use the distributive property to express a sum of two numbers with a common factor as a multiple of a sum of two whole numbers.

Of the four standards measured in the study, students in the *MWM students* group showed more significant growth on their overall average score from Benchmark one to Benchmark two

(+7.88%) than they did from Benchmark two to Benchmark three (-0.52%). Table 21 provided data depicting the average scores for the students in the *MWM*$_A$ *students* and *MWM*$_B$ *students* reported by standard. Overall benchmark averages were the average of each standard. One conclusion for the difference between the averages was students did not perform as well when teachers were implementing the Math Workshop Model, but alternate explanations were supported by evidence from the design of the sixth-grade curriculum.

Table 21

*Summary of Benchmark Results by Standard for Students Who Did and Did Not Experience the Math Workshop Model*

| Benchmark | Group | NS.A.1a | NS.B.3 | NS.B.4a | NS.B.4b |
|---|---|---|---|---|---|
| BM 1 | *MWM*$_A$ *students* | 30.42% | 40.36% | 31.33% | 43.37% |
| | *MWM*$_B$ *students* | 29.21% | 58.91% | 43.07% | 36.39% |
| | *district* | 30.5% | 52.43% | 33.09% | 41.2% |
| BM 2 | *MWM*$_A$ *students* | 58.22% | 56.89% | 40% | 40% |
| | *MWM*$_B$ *students* | 47.67% | 57.33% | 31.67% | 44.33% |
| | *district* | 56.38% | 62.38% | 50.29% | 48.9% |
| BM 3 | *MWM*$_A$ *students* | 40.06% | 76.03% | 26.7% | 53.82% |
| | *MWM*$_B$ *students* | 33.66% | 61.39% | 31.19% | 49.17% |
| | *district* | 51.33% | 69.46% | 33.89% | 59.81% |

*Note.* BM stands for benchmark. *traditional*$_A$ *students* and *MWM*$_A$ *students* are subsets of their larger groups enrolled in School A. *traditional*$_B$ *students* and *MWM*$_B$ *students* are subsets of their larger groups enrolled in School B. Names of schools were omitted for confidentiality.

The official beginning of the study was January 15, 2018 when Concordia University-Portland IRB approved the research. The teachers participating in the study, however, were implementing the Math Workshop Model in their classes before this date. The teachers of the *MWM student* group showed interest in implementing the Math Workshop Model as a method of differentiation prior to the beginning of the school year, attended professional development on the topic, and were supported by district leadership through normal district activities. Therefore, when this study began, students in the *MWM students* group were already experiencing some aspects of the Math Workshop Model as their teachers began implementing the instructional strategies they acquired in the summer professional development such as small, guided group learning, conferencing with the teacher, and learning centers (Hoffer, 2012).

The design of the sixth-grade curriculum could have also been a factor in the larger growth experienced by the students in the *MWM students* group from Benchmark one to Benchmark two. The pacing and sequencing of the participating district's sixth-grade curriculum, which aligned with the MLEs, contained many topics in the first half of the year that built on the understanding students brought from fifth grade (Missouri Department of Elementary and Secondary Education, 2017c). In the first half of the year, students expanded on skills from fifth grade, such as operations with whole numbers and understanding of fractions, to learn about operations with positive rational numbers and ratios and proportional reasoning. In the second half of the year, students continued to apply proportional reasoning and began to develop algebraic thinking by writing algebraic expression and equations and solving one-step equations and inequalities. Students also explored geometric concepts of area, volume, surface area, and basic data analysis and probability in the second half of the year. Because the curriculum in the beginning of the year contained topics for review, or that built off skills learned in fifth grade, the first half of the sixth-grade curriculum tended was less rigorous for students than the second half. The difficulty level of the curriculum could have been a factor attributing to the difference in the growth rate exhibited in the academic achievement of the students in the *MWM students* group from Benchmark one to two and from Benchmark two to three.

***Sampling effect on results***. To address the limitation of teachers' knowledge of the Math Workshop Model, the choice was made to use a purposive sample in this study. The impact of that decision was noticeable when analyzing data. Selection criteria established for the purposive sample required teachers to have prior knowledge of the Math Workshop Model and attend the professional development on implementing the Math Workshop Model. These criteria limited the number of students selected for the *MWM students* group (*N* = 187), making the sample significantly smaller than the *district* group (*N* = 1202). Also, the students in the *district* group had different attributes than the *MWM students* group because the specificity of the criteria limited selection of students for the MWM student group from only two of the four middle schools in the district.

When these discrepancies in the demographic distribution were noticed, the academic achievement data was analyzed through different lenses according to anomalies in the data. To perform some of these analyses, it was sometimes necessary to manipulate the group to which the *MWM students* group was compared. The result was the creation of subgroups within existing groups such as $traditional_A$ *students* (*N* = 298) and $traditional_B$ *students* (*N* = 337) groups. When the *MWM students group* was compared to the *district* group (*N* = 1202), the results did not support conclusions made in the literature reviewed about the relationship between implementing the Math Workshop Model and the mathematic academic achievement. When the other factors, such as gender and course enrollment, were considered and the data was analyzed to account for these factors, the effect of the Math Workshop Model was more prominent in the results. Female students' data in the *MWM students* and *traditional students* groups proved to be statistically significant, with the female students' achievement in the *MWM students* group improving from 48.3% to 56.4% from Benchmark one to Benchmark three and nearly equaling the final achievement score of the female students in the *traditional students* group (57.8 % on Benchmark three). Students enrolled in the regular sixth-grade math course in the *MWM students* group showed the most significant results in the study, increasing from 40.2% to 47.4% from Benchmark one to Benchmark three and outscoring the students enrolled in the regular sixth-grade math course in the *traditional students* group on Benchmark three (44.7%)

***Benchmark assessments design***. The benchmark assessments designed in the Galileo assessment platform contained assessment items that were vetted by ATI-Galileo to guarantee statistical validity and reliability (Assessment Technology Incorporated, 2002). The content assessed on the sixth-grade benchmark assessments was aligned to the participating district's sixth-grade curriculum and the sixth-grade MLEs (Missouri Department of Elementary and Secondary Education, 2017c). A certain degree of validity and reliability in the data generated from the assessments was assumed due to the psychometric analysis used by ATI-Galileo to evaluate each of the items used on the assessments (Assessment Technology Incorporated, 2002). One issue regarding the benchmark assessments that was not considered, however, was the type of items used to assess students' understanding. The Galileo benchmark assessments were designed to mirror the Missouri state achievement test, including the types of items used to assess students (Assessment Technology Incorporated, 2002). However, the types of items on the state assessment were no longer simple low rigor, multiple-choice questions (Missouri Department of Elementary and Secondary Education, 2017c). The state assessment contained items such as multiple choice, drag and drop, matching, ordering, and short answer questions (Missouri Department of Elementary and Secondary Education, 2017c). These types of items were relatively new for students in sixth-grade, and the type of item itself potentially posed a challenge completely separate from that of the content.

When item analyses of the benchmark data was performed with groups of teachers, it was noted that often when poor student achievement was recorded, for example, on standard NS.B.4a (find the greatest common factor and the least common multiple) (Missouri Department of Elementary and Secondary Education, 2017c), the type of item used to assess the standard was a more rigorous type to which students had not had extensive exposure. The types of items used to assess the content possibly distorted the final academic achievement data, making it difficult to differentiate between students misunderstanding the item type and students not learning the material. Conversely, the lack of exposure to new types of items could have been addressed through the application of data analysis and implementation of the Math Workshop Model. A key benefit of the Math Workshop Model was that its implementation allowed teachers to use data to provide targeted and specific instruction for individual students, small groups, or whole classes (Hoffer, 2012).

**Discussion of the Results in Relation to the Literature**

Instructional decisions in mathematics classrooms were influenced by the era of high-stakes testing driven by a perceived need for accountability (Au, 2011). The instructional practices teachers choose in response to pressure to meet these standards—for which they were held accountable—may not have served students' best interests or prioritize learning (Au, 2011). Through new research in psychology, especially as it pertains to mathematics education, and neurology, researchers suggested that secondary mathematics teachers should facilitate long term understanding that developed students' problem-solving skills, and encouraged students to build their own meaning by collaborating with peers to synthesize multiple ideas and perspectives (Allen, 2012).

The existing literature attested to the need for new instructional practices in mathematics education (Boaler, 2016b). In addition, the results of this study implied that using formative assessment results more effectively and collaboratively with students in a learning environment that promoted equity had positive effect on students. Through the correct guidance, students shifted their views of assessment from an act that was done to them to a view of being an active participant, taking actions towards learning goals (Marshall, 2018). The instrument used to measure academic achievement in this study contained questions that were more rigorous than sixth-grade students had previously seen on an assessment of its kind. A differentiation structure such as the Math Workshop Model, which allowed teachers time to gather formative assessment feedback, confer with students to provide specific feedback, and listen to students reflect on their learning, promoted the high-yield assessment practices that led to student achievement in the literature reviewed (Chappuis, 2015; Hoffer, 2012). Establishing sound assessment for learning practices that involved the students as partners in the assessment process was an extensive, laborious process that took substantial time (Chappuis, 2015). The students in the *MWM students* group produced achievement growth in a relatively brief study and literature reviewed indicated significant time and effort were required to create assessment-capable learner (Chappuis, 2015). Given more time to devote to implementing the Math Workshop Model and develop assessment-capable learners within the structure, the researcher hypothesized that students learning in classes where the Math Workshop Model was implemented could continue to show growth.

Another aspect reviewed in the study, the practice of ability grouping, or tracking, was traditionally used to group mathematics students at the secondary level to allow like-minded students to receive a similar curriculum focused on their specific needs (Yee, 2013). A growing body of research and literature showed negative effects on students' learning when students were grouped by ability or tracked (Boaler, 2016a). These negative effects include negative self-perception and creation of fixed mindset, lack of flexibility in problem solving, and inequitable opportunities to learn (Boaler, 2016b). The results of this study offered supplementary support for the practice of heterogeneously grouping students in mathematics.

In the participating district, sixth-grade students were enrolled into either a regular sixth-grade course or an advanced sixth-grade course (ability-grouped mathematics courses). The academic achievement data of the students in the *MWM students group* and the *traditional students* group were analyzed based on the course in which students were enrolled, and the results of these analyses supported the call for de-tracking students in mathematics classes. When the $MWM_A$ *students* and $traditional_A$ *students* groups and $MWM_B$ *students* and $traditional_B$ *students* groups were compared, the growth data from the students enrolled in the advanced course were not statistically significant ($p$ values of approximately $p = 0.0823$ for School A and $p = 0.5218$ for School B).

The analyses of the growth data from the students enrolled in the regular sixth-grade mathematics course for the $MWM_A$ *students* and $traditional_A$ *students* groups and $MWM_B$ *students* and $traditional_B$ *students* groups, however, were statistically significant ($p$ values of approximately $p = 0.0065$ and $p = 0.0404$). Based on these analyses, it was argued by the researcher that the growth shown by students enrolled in the regular mathematics classes was impacted by the implementation of the Math Workshop Model. The students in *the MWM student group* enrolled in the regular sixth-grade course were also the only *MWM student group* of which data was analyzed to outscore their peers on the third Benchmark assessment. Learning in the Math Workshop Model allowed students opportunities to be active learners, collaborate with their peers, experience mathematics from multiple perspectives, and learn in their own zone of proximal development when necessary (Hoffer, 2012), especially those who were group using a more heterogeneous method.

It was argued that implementing a differentiation strategy such as the Math Workshop Model offered the same benefits to students as ability grouping, or tracking, without the consequence of being locked into one specific group, or track (Hoffer, 2012; Yee, 2013). There was a greater flexibility afforded to teachers and students when a variety of ability levels were contained within one classroom, and the teacher used instructional time to create engaging experiences that allowed students to build on their current understanding in mathematics and collaborate with peers to create a community of learners (Boaler, 2016b). As students' instructional needs changed, the flexibility of the Math Workshop Model allowed students to fluidly move into the appropriate group to meet their learning needs at that exact moment, unlike ability grouping strategies (Hoffer, 2012). The results of this study supported the idea that students in more diverse settings responded to instructional activities that promote student-centered collaboration and equity. Students in the *MWM students* group enrolled in the regular sixth-grade course, a course that was more heterogeneously grouped than the advanced sixth-grade course, outscored the students enrolled in the regular course in the *traditional students* group on the third benchmark (47.4% to 44.7%, respectively)

Academic achievement data of the students enrolled in the advanced sixth-grade math course (homogeneously group by ability) of the $MWM_A$ *students* and $traditional_A$ *students* groups and $MWM_B$ *students* and $traditional_B$ *students* groups showed no statistical significance, thus the null hypothesis was accepted, and no relationship could be assumed between implementing the Math Workshop Model and the achievement data of students enrolled in the advanced sixth-grade math course. These students achieved academic growth. However, the growth displayed in the students data was statistically as likely to have been caused by chance as the implementation of the Math Workshop Model (McMillan, 2012). Students enrolled in the advanced sixth-grade course were grouped homogeneously based on their ability in mathematics, which was a strategy with a low effect size (Hattie et al., 2017). By learning in a heterogeneous environment, all students, even those who would normally be classified as advanced, had the opportunity to experience ideas developed differently than they would if grouped with like-minded students (Boaler, 2016a). These new experiences expanded their knowledge foundation to drive students past their current ability levels (Boaler, 2016b).

While not a focus in the original literature review, the results of this study and subsequent analyses of the data echoed a growing area of concern in mathematics education, especially at the secondary level. The number of female students pursuing advanced studies in mathematics, while growing, still lagged behind the number of males (Cheryan, Ziegler, Montoya, & Jian, 2017). The academic achievement data of the male students in the *MWM students* group and *traditional students* group was not statistically significant ($p = 0.0895$). However, the academic achievement data of the female students was significant, with a $p$ value of approximately $p = 0.0195$. The importance of the analysis showing statistical significance for females in the study and not males pertained to the hypothesis posed by Research Question 1. Since the achievement data for the female students in the *MWM students* and *traditional students* groups was statistically significant, then the null hypothesis of Research Question 1 (there is no relationship between implementing the Math Workshop Model and students' academic achievement in mathematics) was rejected. It was assumed, then, that there could be a relationship between the growth in academic achievement shown by females in the *MWM students* group and the implementation of the Math Workshop Model.

Conversely, because the male data was statistically not significant, the null hypothesis was accepted, and it was assumed there was no relationship between the academic achievement shown by the male students in the *MWM students* group and the implementation of the Math Workshop Model. There was no statistical support to assume that the collaborative strategies of the Math Workshop Model had an effect on any academic achievement attained by the males in the *MWM student* group, but the female students' data from this group, being statistically significant, could have been positively impacted. Research showed that at the secondary level, male students begin to dominate the whole-class conversation in mathematics classes, and teachers tend to narrow their attention during classroom discussions to exclude female students (McKibben, 2018). The exclusion of females can be the beginning of female students' decline in self-confidence in their mathematical ability, heralding the formation of a fixed mindset in terms of future studies of mathematics (Boaler, 2016b). The trends in male student behaviors at the secondary level in mathematics (McKibben, 2018) paired with results from the study indicating that female achievement was potentially impacted positively by implementing the Math Workshop Model provided a compelling case for further investigation.

**Limitations**

Some aspects of the study's design and methodology were identified by the researcher as potential limitations and delimitation prior to the beginning of the study. Due to the possibility of effecting the internal and/or the external validity, some of these aspects identified as either limitations or delimitations before research began were the fidelity of the implementation of the Math Workshop Model, the timing of the study, and the sampling method used. Upon concluding the study, four aspects were identified as potentially effecting the results of this study to the degree that modifying their implementation could have improved the results' validity and reliably. The design limitations and problems in the study were the timing of the study, the sampling used in the study, the use of a quantitative methodology only, and the independent instructional decisions regarding teaching mindset that effected the students in the $MWM_B$ *students* group.

**Timing of the study.** Identified as a limiting factor prior to beginning the study, the timing of the study in the school year created several problems. First, the natural maturation process of students throughout the course of the school year created potential harm to internal validity (Druckman et al., 2011). The study did not receive approval until January, when approximately four months of the school year had passed. During the four months prior to the beginning of the study, all students were learning and growing. Even though all student took a pretest at the start of the study to determine a baseline of academic achievement, the academic achievement data collected during the study was still potentially affected by the four months of instruction and natural maturation that occurred prior to the start of the study (Druckman et al., 2011).

The second limitation regarding timing dealt with the administration of the third benchmark assessment, which was used as the posttest data for the study. As a district assessment, Benchmark three was originally supposed to be a summative assessment of the entire sixth-grade course administered to students in May. Due to unforeseen complications with the assessment calendar, students had to take Benchmark three earlier than it was originally scheduled. The new delivery date for Benchmark three was March. This timing issue meant that the content assessed on Benchmark three had not been taught at the same depth and thoroughness as the content on Benchmark one and Benchmark two. The possibly affected the academic achievement results of Benchmark three.

The last limitation concerning timing was the short length of the study. The students in the *MWM student* group began experiencing some of the instructional strategies and structures of the Math Workshop Model in their classrooms in early fall as their teachers started implementing these new strategies gradually. Many students in the *MWM students* group were accustomed to learning mathematics in more traditional settings, such as whole group instruction (Leinwand, 2012). The learning experience within the Math Workshop Model was the first time many students had been asked to learn in a collaborative environment where the authority and focus was shifted off the teacher and onto the student. Establishing a learning environment where students learned independently and view their peers and themselves as the mathematical authorities took time (Hoffer, 2012; Lempp, 2017). Research indicated that almost a month was required to establish the norms, routines, and behaviors essential to successful implementation of the Math Workshop Model (Lempp, 2017). Additionally new programs needed an acceptable amount of time for implementation, reflection, and modification to see genuine change in behavior (Leinwand, 2012). The limited amount of time this study lasted restricted the implementation of the Math Workshop Model and results may have been affected.

**Sampling**. A purposive sample was used to minimize the effect of sampling on the study's internal validity and reliability. It was noted that this sampling method was a delimitation to the study. Students chosen for the study needed to learn mathematics from someone who had prior knowledge of the Math Workshop Model and who attended professional development on implementing the Math Workshop Model. Selection criteria was created to establish these factors as the prerequisite for choosing students for the *MWM students* group.

The students in the *MWM students* group were only assigned to two different sixth-grade teachers from two of the four middle schools in the district. The purposive sampling method itself did not seem to cause any issues with the study or its outcomes. Due to the large size of the *district* group (students assigned to teachers who did not attend the professional development on implementing the Math Workshop Model and taught in the same district as teachers who did attend professional development) and the disparity of demographic distribution between the *MWM students* and *district* groups, enlarging the *MWM students* group by providing professional development to more teachers from the other middle schools in the district may have improved the reliablity of the data. If more students met the criteria for selection to the *MWM students* group because more teachers attended professional development on the Math Workshop Model, the size variance between the sample and the population could have been smaller, making the results more reliable (McMillan, 2012).

After the initial analysis of the demographic data, size variance and abnormal distributions of different sub-categories surfaced as potential problems. To address the large size difference in the *MWM student* ($N$ = 187) and *district* groups ($N$ = 1202) that were initially compared, other groups were used to compare to the *MWM student* group. The groups such as *traditional students* ($N$ = 635), $traditional_A$ *students* ($N$ = 298), and $traditional_B$ *students* ($N$ = 337) groups were smaller than the *district* group ($N$=1202) and had more common characteristics with the *MWM students* group. Altering the comparison groups strengthened the validity and reliability of the sampling but using a purposive sampling method rather than a random sampling method introduced a certain level of invalidity (McMillan, 2012). If more teacher attended the professional development on the Math Workshop Model and meet the selection criteria, more students would have been selected for the *MWM students* group, and these students would have represented more than just two of the four middle schools in the district. With more members of the actual population present in the sample, the results from the sample were more likely to be replicated for the population (Simon, 2011).

**Design limitations**. Many studies on the Math Workshop Model and other strategies of differentiating instruction used qualitative methodologies. Anecdotal evidence from students, teachers, and others participating in the studies offered contextual insights that quantitative data could not (McMillan, 2010). However, it was difficult to reach objective conclusions from qualitative studies due to their lack of quantitative data to provide unbiased measurement. Researchers often preferred quantitative methodologies to qualitative studies when attempting to establish how one variable related to another because quantitative methods produced results that were objective, measurable, and predictive (McMillan, 2012). Nonetheless, conducting this study using only quantitative measures proved difficult in some respects. Classroom observations of the participating teachers were performed to ensure the Math Workshop Model was implemented with fidelity and to provide continuing support for teachers implementing the Math Workshop Model. After each observation, teachers were provided feedback from the researcher on their implementation of the Math Workshop Model. During the classroom observations, the researcher also conferred with students and teachers at different points throughout the lesson, gaining key information about the students' perspectives of learning in the Math Workshop Model and the teachers' experiences teaching within the structure. Often, observations of the teachers' implementation of the Math Workshop Model and feedback from students and teachers were more insightful for the researcher than the quantitative data being generated. The observations of teachers implementing the Math Workshop Model and the students reacting to the strategies added context to the analyzed data and meaning to the trends and patterns in the data. Conversations after the observations with the teachers provided insights into the challenges of implementing the Math Workshop Model. Hearing and seeing students work through the curriculum offered ideas for professional development for other teachers. A mixed methods design combined the objectivity and predictability of quantitative research with the interpretive nature of qualitative research (McMillan, 2012). The researcher personally gained a tremendous amount of insight into the implementation of the Math Workshop Model from the qualitative data collected informally during this study, and a mixed method design could have made this study stronger by adding context and understanding from the students learning in and teachers implementing the Math Workshop Model.

***$MWM_B$ students* Group's focus on growth mindset.** The teachers of the students in the *$MWM_B$ students* and *$traditional_B$ students* groups worked together as a professional learning community (PLC). As a PLC, they met regularly to discuss instructional strategies, assessment, and other topics relevant to student learning in their grade in School B. Before the school year began, the PLC decided to use a set of online growth mindset materials with their students the first week of school (Youcubed, 2017). Each day in the first week of school, the students in the *$MWM_B$ students* and *$traditional_B$ students* groups engaged in one of the lessons provided in the free online student course. This decision to focus on growth mindsets with the students in the *$MWM_B$ students* and *$traditional_B$ students* groups was a limitation of the study because this work with mindset could have affected the results of the Mindset survey pretest of the students in the *$MWM_B$ students* group. If the survey was given to the students during the week of focus on mindset or after, the students' answers could have been affected by the exposure to the mindset material. To eliminate the effects of the mindset work on the pretest survey results, the pretest should have been given to the students in the *$MWM_B$ students* group prior to students receiving any direct instruction regarding mindset. The research was not informed of the instructional decisions of the PLC effecting the students in the *$MWM_B$ students* and *$traditional_B$ students* groups until after the lessons were delivered to students. If the researcher had prior knowledge of the instructional plan for the students in the *$MWM_B$ students* and *$traditional_B$ students* groups, explicit instructions on administering the pretest survey would have been given.

**Implications of the Results for Practices, Policy, and Theory**

No causation could be implied from the results of this ex-post facto, quantitative study. However, based on the statistical testing that was completed and data analyses performed, suggestions were made about the implementation of the Math Workshop Model and students' academic achievement in mathematics in regard to practices, policies, and theories of mathematics education. At the root of this study was the theory of constructivism and the belief that students learned best when they were allowed to build on their pre-existing understanding through collaboration with peers and opportunities to experience learning from multiple perspectives (Krahenbuhl, 2016). Supporting the theory of constructivism in this study were neurological research findings that the brain was changing constantly, rather than being set at the end of childhood, as previously thought, and learning and self-perception could be affected well into the secondary grades and beyond (Boaler, 2016b; Dweck. 2016).

**Implications for practice.** The results of the study initially illustrated inconsistent academic achievement growth for the students when the Math Workshop Model was implemented, but unusual distribution of certain demographic data, such as gender and enrollment in ability-grouped course, within the sample and population was used to explore the inconsistencies viewed in the growth data for further explanations. Further analyses uncovered stronger growth for female students in the *MWM students* group and the students enrolled in the heterogeneously-grouped, regular sixth grade course in the *MWM students* group. By implementing the Math Workshop Model, students were given the opportunity to learn in a constructivist environment, collaborate, confer with teachers and peers, and build a learning community (Hoffer, 2012). Hattie et al. (2017) indicated that collaboration and providing feedback (conferring with teachers and peers) were strategies with high effect sizes and thus, had significant effects on learning. Implementing the Math Workshop Model allowed teachers to incorporate research-based instructional strategies into their classrooms (Hoffer, 2012), and the results of this study indicated that the achievement of female students and students who were heterogeneously grouped improved when the Math Workshop Model was implemented.

Traditional secondary mathematics instruction tended to support a structure in which male students thrived and female students became passive, developing a fixed mindset (McKibben, 2018). This study revealed that female students exhibited growth potential when learning in an environment where the Math Workshop Model was implemented and equity of opportunity was created (Hoffer, 2012). Gender equity and equity of opportunity in secondary mathematics was concerning with female enrollment in upper level mathematics classes is alarming, and the role of instructional choices needed to be considered in this trend (Kuo, 2016). Instructional practices in mathematics, especially at the secondary level, needed to focus on providing female students with the same learning opportunities as their male peers while also building positive mathematical mindsets in female students (Boaler, 2016b).

**Implications for policy.** One of the most contested topics in mathematics education was the practice of grouping students by ability (Yee, 2013). Research showed grouping students by ability was ineffective (Hattie et al., 2017). The results of this study supported the research regarding the ineffectiveness of ability grouping, especially when the desired outcome is establishing a learning community where students collaborate and engage in rich mathematical discourse (Boaler, 2016a). The traditional secondary mathematics course structure, which placed some students into advanced courses while some students found themselves in remedial classes, were scrutinized for the effect the practice had on students' learning and mindset (Buckley, 2010). Heterogeneously mixed classes provided all students opportunities to learn content at a high-level, acquire a growth mindset in mathematics, and learn flexibility in problem solving from exposure to a variety of strategies through collaboration (Boaler, 2016a). The students enrolled in the regular sixth-grade math course, a heterogeneously grouped course, in the *MWM students* group indicated the most significant results of any group analyzed in the study. The achievement data of the students enrolled in regular sixth-grade math in the *MWM students* group not only exhibited growth from the beginning to the end of the study, but they also outscored the students enrolled in the regular sixth-grade math course in the *traditional students* group. The strength of the growth of the students in the *MWM students* group taking the regular sixth-grade math course provided support to the research calling for reform in the practice of grouping students in mathematics.

Changing the current structure from ability grouping to heterogeneously grouped students in secondary mathematics classes could equalize students' opportunities to learn, preventing the creation of mindsets that lead to some students believing there is a predetermined "math-type" or "math brain" (Boaler, 2016a). Change of this magnitude did not usually begin at the classroom level, but instead, this type of change needed to begin at the district level. Research showed that attempts to de-track students in one United States high school began with the noblest intentions; Equitable opportunities to experience rigorous mathematics for minority students was the goal when courses were redesigned and tracking was dismantled (Buckley, 2010). The end result, however, was not more minority students taking higher level mathematics classes or developing a growth mindset in mathematics because the mathematics tracks that were supposed to be eliminated by restructuring the mathematics courses were actually strengthened (Buckley, 2010). With evidence supporting the difficulty in rebuilding an entire school or district structure, implementing instructional practices that promoted equity at the classroom level, such as the Math Workshop Model, were even more important (Hoffer, 2012).

**Implications for theory.** Promoting equity in secondary mathematics continued to be challenging for educators and educational leaders, and the inconsistent results from this study reflects this challenge. Certain strategies were identified, through research, to promote equity, engagement, and learning (Hoffer, 2012). However, inconsistent repetition of these results left opportunities for further exploration. Strategies such as providing feedback, response to intervention, cooperative learning, peer tutoring, student-centered teaching, and small group learning had higher effect sizes and optimize student learning (Hattie et al., 2017). These strategies were incorporated in the implementation of the Math Workshop Model in this study, but the results of the study did not illustrate reliable academic achievement growth to make assertive conclusions. In light of inconsistencies between the results of this study and the existing literature, the literature could be explored further to find reasons for these discrepancies. One possible reason for this anomaly in the data is professional development provided to teachers implementing the Math Workshop Model. Hattie et al. (2017) identified professional development as having an effect size of 0.51, placing it in the high zone of desired effects. While criteria were established to ensure students selected to the *MWM students* group were learning with teachers who received professional development on implementing the Math Workshop Model, and the researcher continued to provide teachers with on-going support throughout the study, there was no exemplar template for Math Workshop Model professional development to ensure those who attended would implement the structure with success. The professional development provided by the researcher was developed based on recommendations for highly-quality professional development, but there were no guarantees that the professional development met the learning needs of the teachers to successfully implement the Math Workshop Model (Zepeda, 2013).

Another possible explanation for the differences in learning outcomes could have been the existing students' mindsets pertaining to mathematics when entering the class. Students with strong fixed mindsets about their mathematics ability achieved worse learning outcomes and took longer to develop growth mindsets (Boaler, 2016b). Students began establishing their mindsets regarding their abilities in mathematics well before they entered sixth-grade (Boaler, 2016b; Dweck, 2016). While secondary mathematics teachers were made more aware of the effects of students' mindset on learning at the secondary level, the deeply-rooted mindsets of students entering the secondary level was more difficult to overcome (Sun, 2018). Mindset theory was introduced to education initially through the work of Dweck (2016) over a decade ago, but the application of her work in terms of instructional practices has been misinterpreted. To establish students' mindset in a positive manner, mindset theory and its application needed clarified for all teachers.

**Recommendation for Further Research**

As an identified limitation, the timing of the study introduced potential restrictions to the results of the study. The short length of the study and the study beginning in the middle of the school year were specific elements of the study design pertaining to timing that were not optimal to completely study the effects of implementing the Math Workshop Model on students' academic achievement. One potential area to extend the research was to continue the study over the course of the students' middle school career. Given the vast changes in physical and mental development that occurred during the span of the middle school years, extending this study to track students' progress from sixth-grade through eighth-grade could allow for more extensive examination of the developmental and academic changes of students of this age group when the Math Workshop Model was implemented (Armstrong, 2016; Jensen & Snider, 2013). Extending the length of the study could have given students more time to adjust to the Math Workshop Model and to become fluent in the strategies of collaboration and discourse. Student-centered strategies that required students to be more autonomous and rely on themselves rather than the teacher took time to establish and solidify (Hoffer, 2012). Conducting a study that encompassed a longer period of time would give students more time to develop the skills necessary to determine if the Math Workshop Model did affect academic achievement and mindset.

Adding a qualitative component to this quantitative study could provide additional research on the Math Workshop Model. The contextual evidence that could be added by using a qualitative method or a mixed-method study could allow the reader to better understand the study scenario, implementation, and outcomes (McMillan, 2012). Qualitative data such as classroom observations, student and teacher interviews, and open-ended questionnaires could be used to determine what happened in the study, how it happened, and why it happened (McMillan, 2012). Answering the qualitative questions of how and why could begin to bridge the gap between the existing research, which exhibited more positive academic achievement growth, and this study's results.

Unforeseen consequences from the limitations placed on the sample because of the use of a purposive sampling method required alterations of the *district* group throughout the data analysis process to yield a population that was more similar to the *MWM students group*. When the groups being compared vary drastically in size and demographic composition, threats to internal reliability grow and the results of the study are less applicable to larger populations or other groups (McMillan, 2012). Additional research that expanded the number of students in the study group could strengthen both the internal and external validity of future studies. A purposive sample was needed to ensure students selected for the study learned while the Math Workshop Model was implemented (McMillan, 2012). Therefore, more teachers needed to participate in professional development on implementing the Math Workshop Model in order for more students to be selected for the study.

As the data from this study was analyzed through multiple lenses, potential relationships emerged for future research. One of the topics which emerged was the relationship between gender and differentiating instruction using the Math Workshop Model. This study indicated that, based on tests for statistical significance, implementing the Math Workshop Model had no relationship on male students' academic data. However, the study showed there was potentially a relationship between the Math Workshop Model and female academic achievement data, and the female students' achievement data demonstrated growth from throughout the course of the study. Given that gender bias was a documented issue in secondary mathematics classes throughout the literature and research (Boaler, 2016b; McKinneb, 2018; Niederle & Vesterlund, 2010), more study was warranted to determine which instructional practices deconstructed pre-existing notions of gender inequality and promote equity of opportunity for all students, especially female students. Furthermore, research on gender bias could be beneficial at the elementary level to determine when the gender bias in mathematics begins. Some literature indicated that gender disparity was simply the result of students reacting to the competitive nature of subjects like mathematics and science or felling a strong need to identify with traditional norms (Niederle & Vesterlund, 2010). Additional research was needed to help identify when female mathematics students began to experience a shift towards a negative mindset and the causes of these shifts.

Finally, the results from analysis of academic achievement data of students enrolled in heterogeneously and homogeneously grouped math courses provided evidence that supported future studies. As indicated by the results of the study, achievement data of students enrolled in the advanced sixth-grade math course were not affected by implementing the Math Workshop Model (data were not statistically significant). However, there was possibly a relationship between the achievement of students enrolled in the regular sixth-grade math course and the implementation of the Math Workshop Model (data were statistically significant). As the literature indicated, ability grouping did not promote notable learning in students in secondary mathematics (Boaler, 2016a). The students enrolled in the regular sixth-grade math course in the *MWM students* group, who learned in classrooms where the Math Workshop Model was implemented, not only displayed growth throughout the study, but they also outscored the students enrolled in the regular sixth-grade math course in the *traditional students* group on the final benchmark assessment. The results from the data analysis of the students enrolled in the regular sixth-grade math course provided supporting evidence to the existing research calling for mathematics classes to be heterogeneously grouped (Boaler, 2016b) and warranted further research on the topic.

## Conclusion

This study was to designed to examine the Math Workshop Model as a strategy for differentiating instruction and to determine the effects of implementing this strategy on students' academic achievement and growth mindset in sixth-grade mathematics. The need for studies that explored the relationships between instructional strategies that provided more equitable opportunities for all students and academic achievement, as well as students' mindset, was emphasized by advances in neurological and psychological research, which have changed educators' views on the role of instructional activities in shaping learning and students' perceptions of their own abilities (Armstrong, 2016; Boaler, 2016; Jensen & Snider, 2013). Overwhelming data indicated that how students learned was just as important as what they learned (Armstrong, 2016; Boaler, 2016b). To gain more insight into the ways in which students learned most effectively, more research was recommended. Based on the results generated in this study, future studies were recommended to explore the relationships between differentiate instruction through implementing the Math Workshop Model and academic achievement and mindset in secondary mathematics, particularly for female students and students in heterogeneously grouped mathematics classes.

The results of this study aligned with the trend in the existing literature for teachers and educational leaders to examine classroom practices to ensure equitable opportunities for all students, especially in secondary mathematics (Boaler, 2016a; Buckley, 2010; Hoffer, 2012; Lempp; 2017). The instructional decisions made by teachers affected the way mathematics students developed their mindset and built meaning constructs (Sun, 2018). The results of this study have demonstrated that the Math Workshop Model, which allowed students to collaborate and engage in rigorous mathematics at multiple levels within the same classroom, could enhance academic achievement. In conclusion, all students, regardless of their ability level, deserved an equitable opportunity to learn mathematics at high levels. Differentiating instruction by implementing the Math Workshop Model offered equity for all students and the potential for a greater numbers of students the chance to engage in rich mathematics tasks and experience academic achievement.

## References

Abbati, D. (2012). *Differentiated instruction: Understanding the personal factors and organizational conditions that facilitate differentiated instruction in elementary mathematics classroom* (Doctoral dissertation). Retrieved from https://gse.berkeley.edu/sites/default/files/docs/leep/Differentiated%20Instruction-%20Personal%20Factors%20and%20Organizational%20Conditions%20that%20Facilitate%20Differentiated%20Instruction%20in%20Elementary%20Mathematics%20_Abbati,%202012_-2.pdf

Accardo, A. L., & Kuder, S. J. (2017). Monitoring student learning in algebra. *Mathematics Teaching in the Middle School, 22*(6), 352–59. Retrieved from http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/2017/Vol22/Issue6/Monitoring-Student-Learning-in-Algebra/

Allen, K. C. (2012). Keys to successful group work: Culture, structure, nurture. *Mathematics Teacher, 106*(4), 308–312. Retrieved from https://www.nd.gov/dpi/uploads/1376/KeysToSuccessfulGroupworkMathTeacherArticle.pdf

Armstrong, T. (2016). *The power of the adolescent brain.* Alexandria, VA: ASCD.

Ashley, L. (2016). *Implementation of a math workshop model in the elementary classroom: Understanding how teachers differentiate instruction* (Doctoral dissertation). Retrieved from https://repository.library.northeastern.edu/files/neu:cj82m2381/fulltext.pdf

Assessment Technology Incorporated. (2017). *Research.* Retrieved from http://ati-online.com/pdfs/K12/ati-research-program.pdf

Assessment Technology Incorporated. (2002). *Research.* Retrieved from http://ati-online.com/galileoK12/k12-research-services.php

Association for Middle Level Education. (2012). *This we believe: Implementing successful middle level schools (2nd ed.).* Westerville, OH: Association for Middle Level Education.

Au, W. (2011). Teaching under the new Taylorism: High-stakes testing and the standardization of the 21st century curriculum. *Journal of Curriculum Studies, 43*(1),1–25. https://doi.org/10.1080/00220272.2010.521261

Bellanca, J. (2016). *21st century assessment driving instruction.* Retrieved from http://www.p21.org/news-events/p21blog/2093-21st-century-assessments-driving-instruction

Benders, D., & Craft, T. (2016). The effect of flexible small groups on math achievement in first grade. *Networks: An Online Journal for Teacher Research, 18*(1), 1–9. Retrieved from http://cupdx.idm.oclc.org/login?url=https://search-proquest-com.cupdx.idm.oclc.org/docview/1969021039?accountid=10248

Bergan, J., Burnham, C., Bergan, J., & Bergan, K. (2011). *Benchmark assessment development in Galileo educational management system.* Retrieved from http://ati-scanline.com/pdfs/researchK12/K12TechManual.pdf

Blackwell, L.S., Trzesniewski, K.H., & Dweck, C.S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246–263. Retrieved fromhttps://www.mtoliveboe.org/cmsAdmin/uploads/blackwell-theories-of-intelligence-child-dev-2007.pdf

Blakemore, S., & Choudhury, S. (2006). Development of the adolescent brain: Implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry, 47*(3), 296–312. Retrieved from https://doi.org/10.1111/j.1469-7610.2006.01611.x

Blanke, B. (2018). *Mathematical discourse: Let the kids talk.* Huntington Beach, CA: Shell Education.

Boaler, J. (2016a). Designing mathematics classes to promote equity and engagement. *Journal of Mathematics Behavior, 41*, 172–178. Retrieved from https://dx.doi.org/10.1016/j.jmathb.2015.01.002

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

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside School. *Teaching College Record, 110*(3), 608–645. Retrieved from https://doc.uments.com/download/s-creating-mathematical-futures-through-an-equitable-teaching-approach.pdf

Buckley, L.A. (2010). Unfulfilled hopes in education for equity: redesigning the mathematics curriculum in a US high school. *Journal of Curriculum Studies, 42*(1), 51–78. https://doi.org/10.1080/00220270903148065

Chappuis, J. (2015). *Seven strategies of assessment for learning*. Boston, MA; Pearson Education.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin, 143*(1), 1–35. http://dx.doi.org/10.1037/bul0000052

Coomes, J., & Lee, H.S. (2017). Empowering mathematical practices. *Mathemtics Teaching* *in the Middle School*, *22*(6), 360–367. Retrieved from http://www.jstor.org.cupdx.idm.oclc.org/stable/pdf/10.5951/mathteacmiddscho.22.6.0360.pdf?refreqid=excelsior%3Abe97becc0b0fc20b5290b484577f781a

de Gentile, P. L., & de Orue, A. M. L. (2012). Getting teens to really work in class. *English Teaching Forum, 4*, 16–21. Retrieved from http://files.eric.ed.gov/fulltext/EJ997533.pdf

Dean, S., & Zimmerman, M. (2012). Math groups that make sense. *Educational Leadership, 69*(5). Retrieved from http://www.ascd.org/publications/educational-leadership/feb12/vol69/num05/Math-Groups-That-Make-Sense.aspx

Dekker, R. & Elshout-Mohr, M. (2004). Teacher interventions aimed at mathematical level raising during collaborative learning. *Educational Studies in Mathematics, 56*(1), 39–65. Retrieved from http://www.jstor.org/stable/4150263

DeJarnette, A., Doa., J., & Gonzalez, G. (2014). Learning what works:  Promoting small-group discussions. *Mathematics Teaching in the Middle School, 19*(7), 415–419. Retrieved from http://jwilson.coe.uga.edu/EMAT7050/articles/Small%20Group%20Discussion.pdf

Druckman, J., Green, D., Kuklinski, J., & Lupia, A. (2011). *Cambridge handbook of experiment political science*. New York, NY: Cambridge University Press.

DuFour, Ri., DuFour, Re., Eaker, R., Many, T., & Mattos, M. (2016). *Learn by doing: a handbook for professional learning communities at work (3rd ed.).* Bloomington, IN: Solution Tree Press.

Dweck, C. (2016). *Mindset:  The new psychology of success.* New York, NY: Ballantine Books.

Erneling, C. (2012). The importance of Jean Piaget. *Philosophy of the Social Sciences, 44*(4), 522–535. https://doi.org/10.1177%2F0048393112454994

Esmonde, I. (2009). Mathematics learning in groups: Analyzing equity in two cooperative activity structures. *Journal of the Learning Sciences, 18*(2), 247–284. Retrieved from https://tspace.library.utoronto.ca/bitstream/1807/32369/3/Esmonde_JLS2008FINAL.pdf

Ferguson, D. (2008). International trends in inclusive education: The continuing challenge to teach each one and everyone. *European Journal of Special Need Education, 23*(2), 109–120. https://doi.org/10.1080/08856250801946236

Ghousseini, H., Lord, S., & Cardon, A. (2017). Supporting math talk in small groups. *Teaching Children Mathematics, 23*(7), 422–428. Retrieved from http://www.jstor.org.cupdx.idm.oclc.org/stable/pdf/10.5951/teacchilmath.23.7.0422.pdf?refreqid=excelsior%3A7b27dcd2c5ca48d143f9dd2577229d8b

Grossmann, T. (2013). The role of medial prefrontal cortex in early social cognition. *Frontiers in Human Neuroscience, 7*(340), 1–6. Retrieved from doi:10.3389/fnhum.2013.00340

Hanson, J., Bangert, A., & Ruff, W. (2016). A validation study of what's my school mindset? survey. *Journal of Educational Issues, 2*(2), 244–266. Retrieved from https://files.eric.ed.gov/fulltext/EJ1127532.pdf

Hattie, J., Fisher, D., Frey, N., Gojak, L., Moore, S., & Mellman, W. (2017). *Visible leaning for mathematics.* Thousand Oak, CA: Corwin.

Heim, J. (2016, Dec. 6). On the world stage, U.S. students fall behind. *The Washington Post.* Retrieved from https://www.washingtonpost.com/local/education/on-the-world-stage-us-students-fall-behind/2016/12/05/610e1e10-b740-11e6-a677-b608fbb3aaf6_story.html?utm_term=.dba0c9315c59

Herman, J., Osmundson, E., & Dietel, R. (2010). *Benchmark assessment for improved learning* (AACC Policy Brief). Los Angeles, CA: University of California.

Hill, T. L. (2012). *Implementing constructivist mathematics methods in the elementary classroom* (Order No. 3499656). Available from Education Database. (945733088). Retrieved from http://cupdx.idm.oclc.org/login?url=https://search-proquest-com.cupdx.idm.oclc.org/docview/945733088?accountid=10248

Hoffer, W. W. (2012). *Minds on mathematics: Using math workshop to develop deep understanding in grades 4-8.* Portsmouth, NH: Heinemann.

Huebner, T. A. (2010). What research says about differentiated learning. *Educational Leadership, 67*(5), 79–81. Retrieved from http://www.ascd.org/publications/educational-leadership/feb10/vol67/num05/Differentiated-Learning.aspx

Hunt, A. (2015). *A researcher's guide to power analysis*. Retrieved from http://rgs.usu.edu/irb/wp-content/uploads/sites/12/2015/08/A_Researchers_Guide_to_Power_Analysis_USU.pdf

James, S. D. (2013). *Does differentiated instruction raise student performance in mathematics: An action research study* (Order No. 3599200). Available from ProQuest Dissertations & Theses Global: Social Sciences. (1461413137). Retrieved from http://cupdx.idm.oclc.org/login?url=https://search-proquest-com.cupdx.idm.oclc.org/docview/1461413137?accountid=10248

Jensen, E. & Snider, C. (2013). *Turnaround tools for the teenage brain.* San Francisco, CA: Jossey-Boss.

Kastrun, T. (2016). *Using the statistical programming R for running statistics.* Retrieved from http://www.sqlservercentral.com/articles/R+Language/106760/

Kelly, G. (2013). *Differentiated instruction in the classroom* (Order No. 3568331). Available from Education Database; ProQuest Dissertations & Theses Global: Social Sciences. (1424274598). Retrieved from http://cupdx.idm.oclc.org/login?url=https://search-proquest-com.cupdx.idm.oclc.org/docview/1424274598?accountid=10248

Kerr, J. C. (2016, Dec. 6). Internationally, U.S. students are falling. *U.S. News and World Report.* Retrieved from https://www.usnews.com/news/politics/articles/2016-12-06/math-a-concern-for-us-teens-science-reading-flat-on-test

Koestler, C., Felton, M.D., Bieda, K.N., & Otten, S. (2013). *Connecting the NCTM process standards and the CCSSM practices.* Reston, VA: NCTM

Konrad, M., Keesey, S., Ressa, V., Alexeeff, M., Chan, P., & Peters, M. (2014). Setting clear learning targets to guide instruction for all students. *Intervention in School and Clinic, 50*(2), 76–85. doi:10.1177/1053451214536042

Krahenbuhl, K. S. (2016). Student-centered education and constructivism:  Challenges, concerns, and clarity for teachers. *The Clearing House:  A Journal of Educational Strategies, Issues and Ideas*, *89*(3), 97–105. https://doi.org/10.1080/00098655.2016.1191311

Larson, L.C. & Miller, T.N. (2011). 21st century skills: prepare students for the future. *Kappa Delta Pi Record*, *47*(3), 121–123. https://doi.org/10.1080/00228958.2011.10516575

Leinwand, S. (2012). *Sensible mathematics.* Portsmouth, NH: Heinemann.

Lempp, J. (2017). *Math workshop:  Five steps to implementing guided math, learning stations, reflection, and more.* Sausalito, CA: Math Solutions.

Liu, C.C., & Chen, I. J. (2010). Evolution of Constructivism. *Contemporary Issues in Education Research*, *3*(4), 63–66. Retrieved from http://files.eric.ed.gov/fulltext/EJ1072608.pdf

Loyens, S.M.M. & Gijbels, D. (2008). Understanding the effects of constructivist learning environments: introducing a multi-directional approach. *Instructional Science*, *36*(5-6), 351—357. Retrieved from https://link.springer.com/article/10.1007/s11251-008-9059-4

Malone, C. (2015). *The impact of mathematics education research and brain-learning research on student performance in algebra 1* (Doctoral Dissertation). Retrieved from http://cupdx.idm.oclc.org/login?url=http://search.proquest.com.cupdx.idm.oclc.org/docview/1727612846?accountid=10248

Marshall, K. (2018). In praise of assessment (done right). *Phi Delta Kappa*, *99*(6), 54–59. Retrieved from https://doi-org.cupdx.idm.oclc.org/10.1177%2F0031721718762424

Mattos, M. (2015). *It's about time: Planning interventions and extensions in secondary school*. Bloomington, IN: Solution Tree.

McKibben, S. (2018). Creating a gender-inclusive classroom. *Education Update, 60*(4), 2–3. Retrieved from http://www.ascd.org/publications/newsletters/education_update/apr18/vol60/num04/Creating_a_Gender-Inclusive_Classroom.aspx

McLeod, J., Fisher, J., & Hoover, G. (2003). *The key elements of classroom management: Managing time and space, student behavior, and instructional strategies.* Alexandria, VA: ASCD.

McMillan, J. (2012). *Educational research: Fundamentals for the consumer*. Boston, MA: Pearson.

Merritt, M. A. (2016). *Improving student math knowledge and math attitudes through small* *group instruction: An action research study* (Doctoral dissertation). Retrieved from http://cupdx.idm.oclc.org/login?url=http://search.proquest.com.cupdx.idm.oclc.org/docview/1854162308?accountid=10248

Mindset Works. (2018). *Assess your mindset to begin your journey today.* Retrieved from http://blog.mindsetworks.com/what-s-my-mindset

Missouri Census Data Center. (2017). *Ten things to know about urban vs. rural.* Retrieved from http://mcdc.missouri.edu/TenThings/urbanrural.shtml

Missouri Department of Elementary and Secondary Education. (2017a). *Ft. Zumwalt R-II school district.* Retrieved from https://mcds.dese.mo.gov/quickfacts/SitePages/DistrictInfo.aspx?ID=__bk8100030093002300030083007300

Missouri Department of Elementary and Secondary Education. (2017b). *Accountability.* Retrieved from https://mcds.dese.mo.gov/quickfacts/Pages/Accountability.aspx

Missouri Department of Elementary and Secondary Education. (2017c). *Mathematics.* Retrieved from https://dese.mo.gov/sites/default/files/curr-mls-standards-math-6-12-sboe-2016.pdf

National Governors Association Center and Council of Chief State School Officers . (2010). *Standards for mathematical practice.* Retrieved from http://www.corestandards.org/Math/Practice/

National Center for Education Statistics, & Institute of Educational Sciences. (2016). *Welcome to PISA 2015 results.* Retrieved from https://nces.ed.gov/surveys/pisa/pisa2015/index.asp

Niederle, M., & Vesterlund, L. (2010). Explaining the gender gap in math test scores:  The role of competition. *Journal of Economic Perspectives, 24*(2), 129–144. doi: 10.1257/jep.24.2.129

Nugent, P. (2013). *Academic achievement.* Retrieved from https://psychologydictionary.org/academic-achievement/

Paolicelli, R., Bolasco, G., Pagani, F., Maggi, L., Scianni, M., Panzanelli, P., Giustetto, M., Ferreira, T.A., Guiducci, E., Dumas, L., Ragozzino, D., & Gross, C.T. (2011, July 21). Synaptic pruning by microglia is necessary for normal brain development. *Science.* Retrieved from https://doi.org/10.1126/science.1202529

Pescarmona, I. (2010). Complex instruction: Managing professional development and school culture. *Intercultural Education, 21*(3), 219–227. Retrieved from http://dx.doi.org/10.1080/14675981003760416

Pilgrim, M. E. (2010). *A concept for calculus intervention: Measuring student attitudes toward mathematics and achievement in calculus* (Order No. 3419112). Available from Education Database; ProQuest Dissertations & Theses Global: Social Sciences. (753514625). Retrieved from http://hdl.handle.net/10217/40475

Pink, A., Penn, D., Green, D., Green, M., Buck, B., Healey, K., & Harvey, P. (2013). The social cognition psychometric evaluation study: Results of the expert study and RAND panel. *Schizophrenia Bulletin, 40*(4), 813–823. https://doi.org/10.1093/schbul/sbt081

Riehl, C. (2017). The principal’s role in creating inclusive schools for diverse students:  a review of normative empirical, and critical literature on the practice of educational administration. *Journal of Education, 189*(1-2), 183–197. https://doi.org/10.1177%2F0022057409189001-213

Sammons, L. (2010). *Guided math: A framework for mathematics instruction.* Huntington

Beach, CA: Shell Education.

Simon, M. K. (2011). *Assumptions, limitations and delimitations.* Retrieved from http://dissertationrecipes.com/wp-content/uploads/2011/04/AssumptionslimitationsdelimitationsX.pdf

Smithtown Central School District. (2014). *Mindset survey.* Retrieved from https://www.schoolonwheels.org/wp-content/uploads/2015/06/Week1_GrowthMindsetSurvey_OptionA_new.pdf

Stankov, S., Glavinic, V., & Krpan, D. (2012). Group modeling in social learning environments. *International Journal of Distance Technologies, 10*(2), 39–56. Retrieved from http://dx.doi.org.cupdx.idm.oclc.org/10.4018/jdet.2012040103

Starnes, D., Tabor, J., Yates, D., & Moore, D. (2015). *The practice of statistics.* New York, NY: W.H. Freeman and Company.

Statistical Solutions, Limited Liability Company. (2017). *Power & sample size calculator.* Retrieved from https://www.statisticalsolutions.net/pssZtest_calc.php

Stiggins, R. (2017). *The perfect assessment system.* Alexandria, VA: ASCD.

Sullivan, P., Jorgensen, R., Boaler, J., & Lerman, S. (2012). Transposing reform pedagogy into new context:  Complex instruction in remote Australia. *Mathematics Education Research Journal, 25*(1), 173–184. http://dx.doi.org.cupdx.idm.oclc.org/10.1007/s13394-013-0069-4

Sun, K. L. (2018). The role of mathematics teaching in fostering student growth mindset. *Journal for Research in Mathematics Education*, *49*(3), 330–355. http://doi.org/10.5951/jresematheduc.49.3.0330

Toch, T., & Headden, S. (2014). *How to motivate students to work harder*. Retrieved from https://www.theatlantic.com/education/archive/2014/09/how-to-get-insecure-students-to-work-harder/379500/

Tomlinson, C. (2017). *How to differentiate instruction in academically diverse classrooms*. Alexandria, VA: ASCD.

University of Maryland. (2017). *Secondary mathematics education*. Retrieved from https://www-math.umd.edu/secondary-mathematics-education.html

von Duyke, K., & Matusov, E. (2016). Flowery math: A case for heterodiscoursia in mathematics problems solving in recognition of students' authorial agency. *Pedagogies: An International Journal, 11*(1), 1–21. Retrieved from https://doi-org.cupdx.idm.oclc.org/10.1080/1554480X.2015.1090904

Webel, C. (2013). Classroom collaboration: Moving beyond helping. *Mathematics Teacher, 106*(6), 464–467. Retrieved from http://jwilson.coe.uga.edu/EMAT7050/articles/Webel.pdf

Webel, C. (2010). Shifting mathematical authority from teacher to community. *Mathematics Teacher, 104*(4), 315–318. Retrieved from http://www.montclair.edu/profilepages/media/2831/user/MT_article.pdf

William, D. (2011). What is assessment for learning? *Studies in Educational Evaluation*, *37*(1), 3–14. https://doi.org/10.1016/j.stueduc.2011.03.001

Yanisko, E.J. (2016). Negotiating perceptions of tracked students: Novice teachers facilitating high-quality mathematics instruction. *Journal of Urban Mathematics Education, 9*(2), 153–184. Retrieved from http://ed-osprey.gsu.edu/ojs/index.php/JUME/article/view/262/203

Yee, V. (2013, June 9). Grouping students by ability regains favor in classroom. *The New York Times.* Retrieved from http://www.nytimes.com/2013/06/10/education/grouping-tudents-by-ability-regains-favor-with-educators.html

Youcubed. (2017). *Online student course.* Retrieved from https://www.youcubed.org/online-student-course/

Zain, S., Rasidi, F., & Abidin, I. (2012). Student-centered learning in mathematics-constructivism in the classroom. *Journal of International Education Research, 8*(4), 319–327. Retrieved from https://doi.org/10.19030/jier.v8i4.7277

Zepeda, S. (2013). *Professional development: what works (2nd ed.).* New York, NY: Routledge.

## Appendix A: Mindset Survey

### What kind of mindset do you have?

Direction: For each question, mark the box under the statement which best describes how you feel about the statement.

| **Statement** | **Strongly Agree** | **Agree** | **Disagree** | **Strongly disagree** |
|---|---|---|---|---|
| 1. You can't change your intelligence very much. | | | | |
| 2. You can always change basic things about the kind of person you are. | | | | |
| 3. Anyone can become a learn to play a musical instrument or get into the music business. | | | | |
| 4. Only a few people will be truly good at sports-you have to be "born with it." | | | | |
| 5. Certain subjects are just easier for some people to learn. | | | | |
| 6. No matter what kind of person you are, you can always change yourself. | | | | |
| 7. Trying new things is stressing for me and I avoid it. | | | | |

| | | | | |
|---|---|---|---|---|
| 8. Some people are good and kind, and some are not—people don't usually change. | | | | |
| 9. I appreciate when teachers or other people give me ideas about how I can improve. | | | | |
| 10. All people, under most circumstances, are capable of the same amount of learning. | | | | |
| 11. People are basically good, but sometimes make poor decisions. | | | | |
| 12. You can learn new things, but you can't really change how intelligent/smart you are. | | | | |
| 13. You can make some changes to your behaviors, but the important parts of who you are can't really be changed. | | | | |
| 14. An important reason why I do my school work is that I like to learn new things. | | | | |
| 15. People who are very smart do not need to try very hard. | | | | |

## Scoring Instructions

Based on the students' responses, use the scoring guide below to determine students' overall score, which aligns to a mindset category.

| Statement | Strongly Agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. You can't change your intelligence very much. | **0** | **1** | **2** | **3** |
| 2. You can always change basic things about the kind of person you are. | **3** | **2** | **1** | **0** |
| 3. Anyone can become a learn to play a musical instrument or get into the music business. | **3** | **2** | **1** | **0** |
| 4. Only a few people will be truly good at sports-you have to be "born with it." | **0** | **1** | **2** | **3** |
| 5. Certain subjects are just easier for some people to learn. | **0** | **1** | **2** | **3** |
| 6. No matter what kind of person you are, you can always change yourself. | **3** | **2** | **1** | **0** |
| 7. Trying new things is stressing for me and I avoid it. | **0** | **1** | **2** | **3** |

| | | | | |
|---|---|---|---|---|
| 8. Some people are good and kind, and some are not—people don't usually change. | **0** | **1** | **2** | **3** |
| 9. I appreciate when teachers or other people give me ideas about how I can improve. | **3** | **2** | **1** | **0** |
| 10. All people, under most circumstances, are capable of the same amount of learning. | **3** | **2** | **1** | **0** |
| 11. People are basically good, but sometimes make poor decisions. | **3** | **2** | **1** | **0** |
| 12. You can learn new things, but you can't really change how intelligent/smart you are. | **0** | **1** | **2** | **3** |
| 13. You can make some changes to your behaviors, but the important parts of who you are can't really be changed. | **0** | **1** | **2** | **3** |
| 14. An important reason why I do my school work is that I like to learn new things. | **3** | **2** | **1** | **0** |
| 15. People who are very smart do not need to try very hard. | **0** | **1** | **2** | **3** |

## Scoring Results

Based on a student's overall score, he/she can be assigned one of four mindset categories described below:

| | |
|---|---|
| Strong Growth mindset | 33-45 points |
| Growth mindset with some Fixed ideas | 24-32 points |
| Fixed mindset with some Growth ideas | 15-23 points |
| Strong Fixed mindset | 0-14 points |

## Appendix B: Statement of Original Work

The Concordia University Doctorate of Education Program is a collaborative community of scholar-practitioners, who seek to transform society by pursuing ethically-informed, rigorously-researched, inquiry-based projects that benefit professional, institutional, and local educational contexts. Each member of the community affirms throughout their program of study, adherence to the principles and standards outlined in the Concordia University Academic Integrity Policy. This policy states the following:

### Statement of academic integrity.

> As a member of the Concordia University community, I will neither engage in fraudulent or unauthorized behaviors in the presentation and completion of my work, nor will I provide unauthorized assistance to others.

### Explanations:

#### *What does "fraudulent" mean?*

> "Fraudulent" work is any material submitted for evaluation that is falsely or improperly presented as one's own. This includes, but is not limited to texts, graphics and other multi-media files appropriated from any source, including another individual, that are intentionally presented as all or part of a candidate's final work without full and complete documentation.

#### *What is "unauthorized" assistance?*

> "Unauthorized assistance" refers to any support candidates solicit in the completion of their work, that has not been either explicitly specified as appropriate by the instructor, or any assistance that is understood in the class context as inappropriate. This can include, but is not limited to:

- Use of unauthorized notes or another's work during an online test
- Use of unauthorized notes or personal assistance in an online exam setting
- Inappropriate collaboration in preparation and/or completion of a project
- Unauthorized solicitation of professional resources for the completion of the work.

**Statement of Original Work**

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University-Portland Academic Integrity Policy during the development and writing of this dissertation.
2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association*

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06/12/2018
Date