ANALYZING MIDDLE SCHOOL STUDENTS' MATHEMATICAL UNDERSTANDING: A FLIPPED CLASSROOM APPROACH

by

Paige Rosprim

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ABSTRACT

This explanatory sequential mixed methods study investigated the use of a flipped classroom model in a middle school mathematics classroom. The flipped classroom was implemented over the course of one semester in an effort to reach the needs of all students including gifted and talented, special education, and English language learners. The flipped classroom is a form of learning where instruction and technology are combined to foster a student-centered learning environment. This study gathered data from student test scores over two semesters, one semester with a traditional classroom format and the second semester with a flipped classroom approach. A survey was administered to students to gather perceptions about the flipped classroom regarding instruction. Survey results showed positive and negative perceptions of the flipped classroom. The findings of this study show the effects of the flipped classroom were statistically insignificant for all student groups. The flipped classroom was successful for the gifted and talented group but not the other student groups.

Keywords: flipped classroom, academic performance, middle school, 4-8, mathematics education

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[Chairman, Thesis Committee] [Date]

[Member, Thesis Committee] [Date]

[Member, Thesis Committee] [Date]

[Department Head/Direct Supervisor] [Date]

[Dean, Academic College] [Date]

[Dean, Graduate School] [Date]

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

In a traditional lecture style of instruction, the teacher stands at the front of the classroom and teaches. While lecturing, the teacher delivers the content by introducing the concept and generally working through many practice problems. As the teacher finishes lecturing, students are assigned problems to work independently that are similar to the lecture. If students have questions, they raise their hand and ask their teacher. Before students leave the classroom, they are given homework problems that mirror the problems from the lesson and extend their thinking on the material. Students get home at the end of the school day and work on their homework. Some students understand the content well enough from the class lecture and have no issues completing the assigned problems. However, there are others that have a difficult time retaining the content and need more time to practice achieving mastery. Once students return to the classroom, they turn in their homework and may be given the ability to ask questions over problems that they did not understand.

Historically, this is the type of instruction most students have received in their mathematics classroom – the teacher is the main person to teach through lectures and activities (O'Neill & McMahon, 2005). Yet achievement rates among students in the United States on mathematical assessments are continuing to decline. According NWEA (formerly known as the Northwest Evaluation Association) most students in the United States in grades 3-8 performed similarly in reading to same-grade students in fall 2019, but about 5 to 10 percentile points lower in math (Kuhfeld et al., 2020). Thus, a change

to this type of instruction where students enhance conceptual understanding and develop problem solving skills, deserves research and attention.

In a flipped classroom, content instruction is delivered at home or any place available to the student through technology, then the traditional homework is done in class (Bergmann & Sams, 2014). Students receive the lesson from a video that their teacher has created or curated from various sources. The students may also receive content from readings assigned (Patterson et al., 2018). A benefit of this type of instructional delivery is that students can learn at their own pace. Teachers consistently report that lack of time, the wide range of student's skills, and poor student engagement are the biggest hurdles faced in their classrooms (Tucker, 2012).

In the state of Texas, students in the sixth grade are tasked with 52 standards known as the Texas Essential Knowledge and Skills (TEKS) that they are expected to learn and master during the school year (Texas Education Agency, 2012). At the end of the school year Texas students participate in the State of Texas Assessments of Academic Readiness (STAAR) test. This assessment is designed to measure the extent of which a student has learned the curriculum and is able to apply the knowledge and skills identified in the TEKS. Many other states test their students annually as well. Therefore, it can be suggested that teachers learn and refine their instruction so that they can reach all students and prepare them to master the high standards curriculum.

Different from traditional lecture, one benefit of the flipped classroom approach is that students could stop the video when they need to, rewind to a certain part, and watch any number of times needed until they successfully understand the content. The flipped classroom puts students in control of their learning pace. If students process information

slower than others or speak another language, they can pause the video to look up any information they did not understand and then come back to the video when ready. The videos also contain closed captioning which is beneficial for ELL and Sped students. Several studies (Dallas et al., 2016; Gernsbacher, 2015; Holmes et al., 2009) indicate subtitles and closed captioning can help reading skills for ELLs, students with learning disabilities, and struggling readers.

The goal of the flipped classroom model is to create a space for active learning where students actively engage in the learning process. Once students return to the classroom, students practice thinking like an expert by applying their knowledge and skills to challenging problems (Wallace et al., 2014). Time in the classroom is allocated for instructional activities that foster student collaboration and application of concepts learned in the videos. The teacher intervenes at appropriate times to resolve misconceptions and help students when they get stuck (Wallace et al., 2014).

The purpose of this study is to discover if the flipped classroom approach enhances students' mathematical understanding in a middle school mathematics classroom. In the classroom there are learners with varying abilities and no students are alike. Instruction must be modified to help students succeed and achieve more in mathematics. Therefore, this study seeks to answer the following research questions:

- What types of learners, if any, benefit from the flipped classroom approach in middle school mathematics?
- What are student perceptions of using the flipped classroom approach in terms of delivering instruction?

The designation of types of learners refers to those identified as gifted and talented (GT), special education (Sped), and English language learners (ELL). There are types of learners that have no designation, and we will refer to them as regular students. This study seeks to identify if learners increased their mathematical understanding in a middle school mathematics classroom that implemented the flipped classroom approach. The outcomes of this research will be of interest to K-12 mathematics teachers by communicating the results of modifying instruction. This research study will contribute to the effort to reach all learners and increase student performance in mathematics.

Terminology

The definitions that follow will clarify terms that are used throughout this research study.

Active learning – "A wide concept, most often referring to student-centered and activating instructional methods and instructor-led activities" (Hartikainen, Rintala, Pylväs, & Nokelainen, 2019, p. 1)

ELL – English language learner. A student who is limited English proficient (U.S. Department of Education, 2020).

Flipped classroom – The flipped classroom model moves the instruction outside of class, usually delivered through some type of electronic means including slides, audio, videos, and moves the application assignments, formerly known as homework, into the classroom (Educause, 2012).

Gifted and Talented - GT – learners that perform at high levels compared to other learners of the same age, experience, and environment (National Association for Gifted Children, 2021).

Regular – learners that do not have a special designation. They are not English language learners, do not have a learning disability, and do not identify as gifted and talented.

Special Education - Sped – students with a disability, students receive designed instruction to meet the unique needs of the student (U.S. Department of Education, 2017).

Student-centered – students move from passive receivers of information to active participants of their own learning process (ISTE, 2021).

21st century learner – a student that possesses the skills needed in collaboration, critical thinking, problem solving, communication, adaptability, imagination, and creativity (Saavedra & Opfer, 2012).

II. CONCEPTUAL FRAMEWORK

Every student needs to be held to high standards when it comes to academics. Students are expected to think critically, solve real-world problems, and be successful 21st century learners. The National Council of Teachers of Mathematics (2000) *Principles and Standards* suggest that mathematics lay a foundation that requires students to conceptualize their understanding of the content. In certain cases, this can be difficult for students to do at any age (Booth, 2011). Moreover, there is little time in the classroom for students to learn a topic, apply the new learning, practice, and master the topic.

"According to Bloom (1984), an average student who receives one-on-one attention is enabled by constant feedback and corrective process, can jump into the 98th percentile of the student population in academic achievement" (Houston & Lin, 2012, p. 1177). Teachers work to ensure that all students are mastering content and reaching high standards. The everchanging standards and high stakes testing has caused teachers to adjust their pedagogy and search for new ways to provide meaningful instruction that will deepen their students' understanding of mathematical concepts. One possible solution is the flipped classroom model. Students are presented the content by video and can receive one-on-one instruction, time to problem solve, and collaborate with peers the next time they are in the classroom. However, caveats with this type of instruction do exist. For example, if students are not completing the instructional tasks at home before coming to class, then they may not completely benefit from this classroom model. Students will

need to be given opportunities to watch the assigned videos if they do not have technology available to them at home. Issues with technology access and student adaptation to the flipped instruction have been noted by the past research (Findlay-Thompson & Mombourquette, 2014; Du et al., 2014). With the flipped classroom students need access to the internet and a device that can access the videos, so they are able to complete the videos assigned to them. This can create a divide among upper- and lower-class students (Findlay-Thompson & Mombourquette, 2014). Students must adjust to the new learning environment and draw on their own self-motivation as some students are not as motivated as others. Findlay-Thompson and Mombourquette (2014) stated, "students must overcome their reliance on traditional classroom teaching and be willing to accept responsibility for self-learning that comes with a flipped class" (p.66).

The Flipped Classroom Model

The flipped classroom is an approach to teaching that combines active learning and behaviorist learning theories (Bishop & Verleger, 2013). Teaching processes have been changing from a traditional lecture-example-homework setup to an active learning setup with the intention to engage the students in the learning process (Maldonado & Morales, 2019). In the flipped classroom, time during class becomes a place for collaboration, interactive learning, and one-on-one time with the teacher (Maxson & Szaniszlo, 2015). Class time turns into active learning where students' complete hands-on activities and the practice of problem sets with peers (Gomez-Lanier, 2018). This allows for teachers to intervene when questions arise, reach all students by differentiating instruction and activities, one-on-one instruction, and give immediate feedback. Active learning can be more challenging to implement, but activities will allow concepts to be

stored in students' minds more permanently than students just reading material over the content (Touchton, 2015). In turn, academic achievement will increase for all students (Houston & Lin, 2012). "Benefits of the flipped class model include emphasis on active learner participation, learner collaboration during class time, and focus on using class time to develop and practice higher-order thinking skills" (Shi et al., 2018, pg. 463). Talbert (2014) stated

> To put students in a better position to succeed, the contexts of the traditional classroom need to be reversed: information transfer should be done outside of class using media that give students more control, and high-level tasks should be done inside of class where the instructor is present to guide students in efficient and effective work (p. 362).

High-level activities should be meaningful and challenging. Collaboration with peers allows students to increase understanding of the content that was presented in the video lecture (Patterson et al., 2018). Students will be able to share their thoughts and perspectives on the content with others in their classroom. This can clear up misconceptions and promote conversations about the material (Shi et al., 2018).

Research on the Flipped Classroom Model

Flipping of the classroom occurs when instruction and/or lessons are viewed at home prior to coming to class. As a result, more time in the classroom is allocated for activities that combine application of concepts learned in the lesson with student collaboration. Research on the flipped classroom model has mainly focused on the perspectives of students after their classroom was flipped (Gomez-Lanier, 2018; Sergis et al., 2018; Smith, 2017). Many studies were implemented in college undergraduate

programs (Schlairet et al., 2014; Smith, 2017; Carter et al., 2018; Touchton, 2015; Talbert, 2014; Combs et al., 2018) and high schools (Shi et al., 2018; Bhagat et al., 2016; Sergis et al., 2018; Strayer, 2012). Research on the flipped classroom in middle school mathematics is lacking, as well as research on academic performance of diverse students in the flipped classroom model such as gifted and talented (GT), special education (Sped), and English language learners (ELLs), even students with no special designation.

Much of the previous research on the flipped classroom extends mainly to the college level, where students are independent learners and have a library and technology available to them. Strayer's (2012) mixed methods study found college students preferred flipped instruction because it promoted collaboration and more innovative thinking. Ketsman et al. (2018) conducted a mixed methods study of an undergraduate physics course with 111 students which revealed positive attitudes towards embedded quiz questions in video lessons to keep students engaged in learning the content. Krouss (2020) noted high participation for pre-class comprehension assessments and indicated this intervention was well received by students which can impact their course of study positively. The results of a few mixed-method studies, Hao (2016), Forsey et al. (2013) and Wilson (2013), showed that a considerable number of students were not ready to take responsibility for their own learning and prefer lecture-based instruction over the flipped instruction model. Yorganci's (2020) quasi-experimental, pre-test post-test research design study with 163 first-year students in an associate degree program showed that mathematics achievement post-test scores were higher with flipped learning along with significantly higher self-regulation and self-efficacy.

More one-on-one time can be spent with students in class which has been showed to increase academic achievement (Houston & Lin, 2012). With a flipped classroom model, students are still learning the same content they would in a traditional classroom, but they are given an opportunity to deepen their understanding through guided, in-class, hands-on activities along with time to discuss mathematical concepts with their peers. Students develop deeper understandings of mathematics when they engage in meaningful social interactions (Cobb et al, 1992). This will lead to mastery of the content, increased collaborative opportunities, increased critical thinking skills, and give students the building blocks needed to become 21st century learners (Shi et al., 2018).

The flipped classroom approach is not well-documented in literature in the field of mathematics (Maxson & Szaniszlo, 2015). In addition, previous research has not fully examined the effects of flipped classroom instruction in elementary and middle level mathematics classrooms. While studies have been conducted and as the use of the flipped classroom model permeates other levels of K-12 education, the research should extend to elementary and middle school. In one such study, Kirvan (2015) used a quasi-experimental design to compare flipped instruction to traditional instruction for seventh and eighth grade students. Teachers noted increased engagement and collaboration during activities but found little difference in students' conceptual understanding and achievement. Winter (2018) investigated a 6th grade social studies classroom at a private school. Findings from this study suggested the flipped classroom model improves learning experiences and motivates students using technology. Wei et al. (2020) used a combined method of testing and interviews of 88 sixth-grade students to evaluate the effectiveness of the flipped classroom approach. The flipped classroom approach

benefited math students at a middle level more than a high or low level. Hwang et al. (2020) noted improved students' learning performance especially for students with higher levels of critical thinking tendencies. Hwang et al.'s (2020) study was conducted with 75 fifth graders in a science class where a multilevel concept mapping-based problem strategy was created which assisted students in the flipped classroom, all students believed they could complete activities as they worked in groups with the strategy.

In addition, current studies do not focus on different types of student learners. Therefore, it is a goal of this study to determine if the flipped classroom model will increase student mathematical understanding for ELL, GT, Sped, and regular students. This study is differentiated from previous studies due to the quantitative data collected. In previous studies, qualitative data was collected from student responses on their preferences when learning. This study's results were based on student performance with a population of sixth grade students over a period of two semesters: one semester with traditional instruction and one semester with the flipped classroom instruction along with student perceptions of instruction with the flipped classroom approach.

III. LITERATURE REVIEW

This literature review will describe instruction in mathematics and how flipped learning changes how teachers deliver instruction in the classroom.

Instruction in Mathematics

Mathematics educators primarily base the instructing of mathematics on behaviorism principles (Bloom, 1956; Gange, 1965; Thorndike, 1922). Behaviorist teaching methods rely on facts, formulae, scientific concepts, and vocabulary; but comprehension, composition, and analytics are unverified (Skinner, 1976). Learning is more teacher led as students absorb information given by the teacher. Most mathematics curriculum assumed the learner was a passive absorber of information (Romberg, 2010). There is much criticism to the behaviorism approach in mathematics. Eisenberg (1975) states that developing curriculum exclusively within a behavioral framework will accelerate the illiteracy rate. Therefore, problem solving should be at the core of mathematics curriculum where students have a goal to 'think'.

In a constructivism approach to mathematics, the teacher's role is one of a facilitator. Learning is shifted from teacher led to student led. Students investigate and explore throughout their mathematical development as teachers facilitate the learning (Cobb, 1994). Student-centered learning means that students can learn what is relevant for them in ways that are appropriate (Edwards, 2001). Brooks and Brooks (1999) stressed that educators believe that for students to learn best, they need to construct their own knowledge based on interactions with their environment instead of having someone

else construct knowledge for them. Learner's construct meaning, understanding, and knowledge through experiences. Students' internalization of knowledge and the process of constructing knowledge are emphasized (Wang et al., 2017).

Many proponents of mathematics reform advocate for a constructivist perspective of teaching and learning (Cobb et. al, 1992; Cobb 1994; Simon, 1995; Zazkis, 1999). The constructivist learning theory is important in a flipped classroom as it emphasizes learning activities where students are in the center of learning and teachers facilitate students, so they can master concepts and foster learning (Li, 2016). The flipped classroom is self-directed learning where students learn actively and construct meaning with great enthusiasm (Xu & Shi, 2018). Classroom activities must engage students in student-centered learning which requires students to deepen their understanding of the lesson content.

Learning in Mathematics

Jenkins (2015) states there are seven fundamental conditions of learning; these conditions are awareness, interest, motivation, relevance, engagement, reinforcement, and support. Correa et al. (2008) interviewed 29 mathematics teachers and the findings suggested that students learn best when they are asked to construct their own ideas and strategies related to mathematics. Research on how students think they learn best is limited (Groves & Welsh, 2010; Saul, 2005). Barry et al.'s (2019) study surveyed 1,212 recent high school graduates and the study showed students preferred to watch instructional videos while taking notes to keep them less distracted and more engaged in learning the mathematics material. When students were allowed to collaborate with peers and work independently, students believed they learned the best (Barry et al., 2019).

The 4C's of 21st Century Learning

Learning in the flipped classroom has evolved to compliment the expectations of 21st century learners (Winter, 2013). Students need specific skills to fully participate in today's world, these skills are identified as communication, collaboration, critical thinking, and creativity (NEA, 2015). These skills are known as the 4Cs. To develop the skills a student-centered approach should be implemented which facilitates learning through discussion. Robb (2017) states when student-led conversations are incorporated into the classroom, students are inspired to read, talk, and write about materials they choose which creates a community of learners that support each other. Tindowen et al.'s (2017) study shows that collaboration is one of the lowest developed 21st-century skills. To enhance collaboration, teachers should allow for more active learning and listening skills in the classroom (Bell, 2010). Onyema & Daniil (2017) proposed the use of the flipped classroom model as a way to impact learning and engage learners as it allows new technology to be effective in the creation of knowledge. The flipped classroom model ties technology skills with individual learning and content knowledge expansion (Gomez-Lanier, 2018).

Different Types of Learners

Learners have different learning styles, abilities, preferences, and skill levels. All students have different needs when it comes to learning and as a teacher, part of the job is to meet the needs of every one of these students. The learning needs of each student must be addressed and is an important part of creating meaningful classroom experiences. These learners may have learning difficulties, be gifted, and/or be students with no identified need or exceptionality. According to the Texas Education Agency in 2019-

2020 there were 1,110,548 students who were limited in their English proficiency (TEA, 2020). These students are learning the English language and speak more than 120 different languages. The Texas Education Agency identifies a gifted and talented student as performing at or shows the potential for performing at a remarkably high level of accomplishment when compared to other students of the same age, experience, or environment (TEA, 1995). According to the National Center for Learning Disabilities, 419,014 students in Texas were identified as receiving special education services. These services include but are not limited to autism, emotional disturbance, intellectual disabilities, and specific learning disabilities (NCLD, 2017).

To reach such a wide range of learners, instruction must be differentiated. Instructors modify their teaching approach to be able to address the diverse needs of individual learners (Tomlinson et al., 2003). Tomlinson et al. (2003) also states that effective differentiated instruction is learner-centered; teachers scaffold learning in order for learners to see relevance and oversee their own learning. To reach learners, teachers spend time working one-on-one or in small groups with students. With the flipped classroom, teachers rethink the use of classroom which can include one-on-one and small group instruction which allows students more time for collaboration with their peers and application of math concepts learned in the videos. Students with learning difficulties or language barriers can watch the videos as many times as needed to learn the content; pausing and rewinding the lessons as needed. In addition to the instruction, activities can be implemented which cover a variety of learning levels. Flipping the classroom adds flexibility to the classroom which extends learning far beyond the traditional lesson by allowing self-paced, mastery learning (Tucker, 2012). This allows students who need

more support to watch the video repeatedly and students who learn faster to move on to content that offers more of a challenge. The flipped model has allowed teachers to spend most of the class walking around helping students who struggle most (Bergmann & Sams, 2012). Most of the teacher's attention is directed to students who need help the most, not the students who raise their hands first. The student-centered instruction in a flipped classroom model can create a meaningful learning environment which requires students to build their conceptual understanding of the curriculum.

IV. METHODOLOGY

This study aimed to understand if learners' mathematical understanding was enhanced in a middle school mathematics classroom when a flipped classroom approach was implemented. Specific learners under consideration included gifted and talented (GT), special education (Sped), and English language learners (ELLs). Four groups were selected to encompass the possible learners that are in the mathematics classroom. These groups were identified ELL, GT, Regular, and Sped. In response to the research questions, an explanatory sequential design was utilized. An explanatory sequential design research study is completed when a researcher wants to receive participant feedback and examine long-term sustained effects (Creswell & Creswell, 2018). This methodology was selected to expand knowledge on a familiar topic; instruction in mathematics using the flipped classroom approach. In this mixed methods study, the researcher first collected quantitative data involving student achievement measures, then qualitative data in the form of a survey. The analysis of the qualitative data was used to explain and reinforce the quantitative data by reviewing student perceptions and comments about the flipped classroom. The effect of the flipped classroom would not accurately be known at the beginning of the study.

Setting and Participants

Setting

The research was conducted at a public middle school located in a Southwest region of the United States. The school within this study has approximately 400 students enrolled. This campus is a sixth grade only campus. The ethnicities of the student population were comprised of Hispanic (73.8%), African American (2.7%), American Indian (0.5%), Asian (1.7%), White (20.5%), and Two or more races (0.7%). The campus identified 54.3% of enrolled students as being at risk of dropping out of school based on state-defined criteria. 85.6% of students enrolled are economically disadvantaged whereas he/she are eligible for free or reduced-price lunch. Sub-populations receiving various academic supports consisted of students receiving support in a bilingual/ESL program (23.2%), 7.1% are in a gifted and talented program, and 13% receive academic support with a special education program.

Participants

A total of 312 sixth grade students served as participants for this study. Seven students were removed from the study due to double coding, meaning some students were labeled with more than one group designation. Student participants were in mathematics classes taught by four different teachers. A total of 18 mathematics classes were included in the study. Out of these classes, 6 were advanced, 6 were regular, and 6 were co-taught. A co-taught mathematics class has a regular mathematics teacher and a special education teacher in the classroom. The students were taught the same curriculum and given the same tests.

Data Sources

Data was collected from a total of ten assessments given to the students. Five assessments were given during the fall semester where students were taught in a

traditional format. Five assessments were given during the spring semester where the flipped classroom model was implemented. The test medians for each semester and each group were found. A ten-question survey was given to all participants. The survey included nine close-ended questions and a one open-ended question. The close-ended questions used Likert-type items based on a five-point scale and the open-ended response question allowed participants to elaborate further about the flipped classroom model. Before beginning the data collection, Internal Review Board approval was sought, and a consent form gathered from each student and their parent/guardian gave permission for the survey to be administered and data to be collected from the student's test scores. The data collected for this study did not include any students' names or personal information.

Data Analysis

For the quantitative phase of the study, a summary statistic approach was taken due to the exploratory nature of this study. Student assessment scores were used to determine student achievement during semester one where classroom instruction followed a traditional format and semester two where the flipped classroom was implemented. Data was compiled and included each student's test scores and classification. There were 305 students included in this population. Out of the 306 students, 64 students were in the ELL group, 25 in the GT group, 195 in the Regular group, and 21 in the Sped group.

Error! Not a valid bookmark self-reference. and Figure 2 compare the test scores for this study (2019-2020) with students from the following year (2020-2021). During the study, a global pandemic was in effect during the second semester. The pandemic did not affect the content taught to students as the standards were already

covered prior to a school shutdown. Tests for both school years covered the same standards. When breaking the tests between semesters, tests 1-5 are from the traditional classroom and tests 6-10 are from the flipped classroom. When looking at the study test scores from each semester, there is a clear increase in variation in the second semester when flipped classroom was implemented. The variation in the test scores for the study year with the traditional classroom instruction are similar to the variation in student test scores from the following school year where the flipped classroom was not a part of the mathematics classroom. The 2020-2021 data was acquired for comparison purposes to provide support for the difference observed in student test score distributions with implementation of the flipped classroom. This difference is likely attributed to the flipped classroom based on the similar distribution of test scores between the 2020-2021 data and the study data prior to the flipped classroom implementation. It should be noted that students from the 2020-2021 school year were unusually high performing. The shape of the test score distributions for the traditional classroom models, 2019-2020 versus 2020-2021 are about the same and variation in the test scores was similar, however the distributions are higher for the 2020-2021 school year.

Figure 1: Boxplot of Test Scores – 2019 – 2020 School Year

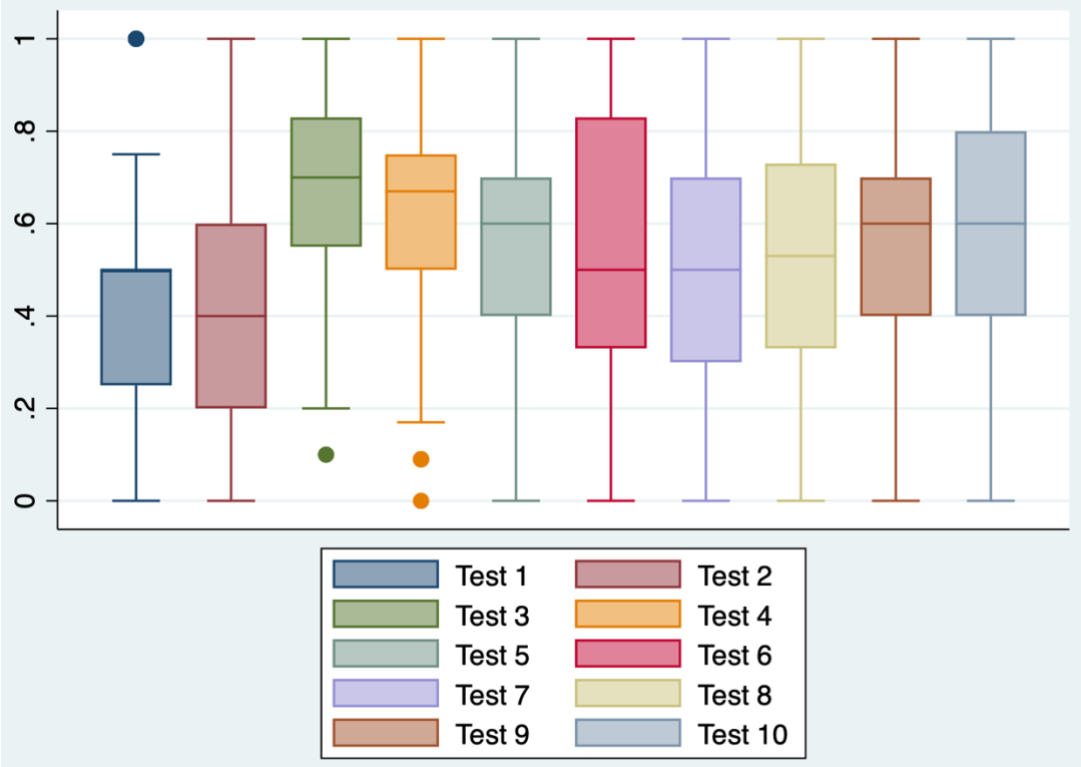
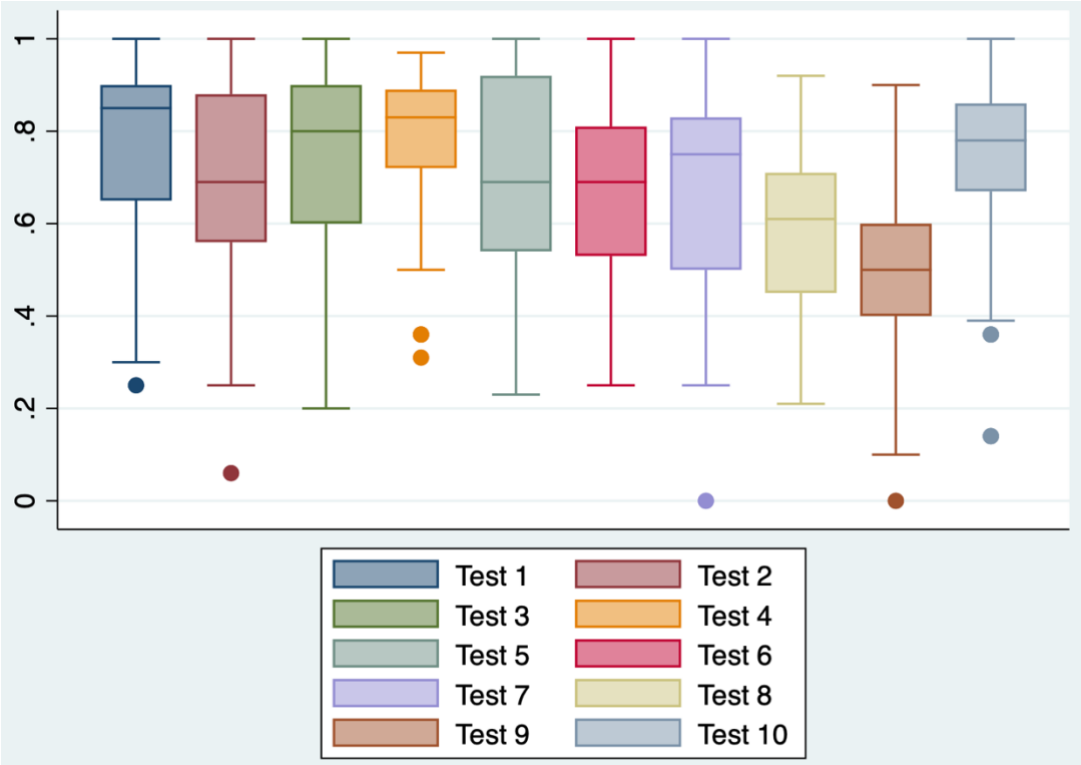


Figure 2: Boxplot of Test Scores – 2020 – 2021 School Year



Statistical analyses were performed in STATA (v.16.1). A significance level of .05 was used for all statistical tests and a Bonferroni correction for multiple comparisons was used. A Shapiro-Wilk test (Shapiro & Wilk, 1965) was performed on each of the ten test scores to test for normality, as well as the test scores for each group. A Wilcoxon signed-rank test (Wilcoxon, 1945) was performed to determine if the medians of our test scores were equal for the traditional and flipped classroom due to the non-normality of the data.

For the qualitative phase of the study, data collected from a ten-question survey provided details about student perceptions regarding the flipped classroom method of classroom instruction and explain the results of the quantitative student achievement. Student responses to the open-ended question "add any other comments you would like to make about the Flipped Classroom" were chosen at random to be included.

IV. RESULTS

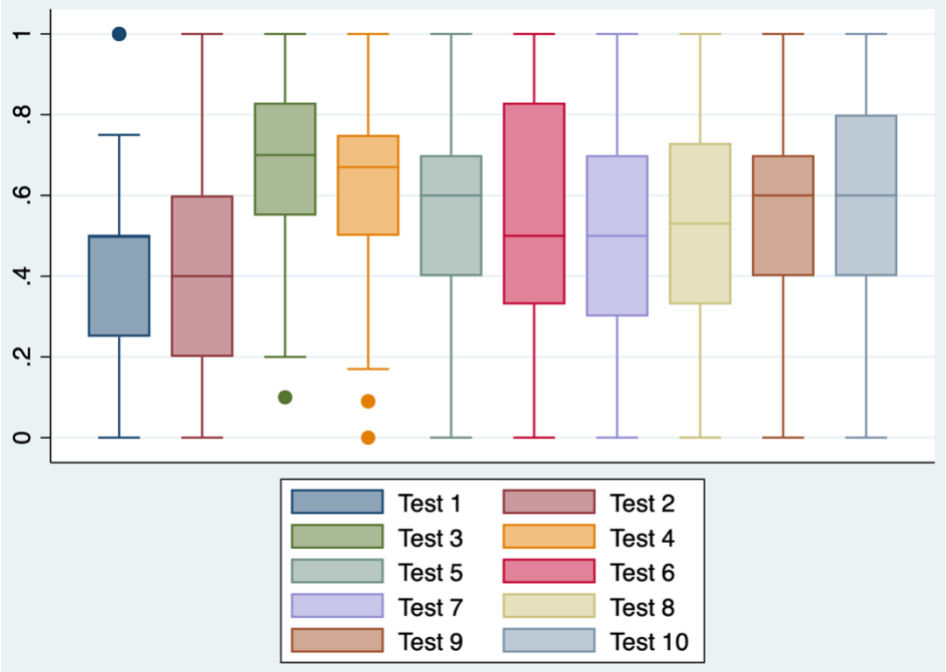
Quantitative data was analyzed through a collection of tests measures of center from the population of 305 sixth grade mathematics students for two consecutive semesters. Descriptive statistics for the semesters by groups are reported in Table 1.

Table 1: Descriptive Statistics for Semester

	Semester One (n = 305)			Semester Two (n = 305)		
Group	*Mean*	*Std. Dev.*	*Median*	*Mean*	*Std. Dev.*	*Median*
ELL (n = 64)	.508	.174	.48	.508	.199	.47
GT (n = 25)	.758	.144	.77	.788	.162	.80
Regular (n = 195)	.545	.164	.54	.568	.187	.58
Sped (n = 21)	.389	.120	.39	.357	.140	.33

Figure 3 provides an illustration of the test scores for the population.

Figure 3: Boxplot of Test Scores - Population



Figures 4-7 provide an illustration of the test scores for each group.

Figure 4: Boxplot of Test Scores – ELL

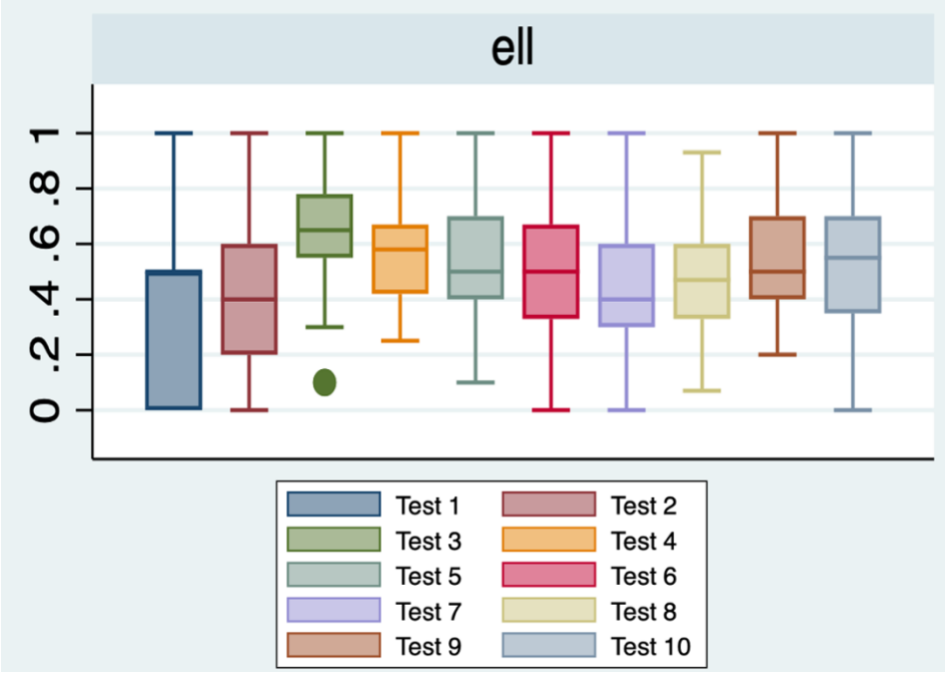


Figure 5: Boxplot of Test Scores – GT

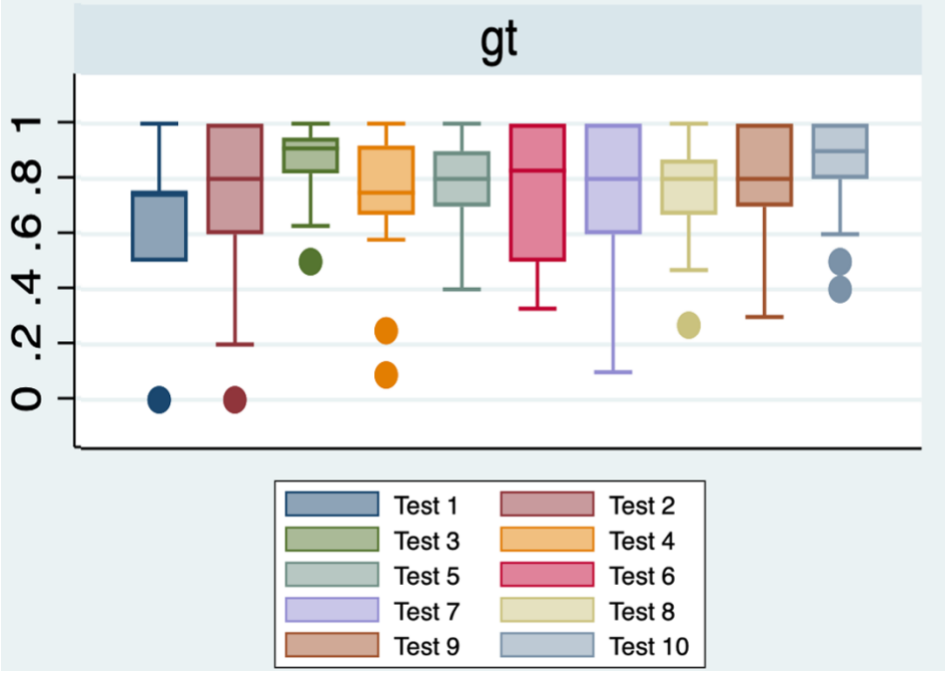


Figure 6: Boxplot of Test Scores – Regular

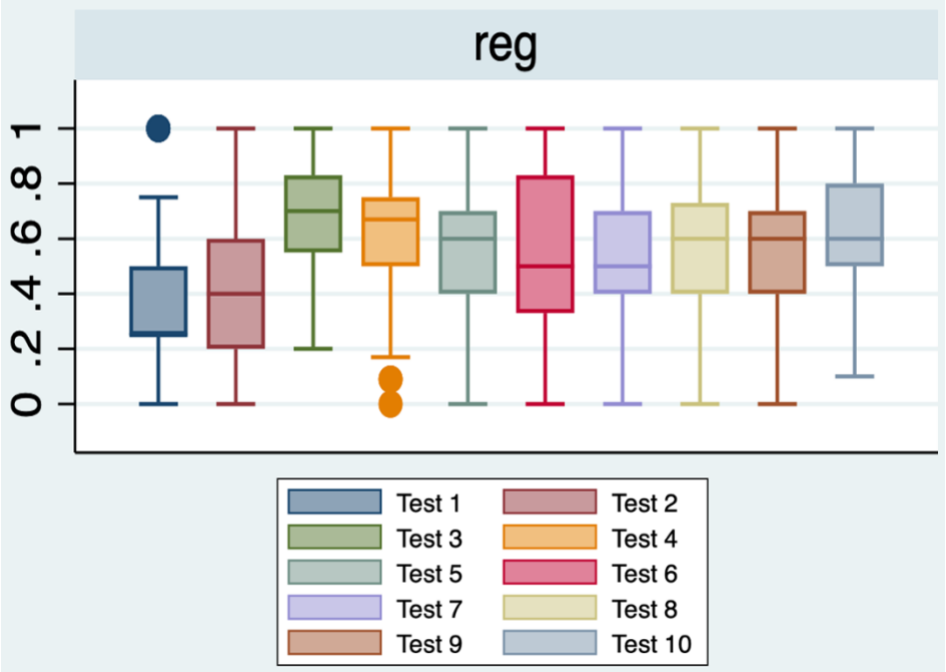
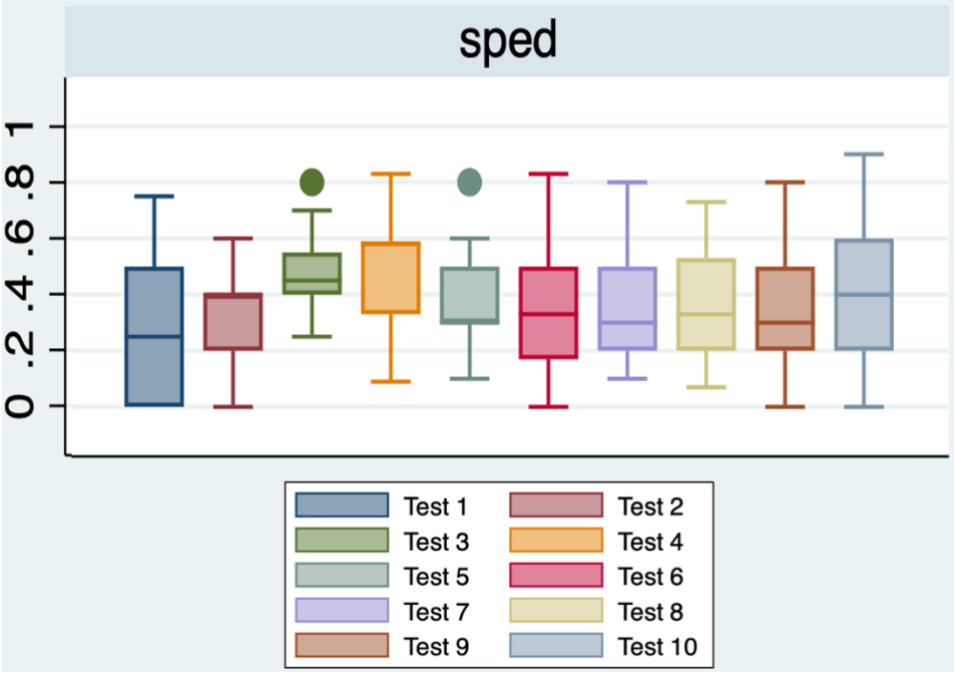


Figure 7: Boxplot of Test Scores – Sped



A Shapiro-Wilk test was performed on each of the ten test scores to test for normality along with the test scores for each group. Test scores were not normally

distributed for five tests. These tests included Test 3, 4, 7, 8, and 10. For the four groups, tests were not normally distributed for all groups as seen in Table 2.

Table 2: Shapiro-Wilk Test Prob>z Results

Test 1	Test 2	*Test 3	*Test 4	Test 5
ELL 0.023	*ELL 0.324*	*ELL 0.552*	*ELL 0.471*	*ELL 0.864*
GT 0.044	**GT 0.005*	**GT 0.0005*	**GT 0.002*	*GT 0.460*
Regular 0.021	*Regular 0.803*	**Regular 0.002*	**Regular 0.004*	*Regular 0.547*
Sped 0.023	*Sped 0.999*	*Sped 0.793*	*Sped 0.066*	*Sped 0.121*

Test 6	*Test 7	*Test 8	Test 9	*Test 10
ELL 0.728	*ELL 0.078*	*ELL 0.152*	*ELL 0.332*	*ELL 0.996*
GT 0.806	**GT 0.001*	*GT 0.054*	**GT 0.002*	**GT 0.006*
Regular 0.281	*Regular 0.685*	**Regular 0.006*	*Regular 0.914*	**Regular 0.002*
Sped 0.351	*Sped 0.272*	*Sped 0.382*	*Sped 0.648*	*Sped 0.912*

*Not normally distributed

Due to normality issues, median test scores for each group were found and are reported in Table 3.

Table 3: Median Test Scores by Group

		ELL (n = 64)	GT (n = 25)	Regular (n = 195)	Sped (n = 21)
Semester One	Test 1	*.50*	*.75*	*.25*	*.25*
	Test 2	*.40*	*.80*	*.40*	*.40*
	Test 3	*.65*	*.91*	*.70*	*.45*
	Test 4	*.58*	*.75*	*.67*	*.58*
	Test 5	*.50*	*.80*	*.60*	*.30*
Semester Two	Test 6	*.50*	*.83*	*.50*	*.33*
	Test 7	*.40*	*.80*	*.50*	*.30*
	Test 8	*.47*	*.80*	*.60*	*.33*
	Test 9	*.50*	*.80*	*.60*	*.30*
	Test 10	*.55*	*.90*	*.60*	*.40*

A Wilcoxon signed-rank test was conducted to determine the effect of the flipped classroom on students' test scores. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve. There was a median decrease in student test scores (-0.05) when students participated in

the flipped classroom (.53) compared to the traditional classroom (0.58), and this difference was not statistically significant, $z = 0.617, p = .538$. Of the 305 participants, the flipped classroom elicited an increase in the test scores of 137 students compared to the traditional classroom, whereas 49 students saw no change in test scores and 119 students did not increase their scores on the tests given in the flipped classroom.

A Wilcoxon signed-rank test determined that there was not a statistically significant median difference in test scores for each group when students participated in the traditional classroom and flipped classroom. Of the 64 students in the ELL group, 31 students had an increase in their tests scores with the flipped classroom compared to the traditional classroom, 9 students saw no change in test scores and 24 students did not increase their test scores with the flipped classroom, $z = 0.754, p = .455$. Of the 25 students in the GT group, 14 students increase their test scores with the flipped classroom, whereas 3 students did not have a change in their scores and 8 students did not have an increase in test scores, $z = 1.172, p = .249$. 195 students belong to the regular group, the flipped classroom generated an increase in test scores for 82 students, 36 students had no change in test scores, and 77 students did not progress, $z = 0.029, p = .978$. Of the 21 students in the Sped group, 10 students improved their test scores in the flipped classroom, 10 students did not improve their test scores, and one student had no change in test scores from the traditional classroom to the flipped classroom, $z = -0.435, p = .676$.

For the qualitative phase of the study, qualitative data provided further details about the active learning experiences as well as student perceptions of the flipped classroom model. The student survey provided all participants with a Likert scale to

determine the average responses of each question. The survey data showed many positive responses from students in terms on the flipped classroom model, as well as some mixed reviews. According to question three on the survey, 81% of students liked how they were able to watch the video at their own pace and rewind or pause the video if needed, see Figure 8. Survey question five asked students if the flipped classroom gave them more time to perform activities and practice problems in class and 85% agreed, see Figure 9.

Figure 8: Survey Question #3

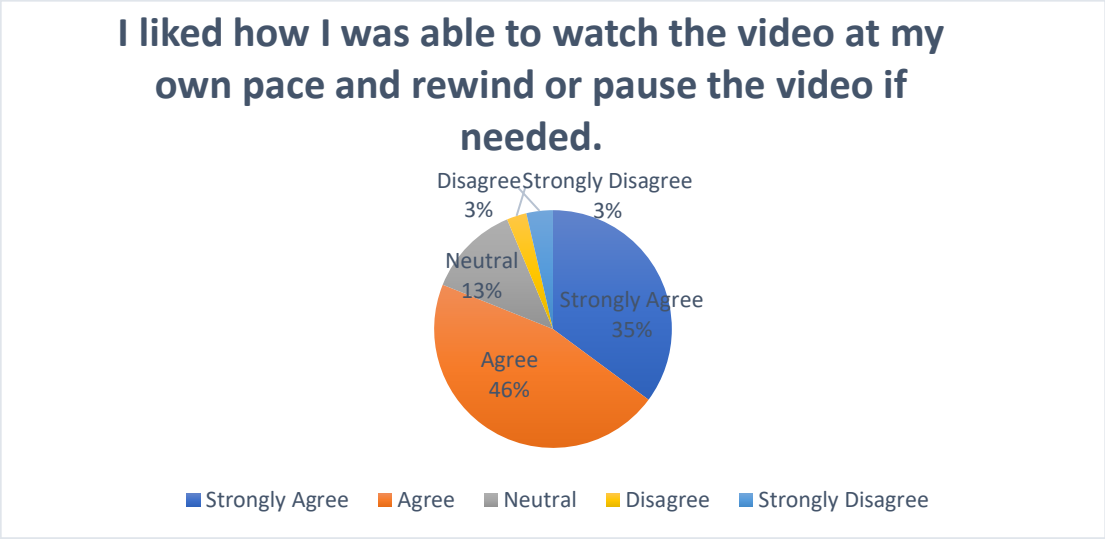
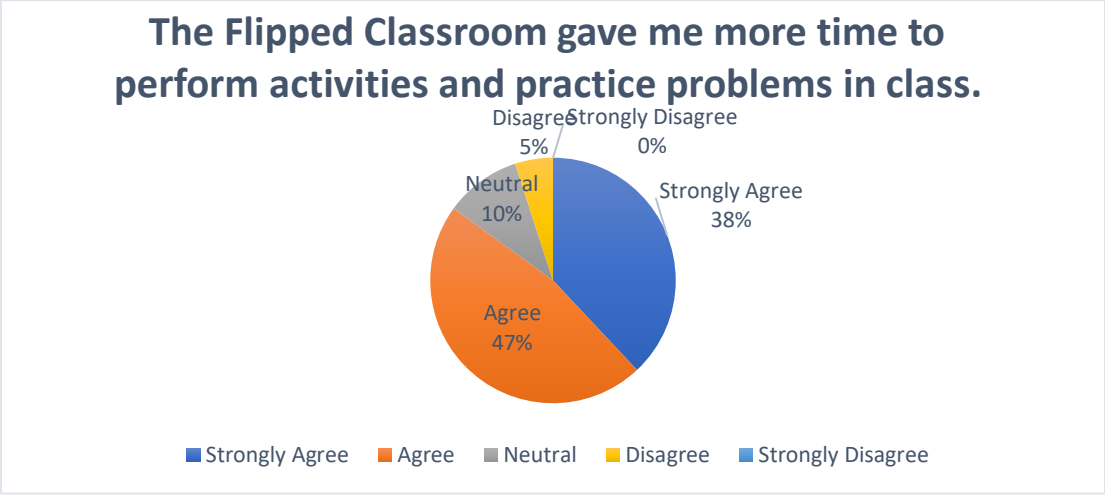


Figure 9: Survey Question #5



In addition, the open-ended survey question, “add any other comments you would like to make about the Flipped Classroom”, showed many students made comments about the flipped classroom being a great way for everyone to rewind the videos, work at their own pace, work on activities and gave more time in class to complete and practice assignments. Many students liked that they could watch the videos multiple times. For example, one student noted that:

> I love [flipped classroom] because I am not very good at understanding math problems on the first try but now, I can watch the video as much as I want. I am able to pay more attention because no one is talking and distracting me.

Multiple students stated that the flipped classroom was perfect because they could work at their own pace. For example, a student said:

> The flipped classroom is a great idea! It’s a great way for everyone to rewind the video if needed and gave more time in class to complete and practice the assignments. I could work at my own pace which I really liked.

Other students stated:

> “I really liked it, I started doing so much better after we started using flipped classroom and I understood what we were learning so much better!”
>
> “We had extra time in class to do fun things.”
>
> “It helps because the videos are short and before we used to spend too much class time taking notes.”

According to a few comments, there were also students who did not like the flipped classroom. A few students said it was easier to learn the [traditional] way because they were not able to ask questions right away in the flipped classroom model. In the

traditional classroom, as the teacher is lecturing, students can raise their hands to ask questions. In the flipped classroom, as students watch the video, they are not able to raise their hand to ask a question. Students must wait until they come into class the next day to ask any questions. One student stated:

> I wasn't motivated to watch the videos because I couldn't get questions answered as I watched the video so [flipped classroom] was not helpful.

V. DISCUSSION

Implementation of the Flipped Classroom

For this study, students were introduced to the flipped classroom by watching a video about what the flipped classroom is. After the video, I led a discussion to answer any questions that students had over the flipped classroom approach. Students were surveyed and asked about their access to internet and any device they had at home that would be able to access the internet and allow them to watch a video. Out of the 305 participants, 10 students did not have access to internet and/or did not have access to a device. To accommodate all students, the school library was opened 30 minutes before school started and remained open 30 minutes after the end of day bell rang so that students had the opportunity to watch the videos needed for mathematics class. Even students that had access to devices and internet, had the option to watch their video in the library before they left school or before they begin going to their classes in the morning. Some students did choose not to watch the video. To remedy this, students were reminded of library hours and discussions of the video material were conducted at the beginning of each class. Students were given a list of questions to answer, and they answered the questions within their group. Even if a group member did not watch the video, they were still responsible for discussion within their group but often they were behind and missing critical content information. This discussion piece helped motivate students to watch the assigned videos. Not adequately completing the videos is likely to

have impacted the students' learning the content over the course of the semester which subsequently impacted the overall performance on tests.

Connecting to Results

The purpose of this study was to determine if the flipped classroom benefited all students, including students with learning disabilities and gather perceptions of the flipped classroom. These ideas were to directly respond to the following research questions:

- What types of learners, if any, benefit from the flipped classroom approach in middle school mathematics?
- What are student perceptions of using the flipped classroom approach in terms of delivering instruction?

The purpose of this research study was to determine if all learners benefited from the flipped classroom model in the middle school mathematics classroom. The results in the context of this study's research questions, related to previous findings from other studies, and the overall impact of flipped learning on sub-populations. The relevance of this study will be discussed in reference to past studies, suggestions made to K-12 educators interested in integrating the flipped classroom model into their mathematics class, and a solution is offered for the shortcomings of this study as may be applicable for future research.

For both research questions, the comparison of test scores from traditional and flipped classroom were the determinant of the effects of the flipped classroom approach. The primary findings from the statistical summary show the participants of the study under traditional instruction and the students from the following year (2020-2021) show a

similar test score trend. The following year's students performed at a higher level which is similar to the GT group of our study. This comparison shows that there is not just an overall trend in test scores. The participants in the study had an increased variation of test scores when the flipped classroom approach was executed in the mathematics classroom. In our study, during the traditional classroom format, test scores were not consistent and had major changes in variation. During the flipped classroom, the middle 50% of students had test scores that ranged from 30% to 70%. The median test scores were consistently at 50% to 60%. In the traditional classroom, the median test scores were higher with three out of five test medians in the 60% to 70% range.

In the ELL group, test scores for the middle 50% ranged between 40% to 60%. The median of test scores was 50% during the flipped classroom, with the traditional classroom there were two test medians that were in the 60% to 70% range with the other three test medians between 40% to 60%. The range of test scores during the traditional and flipped classroom format was the same, with traditional having two test medians with a higher test median than any test medians in the flipped classroom. In the regular group, test scores ranged from 40% to 70% for the middle 50% of students. Test medians were consistently at 50% to 60% during the implementation of the flipped classroom. Prior to the flipped classroom, test medians for three tests were between 60% and 70%. In the Sped group, the middle 50% of students' test scores were in the 20% to 60% range. The median test scores of the Sped group were in the 30% to 40% range with the flipped classroom and traditional classroom. In the traditional classroom, there were two test medians at 50%. In the GT group, the middle 50% of students scored in the 50% to 100% range with the top 25% of students scoring 100% on four out of five tests. With

the traditional classroom, test scores ranged from 50% to 90% with test medians around 70% to 80%. This indicates the flipped classroom as a positive impact for students in the GT group only.

When assessing the effects of flipped learning on test scores, a Wilcoxon signed rank test revealed a decrease in test scores from a traditional to flipped classroom. This decrease was not statistically significant. Student test scores did change, regardless of their group classification, just not a statistically significant change. This indicates that overall students did not benefit from the flipped classroom. There was an expectation that grades would be higher in the flipped classroom based on previous research (Hwang et al. 2000; Winter 2018; Patterson et al. 2018; Yorganci 2020; Houston & Lin 2012; & Wei et al. 2020). This was not found during this study, the GT group benefited from the flipped classroom but the ELL, regular, and Sped groups did not benefit. During the traditional classroom format, the test scores for students were varied but there was a greater variation in test scores after the flipped classroom was implemented. The interquartile range was larger with each test with test medians more consistent within the student groups.

As noted by survey responses, many students felt that they had more time in class to work on assignments, watch the videos repeatedly until they understood the material, and work at their own pace while learning, even though the test scores were not higher in the flipped classroom compared to the traditional classroom. Students showed a higher satisfaction with the flipped classroom approach than with the traditional classroom but there were still some negative beliefs.

The findings of this study show that the flipped classroom model did not increase student performance for three out of four groups. The GT group increased performance on tests, but all other groups were not successful. The flipped classrooms' effectiveness was limited as student's performance on tests did not increase once the flipped classroom approach was used. Most of the research showed increased student performance in the flipped classroom than students in a traditional setting (Bhagat et al. 2016; Carter et al. 2018; Hwang et al. 2000; Patterson et al. 2018; Yorganci 2020; & Wei et al. 2020) or there were no differences in grade results (Findlay-Thompson & Mombourquette 2014; Winter 2013; Ketsman et al. 2018; & Chen 2016). Although studies found similar results to this study's findings, their comparisons of learning environments are different from this study. Four studies associated the flipped classroom as yielding similar academic results to traditional instruction. Research still suggests that the flipped classroom works, and test scores increase when implemented in the classroom.

For the flipped classroom to work the way we want it to, we as educators must teach our students how to learn. Time needs to be spent during class to help students understand intended learning outcomes, expectations for student work, and make sure students know what they are supposed to do and why they are doing it. Also, time must be spent teaching students how to work effectively in their group and with their peers. Gathering student feedback, support for students, and clear communication with your students cannot be pushed to the side.

Limitations and further research

This study has some limitations that the reader should take into consideration. The findings of this study should not be generalized without caution as the sample is

small (305 participants) and consisted of students in the sixth grade only. The number of students in each group was also a limitation, the regular group was nine times larger than the Sped group, which was the smallest group. The personality and self-motivation of the students participating in the study can influence the results. Further research should investigate consecutive uses of the flipped classroom approach with a longer time frame (Bhagat et al. 2016).

VI. CONCLUSION

The purpose of this study was to analyze students' mathematical understanding in middle school mathematics classrooms implementing the flipped classroom approach. The learners in a classroom include gifted and talented, special education, regular, and ELLs. All learners need to master the content to be successful in future classes. The flipped classroom provides multiple avenues for students to learn the material. Students can work with technology to watch video lessons and research topics outside of the classroom. Students can work at their own pace and take extra time if needed without the time restraints of a normal classroom schedule. With the videos watched before class, the teacher can review concepts, clear up misunderstandings, and challenge students with higher-order thinking activities during class time. As previous literature has presented, the flipped classroom approach develops a learning environment that uses technology to move from a teacher-centered to a student-centered learning environment.

The results of this study indicate the overall impact of flipped learning was not beneficial for majority of students. In comparison between semesters, the performance of each group with the flipped classroom was not effective in all groups except the GT group. This finding was based on the statistical insignificance in test median differences. Overall, GT students were the only group who benefited from the flipped classroom approach. The flipped classroom was well suited for GT students due to the students learning the concept and having the opportunity to explore farther. I observed a slight

increase in grades for students, but many students struggled more with the flipped classroom than with direct teaching. I was able to help students one-on-one or in a small group but the number of students needing my help increased when using the flipped classroom approach. Ideally, we would like to level the playing field so that the flipped classroom approach benefited all groups of students, not just the GT students. Within our classrooms, there are many different learners, each class and each year looks different from the last. Many different learning styles can be explored so that all students can benefit, the flipped classroom is one possible learning style.

In conclusion, the research on the flipped classroom is still in its infancy in relation to K-12 public education, especially in the field of mathematics. Though this study's findings show the effects of the flipped classroom were statistically insignificant in comparison, results indicate that it is not an inferior learning environment for all students. For K-12 teachers, the findings along with past studies still signify that teachers adjust their instruction and learning environments to foster student-centered learning, the flipped classroom could be adjusted or blended with other learning environments to meet the learning needs of all students.

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APPENDIX A

Assent Form
How the Flipped Classroom Enhances Performance for All Learners

My name is Paige Rosprim. I am a graduate student at West Texas A&M University and currently teach sixth grade at Bowie 6th. I am inviting you to participate in a research study about the flipped classroom approach we used last year. Your parent(s) know we are talking with you about the study. This form will tell you about the study to help you decide whether you want to take part in it.

What am I being asked to do?
If you decide to be in the study, I will ask you to take a survey based on your experiences last year with the flipped classroom approach we used during the second semester. Based on those survey responses, I will conduct a 20-minute interview with some students to get a better explanation of their survey responses. I plan to audio record these interviews with your permission.

What are the benefits to me for taking part in the study?
Taking part in this study may not have direct benefits to you, but it will help me determine if students benefited from the flipped classroom model in our math classroom.

Can anything bad happen if I am in this study?
I do not expect anything bad happening to you.

Who will know that I am in the study?
If you decide to be in the study, I will not tell anyone else how you respond or act as part of the study. Even if your parents or teachers ask, I will not tell them about what you say or do in the study.

Do I have to be in the study?
No, you don't. The choice is yours. No one will get angry or upset if you don't want to do this. And you can change your mind anytime if you decide you don't want to be in the study anymore.

What if I have questions?
If you have questions about the study, you can ask me now or anytime during the study. You can also email me at paige.rosprim@amaisd.org. You may also contact my advisor Dr. Audrey Meador at ameador@wtamu.edu or call her at 806-651-2527. West Texas A&M University also has a Board that protects people who join a research study. You can call them at 806-651-2270 if you have a question. You can also call Dr. Angela Spaulding, Vice President of Research and Compliance at West Texas A&M University. Her number is 806-651-2731. You will receive a copy of this form for your records.

Signing below means that you have read this form, understand what we are asking you to do, and that you are willing to be in this study:

Name of the Participant (Write your name on the line):
_____

Signature of the Participant (Put your signature on the line):
_____

Date: _____

APPENDIX B

Parental Consent
How The Flipped Classroom Enhances Performance for All Learners

INVITATION TO PARTICIPATE:
Dear Parent/Legal Guardian,

My name is Paige Rosprim, and I am a graduate student at West Texas A&M University and currently teach sixth grade at Bowie 6th. I am conducting a research study to determine if all students benefit from the flipped classroom approach in a mathematics classroom. The purpose of this form is to provide you with information that will help you decide if you will give consent for your child to participate in this research.

KEY INFORMATION ABOUT THIS RESEARCH STUDY:
The following is a short summary to help you decide whether you want your child to be a part of this study. Information that is more detailed is listed later in this form.

The purpose of this study is to determine if all learners benefit from the flipped classroom model in the middle school mathematics classroom. Your child will be asked to complete a survey based on their experiences with the flipped classroom they participated in the second semester of their 6th grade year. Based on the information gathered in the survey, your student may be asked to participate in a 20-minute interview. We hope that your child will be in this research study for the duration of the survey and 20-minute interview.

STUDY PURPOSE:
The purpose of this study is to show whether the flipped classroom approach works for all students and if it allows students to work at their own pace and master standards in their math class.

NUMBER OF PARTICIPANTS:
If you agree to participate, your child will be one of 123 student participants who will be participating in this research.

PROCEDURES FOR THE STUDY:
If you agree for your child to participate in the study, she or he will take a survey. Based on the responses from the survey, your child may be asked to participate in a 20-minute interview. This interview will be audio recorded. All identifying information will be removed. No information will be used for future research studies.

RISKS AND INCONVENIENCES:
There are minimal risks and inconveniences to participating in this study. These include time to take the survey and possibly time to participate in the interview.

SAFEGUARDS:

To minimize these risks and inconveniences, the following measures will be taken: students may skip any questions that he or she feels uncomfortable answering while taking the survey or during the interview. The survey and/or interview may be scheduled at a time that is convenient for the child and parent.

CONFIDENTIALITY:
Your child's responses and information will be confidential.

The results of this study may be used in reports, presentations, or publications but your child's name will not be used, and they will not be able to be identified in any way. The data will be stored on a password protected computer. The researcher and advisor will have access to the data and the data will be retained up to three years after the project is completed after which the data will be erased.

VOLUNTARY PARTICIPATION:
Your child's participation in this study is voluntary. Your child may decline participation at any time. You may also withdraw your child from the study at any time; there will be no penalty. There is no affect to your child's grade or care. Likewise, if your child chooses not to participate or to withdraw from the study at any time, there will be no penalty.

BENEFITS OF TAKING PART IN THE STUDY:
There may be no direct benefit to your child, the possible benefit of your child's participation may help me determine if all students benefited from the flipped classroom model in a math classroom. This information will be of interest to teachers, administrators, and parents.

PAYMENT OR INCENTIVE:
For participating in this study, your child will not receive a payment or incentive.

CONTACT INFORMATION:
If you have questions about the study, please contact me at paige.rosprim@amaisd.org or my advisor Dr. Audrey Meador at ameador@wtamu.edu or 806-651-2527. If you have any questions about your child's rights as a participant in this research or if you feel your child has been placed at risk, West Texas A&M University also has a Board that protects people who join a research study. You can call them at 806-651-2270 if you have a question. You can also call Dr. Angela Spaulding, Vice President of Research and Compliance at West Texas A&M University. Her number is 806-651-2731. You will receive a copy of this form for your records.

PARENT'S CONSENT:

By signing below, you are giving consent for your child to participate in the above study and fully understand what you and your child are being asked to do. Please check the option that applies to you before signing:

☐ I give permission for my child to be audio taped.
☐ I do not give permission for my child to be audio taped.

Your child's name: _____

Parent's name: _____

Parent's Signature: _____

Date: _____

APPENDIX C

Survey Questions

1. I regularly watched the video assignment on time.
2. I felt confident about the material after watching the video lessons.
3. I liked how I was able to watch the video at my own pace and rewind or pause the video if needed.
4. Where did you watch the videos the majority of the time?
5. The Flipped Classroom gave me more time to perform activities and practice problems in class.
6. I was more motivated to learn in the Flipped Classroom.
7. The Flipped Classroom was more engaging than traditional classroom instruction.
8. I would recommend the Flipped Classroom to a friend.
9. Learning how to use a Flipped Classroom will benefit me in my future education.
10. Add any other comments you would like to make about the Flipped Classroom.