Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation

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ABSTRACT

The intent of this study was to investigate changes in students' self-efficacy, motivation, and achievement related to Formative Assessment Lesson (FAL) implementation in the Algebra 1 classroom. The effect of FAL implementation on students was examined using an embedded experimental model. Students' self-efficacy and motivation were measured using the Sources of Middle School Self-Efficacy (SMSSE) and Activity Feeling States (AFS) scales. Student achievement was measured using a researcher-created test built from questions intended to prepare students for the Georgia End-of-Course (EOC) Test. Qualitative data were collected from monthly teacher logs and teacher interviews conducted at the end of the school year.

The data were analyzed by *t*-test, correlation analysis, and directed content analysis. Although no statistically significant differences were present for self-efficacy, motivation, and achievement between students who participated in FALs and those who did not, the descriptive results and qualitative results suggested that FAL implementation might affect students by targeting subcomponents of self-efficacy and motivation as well as student achievement. In addition, FAL implementation might influence teachers by challenging them to move from traditional instructional strategies to instruction focusing on students and providing more opportunities for student inquiry.

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CHAPTER I

INTRODUCTION

Overview

Despite the creation of numerous STEM-related jobs in the United States, employers are having difficulty filling jobs because applicants do not have the necessary skills. There is a significant gap between the skills applicants have versus the skills applicants need when applying for STEM-related careers (Lazio & Ford, 2019). Although the number of conferred bachelor's degrees in STEM-related fields increased from 2016-2017, conferred bachelor's degrees and associate's degrees in STEM-related fields still only represented 19% and 8%, respectively, of all degrees conferred in 2017 (National Center for Education Statistics, 2019). This is concerning for educators and economists alike because not only are STEM careers important in a growing economy, but skills required to be successful in STEM-related careers are crucial for students to be successful in today's fast-paced world (Lazio & Ford, 2019).

Student achievement levels in the United States fail to compete with students from other countries, especially concerning STEM classes and mathematics (Hushman & Marley, 2015). The Programme for International Student Assessment (PISA) results provided by the Organization for Economic Co-operation and Development (OECD) showed students from the United States performed below the OECD average on the PISA mathematics assessment for 2018 (OECD, 2019). Students from the United States performed lower than 36 of the 79 countries that participated in the 2018 PISA assessment in mathematics, including China, Canada, Russia, Korea, and the United Kingdom (OECD, 2019). Low achievement levels have led researchers and policymakers to search for ways of improving student achievement to better compete with other nations. Efforts to improve student achievement include adjusting curriculum to introduce common standards to be adopted across the nation (Research for Action, 2011). Research efforts have focused on addressing student achievement directly through the implementation of various instructional strategies, including specialized formative assessment lessons (Edmond, 2010), flipped instruction models with active learning strategies, flipped instruction models with mastery learning strategies (Wiginton, 2013), and conceptual teaching strategies (Yu & Singh, 2018). Other research efforts have indirectly addressed student achievement by targeting students' self-efficacy through increased teacher training (Siegle & McCoach, 2007).

Efforts to address student achievement through curriculum and instructional strategies include the introduction of Common Core standards (Seashore, 2015). One emphasis of Common Core standards is the standards for mathematical practice, developed to help students reach higher levels of thinking and application. The introduction of Common Core standards led to the creation of instructional strategies and learning tasks to help teachers address the standards for mathematical practice in the classroom (Duffy & Park, 2012).

One major instructional strategy created in response to Common Core standards was Formative Assessment Lessons (FALs), also known as classroom challenges, which were developed by the Mathematics Design Collaborative (Bill and Melinda Gates Foundation, 2017) as part of the Mathematics Assessment Project (MAP) (MARS, 2015a). FALs are instructional tasks intended for periodic implementation in the high school mathematics classroom to help reinforce standards for mathematical practice. These tasks can either introduce new concepts by connecting current concepts to prior knowledge or help students synthesize learning near the end of an instructional unit (Bill and Melinda Gates Foundation, 2017; MARS, 2015a). Previous research has shown that teachers believe FAL implementation improves students' math skills, math knowledge, problem-solving skills (Research for Action, 2011), and students' understanding, as evidenced by a decrease in the number of mistakes present on assessments (Wilder, 2015). However, FALs are intended to be implemented approximately four to five times in a semester rather than as part of daily instruction. This periodic implementation calls to question the significance of FAL implementation's impact on students (Seashore, 2015).

To be successful in high school mathematics courses, students must be willing to engage in learning processes to build skills necessary for success, such as problem-solving, critical thinking, and logical reasoning (Borgonovi & Pokropek, 2019; Yurniwati & Hanum, 2017). Problem-solving, critical thinking, and logical reasoning are skills emphasized in the standards for mathematical practice and therefore are the main focus of FALs. Students' willingness to engage in such activities is affected by many factors, including their self-efficacy and motivation to learn (Recber et al., 2018; Siegle & McCoach, 2007). Self-efficacy refers to a person's belief that he or she can successfully complete a task (Bandura, 1997; Brookhart & Durkin, 2003; Stevens et al., 2004; Zimmerman, 2000). Mathematics self-efficacy is context-specific self-efficacy which refers to a person's belief that he or she can successfully complete a mathematical task.

Previous research has revealed that higher levels of self-efficacy are related to higher levels of student achievement and motivation (Brookhart & Durkin, 2003; Kwan, 2016; Stevens et al., 2004; Zimmerman, 2000). The intended use and structure of FALs are related to mastery, social, and physiological factors self-efficacy (Bandura, 1997) by providing structured tasks with achievable goals, opportunities for collaboration among peers, frequent feedback from peers and instructors, and self-reflection. Previous research has shown such tasks and opportunities positively affect students' mathematics self-efficacy (DeThomas, 2017; Fidan, 2017; Kwan, 2016). Additionally, students are challenged to apply their learning and must persevere in solving problems with their peers during FAL implementation. Fast et al. (2010) and Kwan (2016) found that appropriately challenging classrooms are positively related to student self-efficacy. In return, students with higher levels of self-efficacy are more likely to partake in challenging tasks and more likely to persevere in solving problems than students with lower self-efficacy (Bandura, 1977; Zimmerman, 2000).

Student motivation is closely related to self-efficacy because a student's belief in his or her ability to complete a mathematical task can affect their motivation to learn. Many components of classroom instruction that address student self-efficacy, such as opportunities to be successful, regular feedback, and collaboration, also foster student motivation (Bandura, 1997; Ryan & Deci, 2000, 2009). Previous research has shown that self-efficacy and motivation are positively related to each other (Stevens et al., 2004) and that some teachers perceive an increase in student engagement and student abilities in mathematics classes as a result of FAL implementation (Research for Action, 2011). However, the relationship between FALs and increasing student engagement is still developing. Additionally, reported teacher perceptions offered no information about student motivation. No studies have been conducted to determine the impact of FAL implementation on student motivation to learn mathematics or the impact of FAL implementation on student mathematics self-efficacy.

Motivating students to learn is a daunting but necessary task for classroom teachers. Typical efforts of motivating students implemented in classrooms today represent methods that target extrinsic motivation. However, research has revealed that extrinsic motivation can be detrimental to student learning by decreasing student interest in the content and therefore decreasing student motivation to learn (Niemiec & Ryan, 2009). The activities meant to foster intrinsic motivation may help students be more equipped for problem-solving and applying conceptual knowledge, resulting in increased student achievement (Durmaz & Akkus, 2016; Leon et al., 2015).

The intended use and structure of FALs represent instructional strategies recommended for fostering student motivation by addressing motivational needs as outlined by Ryan and Deci's (2000) self-determination theory (SDT). According to SDT, students need to feel that they are respected and belong in a classroom (Ryan & Deci, 2000). FALs are a student-centered approach to instruction in which they are encouraged to collaborate while solving a challenging task. It allows students to come together while discussing mathematics through productive arguments with each other about mathematical processes. Additionally, students need to believe they are competent in mathematics (Ryan & Deci, 2000). FALs are implemented after students have received the necessary instruction to be successful in a challenging task but also allow students to attempt a problem, collaborate with others to gain a deeper understanding, and then apply their new knowledge to the problem. Finally, students need to take control of their own learning to be motivated (Ryan & Deci, 2000). FALs help students take control of their learning through carefully constructed feedback and student-centered tasks. Research has shown that meeting students' needs in these ways helps students be better prepared for problem-solving and ultimately become more successful in the mathematics classroom (Buff, 2019; Griffin, 2018).

However, student motivation is also affected by the difficulty level of the tasks students are asked to attempt (Ryan & Deci, 2000). FALs are created to be directly related to concepts students are learning in class, and suggested implementation guidelines are given to ensure that the difficulty of the tasks challenges students at an appropriate level (Bill and Melinda Gates Foundation, 2017). To ensure an appropriate level of challenge, it is recommended that FALs are implemented approximately two-thirds of the way through an instructional unit (MARS, 2015a). FAL implementation begins with students taking a pre-assessment to apply their current understanding to a novel situation. Using teacher feedback on the pre-assessment to guide discussions, students partake in a collaborative activity during the next class period. Finally, students complete a post-assessment to apply their new understanding after participating in a class discussion about their experiences and findings developed during the collaborative activity.

Many factors inside and outside of the classroom affect student motivation and self-efficacy. Unfortunately, educators do not have control over all possible factors affecting self-efficacy and motivation in the classroom. Instead, educators must focus on influencing self-efficacy and motivation through carefully chosen instructional strategies.

The most influential strategies implemented by teachers do not affect student learning if students are not motivated and do not believe they can successfully complete tasks presented to them (Bandura, 1997; Ryan & Deci, 2000, 2009). Although some instructional strategies often place the responsibility for learning on the student (Wiginton, 2013), researchers have found that a hybrid of traditional and student-centered learning is more appropriate for helping students be successful in mathematics classes (Wiginton, 2013; Yu & Singh, 2018). The structure of FALs and guidelines for FAL implementation encourage both traditional and student-centered approaches to instruction at specific times during an instructional unit. This suggests that FALs may be an ideal instructional strategy for transforming education in the mathematics classroom.

Therefore, the problem addressed in this study is the impact of FALs, on students' mathematics self-efficacy and motivation. Many research studies on FAL implementation related to student achievement were completed during or shortly after the pilot phase of FAL implementation (Research for Action, 2011). The overlap of the pilot implementation phase and the research conducted resulted in significant effects on students' knowledge of specific concepts in the math classroom (Wilder, 2015) but low effects on student achievement on mathematics assessments (Herman et al., 2015).

Researchers have identified the effects of specific instructional strategies on student self-efficacy (Brookhart & Durkin, 2003; Edmond, 2010; McMillan et al., 2010; Stevens et al., 2004) and the effects of instructional strategies targeting conceptual understanding and problem-solving on student motivation as areas in need of research (Yu & Singh, 2018). Studying the impact of instructional strategies developed as a result of current educational reform on students will help teachers make informed decisions for implementing effective instructional strategies in the future, which may ultimately affect student achievement.

Purpose of the Study

The purpose of this study was to add to the research base of information regarding the impact of instructional strategies on student self-efficacy and motivation by examining the effect of FAL implementation on student mathematics self-efficacy, motivation to learn mathematics, and achievement on mathematics assessments in the high school mathematics classroom.

The scope of this study includes factors of self-efficacy and motivation which are addressed by FAL design. Bandura's self-efficacy theory identifies four sources of self-efficacy: mastery experiences, vicarious experiences, social persuasions, and physiological and emotional states (Bandura, 1977). FALs are designed to address mastery experiences, vicarious experiences, and social persuasion sources of self-efficacy by allowing students to observe teacher modeling, participate in collaborative learning, and receive constructive feedback throughout the lesson.

Self-determination theory identifies three factors of motivation: autonomy, competence, and relatedness (Ryan & Deci, 2000, 2009). FALs are designed to promote student competence and motivation by providing prerequisite knowledge for task completion and constructive feedback. FALs are designed to promote student autonomy for motivation by providing student ownership of approaches to completing the learning task based on prior knowledge. Finally, FALs are designed to promote relatedness by allowing students the opportunity to build relationships with peers through collaboration and through constructive feedback given by the teacher.

Research Questions

1. To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy?

2. To what degree, if any, does FAL implementation affect high school students' motivation?

3. To what degree, if any, does FAL implementation affect student achievement for high school mathematics students?

4. Is there any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation?

5. What are the teachers' perceptions of the overall impact of FAL implementation?

The first research question addresses how FAL implementation directly affects student mathematics self-efficacy which is important because previous research does not address this connection. FAL implementation provides mastery and vicarious experiences in the form of participant modeling, performance exposure, teacher modeling, and peer modeling. FAL implementation also provides opportunities for social persuasion in the form of teacher feedback and collaboration with peers. These experiences are identified as sources of self-efficacy by Bandura's self-efficacy theory (Bandura, 1977).

The second research question addresses how FAL implementation affects student motivation to learn which is important because FALs and student motivation have not been a major focus of previous studies. FAL implementation addresses motivation as defined in Ryan and Deci's (2000) self-determination theory by providing collaborative opportunities, optimal challenges, performance feedback, and student ownership which relates to relatedness, competence, and autonomy.

The third research question addresses the extent to which FAL implementation affects student achievement on unit tests. This is important because previous research disagrees on how FAL implementation affects student achievement. FALs are designed to be collaborative opportunities for students implemented during the learning process which is a major focus of Vygotsky's social constructivist theory (Powell & Kalina, 2009). Targeting student learning through collaboration is theorized to help increase student learning and therefore student achievement.

The fourth research question addresses whether or not there is a relationship between mathematics self-efficacy, motivation, and achievement for students in math classes with FAL implementation. This is important because although previous research has shown that self-efficacy and motivation are closely related to each other (Bandura, 1977; Borgonovi & Pokropek, 2019) and that self-efficacy and motivation are positively related to student achievement (Afolabi, 2010; Fast et al., 2010; Lopez & Lent, 1992; Naughton, 2016; Pietsch et al., 2003; Steinmayr et al., 2019), no research has been conducted to investigate the relationship between mathematics self-efficacy, motivation, achievement with respect to FAL implementation in the mathematics classroom.

The fifth research question addresses teachers' experiences preparing FALS and implementing FALs in the classroom. The information gathered from this research question would provide information about how teachers thought FALs affected their students and what they might do if implementing FALs in the future. Through understanding teacher perceptions, details about FALs implementation would be revealed.

Theoretical Framework

Self-efficacy is considered a sub-theory of the well-known and well-referenced social learning theory by Albert Bandura. The theory of self-efficacy relates many factors contributing to a person's belief that he or she can successfully complete a task, including experiencing success, observing successful experiences, receiving verbal and situational encouragement, and other physiological factors (Bandura,1997). Experiencing success relates to mastery experiences which can be obtained through participating in collaborative or individual learning experiences with or without guidance and are the most influential experiences for building self-efficacy (Bandura, 1977). Observing successful experiences relates to vicarious experiences, which can be obtained through watching instructors or peers model successful performances visually or verbally. Situational encouragement, such as feedback, and other physiological factors, such as anxiety and stress, affect self-efficacy but are easily undermined and have less effect than mastery experiences and observational experiences (Bandura, 1977). The potential for mastery and vicarious experiences are embedded in the lesson design for FALs through collaborative activities, instruction prior to the learning task, whole-class discussions, and individual assessments. The theory of self-efficacy also relates processes through which aspects of human functioning are affected by self-efficacy levels, including cognitive, motivational, affective, and selection (Bandura, 1997).

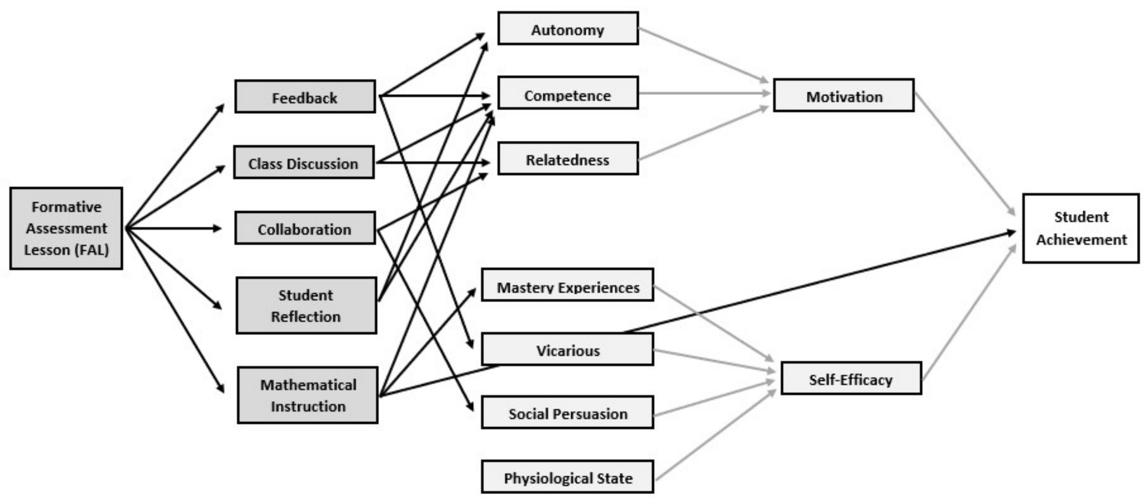
Some sources of self-efficacy, namely mastery experiences, vicarious experiences, and social persuasions, are related to components presented in the self-determination theory of motivation, such as autonomy, competence, and relatedness (Ryan & Deci, 2000). The self-determination theory of motivation indicates that students are motivated when the needs of autonomy, competence, and relatedness are met. These needs are met when students believe they have control over their learning, are capable or skilled enough to complete a task, and feel connected with others through social relationships (Ryan & Deci, 2000). Seifert and Sutton (2017) provided suggestions for addressing each aspect of motivation in the classroom. Control, or autonomy, can be supported by giving students a choice of how to approach a mathematical task or problem. Capability and skill, or competence, can be supported by encouraging active learning and implementing activities with tasks that are challenging yet possible to complete. Finally, connection, or relational needs, can be supported by providing collaborative opportunities. Deci et al. (1991) stated that meeting the needs of autonomy, competence, and relatedness in an educational setting offers the ideal opportunity for increased motivation and performance. The opportunity to participate in collaborative FAL tasks in which students take control of the approaches to solve problems after receiving instruction on skills necessary to complete such tasks contributes to each of the needs presented in the self-determination theory of motivation.

The experiences of success and observation of successful experiences noted in self-efficacy are related to ideas presented in Vygotsky's social constructivist theory, a well-known and widely acknowledged sub-theory of constructivist learning. Vygotsky believed that discussion and collaboration with the teacher and other peers in the classroom was an integral part of learning (Powell & Kalina, 2009). As stated previously, collaboration provides vicarious and mastery experiences to develop self-efficacy and creates a sense of belonging and discussion among students, which promotes student motivation according to the self-determination theory. A major component of the social constructivist theory developed by Vygotsky is the zone of proximal development (Powell & Kalina, 2009). Vygotsky believed that students should be challenged in the learning environment but only at a level between their abilities and potential abilities when working in a social setting and that learning is enhanced when students can collaborate in the learning experience (Powell & Kalina, 2009). FALs are designed to be completed after students have received proper introductory instruction and after students have had the opportunity to develop the skills necessary for completing the FAL task. Providing optimal challenges for students means providing challenges that lie in the zone of proximal development and is related to motivation as described by the self-determination theory.

The theories of self-efficacy, social constructivism, and self-determination are intertwined with each other. Although many theories relate to one another in one way or another, these theories intersect at major points for consideration for this study. For example, the impact of previous learning is a major focus of social constructivist theory by using prior knowledge to create new knowledge and related to self-efficacy by using mastery experiences to gauge beliefs of future ability. The social-constructivist theory emphasizes social interaction, which can affect both motivation and self-efficacy through collaboration. The instructional strategy chosen for this study, FALs, has characteristics that address sources of self-efficacy as identified by Bandura (1977) and components of motivation as defined by Ryan and Deci (2000). The theorized relationship between FALs, self-efficacy, motivation, and achievement is shown in Figure 1. For example, FALs are related to the constructivist theory by activating prior knowledge, self-efficacy by allowing students opportunities for mastery and collaboration, and social-constructivist and self-determination by providing collaborative opportunities and challenging but attainable goals.

Figure 1

Hypothesized Relationship between FALs, Self-Efficacy, Motivation, and Achievement



Methodology

This study adopted the embedded experimental model that qualitative data were embedded within the quantitative design, and the priority of the design was placed on an experimental design. Both quantitative and qualitative data were collected to answer the research questions, including student pre-survey and post-survey, student pretest and posttest, teacher logs, and teacher interviews.

The quantitative portion was a combination of quasi-experimental design including both non-equivalent groups design and pretest-posttest design for self-efficacy, motivation, and achievement. Data were collected through a survey measuring student math self-efficacy and motivation and a researcher-created test measuring student math achievement. The survey was administered to both the treatment and control groups once at the beginning of the semester, before any FALs had been implemented for the treatment group, and then again at the end of the semester, after FAL implementation for the treatment group but prior to the administration of the final exam for both the treatment and control groups. The survey included student demographic questions, Sources of Middle School Mathematics Self-Efficacy Scale (SMMSE), and Activity Feeling States Scale (AFS), which measured the change in self-efficacy and motivation by first establishing a baseline of self-efficacy and motivation for students in the treatment and control groups (See Appendices A, B, and C). Permission to use the SMMSE scale was granted by Dr. Usher (see Appendix D). The AFS scale was free to use for research purposes.

The test was a researcher-created assessment with questions related to concepts taught during the Spring semester for an Algebra 1 course. The test questions were obtained by identifying topics and associated standards taught during the Spring semester of Algebra 1 course and then selecting appropriate questions from various assessments available through the Savvas enVision A|G|A Common Core resources (SAVVAS Learning Company, 2020), Georgia End of Course resources for test preparation (GaDOE, 2004; Winking, 2013) and Georgia Milestone resources for test preparation (Georgia Cyber Academy, 2015; GaDOE, 2019d). The test questions, along with the standard addressed and the depth of knowledge (DOK) level, is presented in a table in Appendix E. The researcher-created test was first administered at the beginning of the semester, after the administration of the survey but prior to any instruction. The test was then administered again at the end of the semester, after FAL implementation for the treatment group, after the second administration of the survey for both the treatment and control groups, but before the final exam for both the treatment and control groups. The same questions were used for both administrations of the test, but the order in which questions were presented changed for each test administration to avoid memorization. The order in which questions were presented for each administration was presented in a table in Appendix F. An average score was calculated for each student for each assessment administration. A pretest-posttest approach is ideal for measuring the change in student achievement by first establishing a baseline of achievement for students in the treatment and control groups.

The qualitative portion analyzed the perceptions of teachers who implemented FALs in their classrooms during the study. Data were collected through teacher logs and interviews. Two teachers in the experimental group were asked to write monthly logs through Qualtrics and attend an interview at the end of the semester after FAL implementation and quantitative data collection from surveys and tests. Questions in the teacher logs focused on teachers' perceptions of FAL preparation for implementation, the effect on students in terms of student achievement, motivation, self-efficacy, and FAL implementation in the classroom (see Appendix G). The interview was conducted in person in a classroom at the chosen school during post-planning. Questions for the interview were provided to participating teachers prior to the interview and focused on their perceptions of FAL implementation, the effect of FALs on student achievement, motivation, and self-efficacy, and the effect of FALs on the classroom (see Appendix H). The qualitative data from teachers helped explain student data collected from surveys and tests.

Significance of the Study

To pursue a career in a STEM-related field, students must leave high school adequately prepared for college. One measure of college readiness for graduating students is the ACT College Readiness Benchmark. The ACT College Readiness Benchmarks are scored on each of the subject area tests that students must achieve to have approximately a 50% chance of obtaining a B or a 75% chance of obtaining a C in a related college-level course during freshman year (ACT, 2019). Although approximately 43% of ACT-tested high school graduates expressed interest in a STEM-related field in 2019, only approximately 20% of those graduates met the benchmark score in the ACT in 2019 (ACT, 2019). This means that almost 23% of graduates interested in STEM-related fields are not academically prepared to pursue such a career. Additionally, only approximately 39% of ACT-tested graduates met the benchmark score for mathematics on the ACT in 2019 (ACT, 2019), indicating that less than half of the graduating students were adequately prepared to be successful in a college mathematics course after high school. Educators should be concerned with low numbers of students representing college readiness upon graduating high school and should be looking for ways to help students be more prepared upon graduation. Duffy and Park (2012) indicated that the correct implementation of MDC tools such as FALs should help students become more prepared for pursuing college and career after high school.

The pursuit of higher-level mathematics classes and STEM-related careers is related to student self-efficacy and motivation in mathematics courses (Lopez & Lent, 1992; Recber et al., 2018). Therefore, choosing instructional strategies that foster student self-efficacy and motivation in the mathematics classroom should be of concern for educators at the high school level. Several components of FAL design are structured in a way that can potentially address sources of student self-efficacy and motivation. Increasing student self-efficacy and motivation would likely affect students' future career trajectories and course selections (Recber et al., 2018).

Assumptions, Limitations, and Delimitations

Assumptions

It was assumed that instructors implementing FALs in their mathematics classrooms would adhere to the guidelines for implementation as outlined by the MDC (Bill and Melinda Gates Foundation, 2017; MARS, 2015a). It was also assumed that students in the mathematics classes had not previously completed the FALs selected for implementation in the Algebra 1 class during the Spring semester. In addition, it was assumed that students completing the survey would answer questions honestly and accurately represent their motivation and self-efficacy to the best of their ability. Another assumption was the teachers would answer all questions in the logs and interviews honestly.

Limitations

The study was limited to students enrolled in Algebra 1 at a single high school in northern Georgia. The limited sample size made it difficult to generalize to larger populations. Randomization of students was not possible because students were randomly assigned to treatment and control groups due to preexisting rosters determined by the school.

Another limitation of this study was that the study was conducted during the COVID-19 pandemic. Data collection was done during the first school year following the shut-down of face-to-face instruction as a result of the COVID-19 pandemic, resulting in limited accessibility of student participants. During the pandemic, students in County A had the option to choose a virtual or in-person school setting at the beginning of the year and the option to change their selection at the end of first semester. Permission was obtained from students and parents towards the end of first semester and over winter break. As a result, some of the students who attended class in-person in the Fall semester did not participate in the study because they would no longer be attending class in-person during the Spring semester. Additionally, other students who attended class virtually during Fall semester decided to attend class in-person during the Spring semester, but permission could not be obtained prior to the beginning of the study.

Protocols for student health and safety related to the COVID-19 pandemic possibly affected the number of students who were able to complete the study. The protocol for dealing with COVID in County A required students to be quarantined if they either tested positive for COVID or were in close contact with someone who reported testing positive for COVID. For this reason, some students who elected to participate in the study may not have been able to complete one or more administrations of the survey or assessment, resulting in a limited sample size at the conclusion of data collection.

This study aimed to measure changes in student self-efficacy, motivation, and achievement related to FAL implementation. However, the COVID-19 pandemic brought challenges to the classroom and students' personal lives, which could not have been foreseen or controlled. Therefore, attending school during COVID could have affected student achievement as measured by assessments and student responses regarding self-efficacy on the survey since many students in the school were sick or quarantined at one point throughout the semester, and potentially quarantined multiple times, leaving students to learn the content via videos available online during that time. Additionally, other challenges related to COVID could have affected student responses related to components of self-efficacy, motivation, or both since many changes were made to school rules, classroom rules, and typical school operations to help stop the spread of COVID.

It was possible that other confounding variables such as whether students are enrolled in a mathematics support class, whether students are repeating Algebra 1, whether a student meets with a personal tutor, or whether students attend tutoring sessions offered at the school may influence the findings from this study. However, the use of a pretest-posttest design for survey and test administration means that data were collected from the same set of participants at two different points in time, which would help deter the possibility that maturation or history has influenced the results. Administering the surveys and tests over a short period, such as a single semester, further deterred the possibility of maturation or history influence on results in this study. Additionally, selecting teachers who plan instruction together through frequent collaboration may help limit the effect of other confounding variables such as lesson design, instructional content, and depth of knowledge addressed during instruction. Comparing results between a treatment and control group and using a single course team of teachers would help isolate the variable of interest in this study, FAL implementation, from other confounding variables that may influence results.

Another limitation of this study is the use of a researcher-created test. The decision not to use locally created exams was made because students could exempt the final exam dependent upon the course average after all unit assessments were administered. Therefore, using a locally created final exam to collect assessment scores for students would likely eliminate a posttest score for high-achieving students. Test questions were carefully chosen to represent content covered during the second semester in Algebra 1 courses and were gathered from resources intended to prepare students for the state Algebra 1 end-of-course exam. Additional information about the test and selection of questions was provided in the instrumentation section.

Delimitations

Delimitations in this study included the selected sample. One major focus of this study was comparing student achievement using locally created tests. The decision to include a single school was made to ensure the locally created tests would be consistent for all classrooms included in the study. The school was purposefully chosen as one whose student population was representative of the same diverse ethnic groups presented in the Georgia high school student population.

Definition of Terms

Formative Assessment Lesson (FAL) – Instructional tasks created as a result of the Mathematics Assessment Project to help students address misconceptions in their knowledge to develop mathematical understanding, make connections between mathematical concepts, and apply mathematical knowledge while participating in problem-solving activities (MARS, 2015a).

Mathematics Self-Efficacy – Context-specific self-efficacy regarding a student's belief that he or she can successfully complete a mathematical task.

Motivation – Desire to partake in mathematical tasks when student needs of autonomy, relatedness, and competence are met through extrinsic and intrinsic sources (Ryan & Deci, 2000).

Student Achievement – Student performance on a locally created summative exam for the Spring semester containing questions directly related to mathematical concepts addressed during the Spring semester in an Algebra 1 course.

Summary

Chapter 1 introduces FAL as an instructional strategy created in response to Common Core Standards to help teachers emphasize the standards for mathematical practice in high school mathematics classrooms. How FALs fit into the conceptual framework of mathematics self-efficacy and student motivation is also discussed, along with the relationship between mathematics self-efficacy and student motivation. Chapter 2 presents a review of the literature regarding FALs, self-efficacy, and motivation. Research efforts regarding FALs, mathematics self-efficacy, student motivation in mathematics classrooms, student achievement, and relationships among the variables will also be discussed. Chapter 3 presents a description of the research design, setting, participants, and intervention. A description of the chosen instruments, data collection methods, and proposed statistical tests for analyzing collected data are also discussed. Chapter 4 presents statistical results and summaries of the quantitative data gathered from surveys and tests. A summary of qualitative data gathered from teacher logs and interviews is also provided. Chapter 5 presents a discussion of the results of this study, implications of the results of this study, and areas in need of further research.

CHAPTER II

LITERATURE REVIEW

Performance is relative, and a country's educational system is often compared to those of other countries through student achievement results. These comparisons show that students in the United States have performed lower than in other high-achieving countries for many years and continue to be outperformed by other countries (Hushman & Marley, 2015). These comparisons have brought students' academic performance in the United States to the attention of many policymakers. Insufficient mathematics achievement levels of students in the United States led researchers, theorists, and educators to put forth significant effort in investigating factors affecting mathematics achievement (Yu & Singh, 2018). Examples of factors examined in recent years include new standards and new instructional strategies for implementation in a mathematics classroom.

Educational Reform

Educational reform efforts in the past decade have begun to address student mathematics understanding by promoting learning through various instructional strategies. Low mathematics performance of students in the United States, when compared to other countries (Howe, 2014), sparked the introduction of Common Core State Standards (CCSS) (Howe, 2014; Seashore, 2015) along with the Standards for Mathematical Practice (Howe, 2014) intended to target higher-order thinking related to mathematical concepts. The CCSS was developed for the purpose of creating a curriculum that all students, regardless of their state of residence, would learn (Howe, 2014) while also moving students away from rote memorization and towards understanding mathematics on a more conceptual level (GaDOE, 2016, 2020). With a constant increase in the number of students requiring remediation upon entering college-level courses, the CCSS was created to help students encounter content at higher levels of rigor to be better able to compete with other countries, be better prepared for college-level courses, and be better prepared to succeed in careers later in life (Howe, 2014). Although computational skills will always have a place in a mathematics course, the CCSS was intended to help teachers lead students to a mathematical understanding that balances the necessary computational skills with the problem-solving skills needed for applying math to novel situations and real-world situations in the 21st century.

The CCSS represents the baseline expectations students should meet for each course (Howe, 2014), but success in an increasingly competitive world in terms of college admission and career readiness, requires teachers to help students learn how to perform beyond the expectations set by CCSS. In addition to knowing the mathematical content, strong mathematics students also show their ability to think mathematically through reasoning, analysis, and articulation. The CCSS gives teachers the content skills students need to be successful but leaves much to be desired for teachers struggling to show students how to be mathematical thinkers. As a result, the Standards for Mathematical Practice were developed to supplement the CCSS by giving teachers and students a description of habits that embody mathematical thinkers (GaDOE, 2016), such as understanding underlying constructs rather than rote memorization of processes and the ability to think critically (Howe, 2014). The Standards for Mathematical Practice emphasize problem-solving, reasoning, effective communication, modeling, precision, strategic thinking, and analyzing mathematical problems which are important for acquiring a higher level of understanding of mathematical concepts. Students who are able to understand content at a higher level are more likely to succeed in college and careers after high school (Howe, 2014). However, teaching standards without successfully engaging students can undermine the intention of the CCSS and Standards for Mathematical Practice. Student engagement in class is crucial for students to achieve the high standards set for them in today's math classes (Howe, 2014; Wiliam, 2007).

In the mathematics classroom, many teachers often resort to instructional strategies focused on procedural understanding rather than conceptual understanding or higher-order thinking skills. These practices lead to a disconnect between mathematical concepts and weak thinking processes for students (Yuliana et al., 2017). Weak thinking processes result in misconceptions and eventually lead to difficulties with mathematics, avoidance of mathematical classes, and inability to understand mathematics applications to daily lives, various professions, and other content areas.

Black et al. (2004) stated that mathematical knowledge related to specific situations limits students' understanding of applications and situations rather than applying underlying concepts to multiple situations and contexts. A deeper understanding of mathematical concepts resulting in students' abilities to explain their processes and justify their reasoning results in students being better able to apply their knowledge to novel situations and transfer their knowledge to other content areas (Howe, 2014). Therefore, educators must find instructional and assessment strategies intended to target depth of understanding and retention via student engagement and active learning strategies (Howe, 2014; Schoenfeld, 2015; Seashore, 2015). Such strategies promote higher-order thinking in mathematics by focusing on conceptual understanding rather than procedural fluency and can positively impact student learning and achievement in the mathematics classroom (Yu & Singh, 2018). Swan (2015) recommended that teachers target higher-order thinking by changing instructional and assessment practices to address the understanding of underlying concepts, reasoning abilities, and problem-solving skills. Howe (2014) recommended students be meaningfully engaged in class by implementing instructional strategies focusing on the construction of meaning rather than memorization of meaning through learning experiences that require active processes such as exploration, inquiry, problem-solving, reflection, explanation, and revision. The introduction of CCSS, together with the Bill and Melinda Gates Foundation, provides teachers with the means to accomplish the depth of knowledge referenced by Swan (2015) and meaningful engagement of students referenced by Howe (2014).

The introduction of CCSS provided teachers with instructional standards but little direction on aligning their instruction to the newly developed standards with an emphasis on the Standards of Mathematical Practice. As a result, the Bill and Melinda Gates Foundation funded the Mathematics Design Collaborative (MDC) initiative to help teachers modify instructional strategies, summative assessment strategies, and formative assessment strategies to help students reach higher-order thinking and embody the aspects of the Standards of Mathematical Practice (Duffy & Park, 2012). Members of the MDC worked together to develop tools and supporting materials for teachers to effectively address the Standards of Mathematical Practice and the level of performance outlined by the CCSS (Bill and Melinda Gates Foundation, 2017).

Tools available on the MDC website include classroom activities centered around best practices for formative assessment and supporting documents to help teachers implement the activities in their own classroom. These supporting documents include course outlines to help teachers select appropriate activities and place the activities within the scope of their curriculum (Bill and Melinda Gates Foundation, 2017). This is an important aspect of the supporting documents because interviews conducted during the pilot phase of FAL implementation revealed that teachers believed they feel less pressured to decide between FAL implementation and covering content when FALs and curriculum pacing guides are aligned (Research for Action, 2011). Other supporting documents include introductory guides to explain the activities, and workshop guides to explain how to effectively implement the activities in their own classrooms (Bill and Melinda Gates Foundation, 2017).

Many of the activities available on the MDC website were created as part of the Mathematics Assessment Project (MAP). The MAP was a joint effort between the Bill and Melinda Gates Foundation, the University of California, Berkeley, and the Shell Center team at the University Nottingham to develop research-based summative tests, tasks, and formative classroom activities (MARS, 2015a). Similar to the MDC, the MAP was formed to help teachers effectively implement the CCSS in their classroom by providing teachers with materials and guidelines. The primary focus of effort put forth by the MDC and the MAP is using formative assessment for effective teaching. Members of the MDC and MAP believe that formative assessment should not be about quantifying a student's position among peers. Instead, the rationale behind the classroom materials provided for teachers is that regular formative assessment should be used to identify disconnects between what is being taught and what students are learning through collecting qualitative data to produce more effective teaching and improved student learning (Bill and Melinda Gates Foundation, 2017; MARS, 2015a). The activities created as a result of efforts by the MDC and MAP were built upon five key strategies of formative assessment outlined by Wiliam (Ann Shannon & Associates, LLC, 2015; Wiliam, 2007). These strategies focus on the importance of clear learning goals, eliciting evidence of student understanding, providing constructive feedback, active learning, and collaboration among peers (Wiliam, 2007).

Formative Assessment

Effective formative assessment strategies help produce a rich learning environment by producing information about student learning which is then used to modify instructional strategies and direct future instruction to meet the needs of individual learners (Black et al., 2004; Brookhart & Durkin, 2003). Teachers use formative assessments daily in the classroom and therefore have the potential to significantly impact student learning and achievement if used appropriately.

Researchers have found that formative assessment can affect student learning perceptions (Black et al., 2004; Edmond, 2010). Black et al. (2004) conducted a study researching formative assessment practices with students in Southern England in which they found that students began to understand learning as an active process of developing their own knowledge rather than passively accepting knowledge from their teacher. Activating students to take ownership of their own learning is one of the five key strategies outlined by Wiliam (2007) and encourages students to stop focusing on comparing themselves with their peers but rather to focus on their own personal growth.

Students who are active in the learning process are more likely to participate and become sources of additional knowledge for peers as students begin to understand that the teacher is the facilitator of knowledge rather than the dispenser of knowledge (Sapon-Shevin, 2013). The rate at which students learn significantly increases when students are able to actively monitor their own learning in a course (Wiliam, 2007). Understanding the learning process in this way could help students achieve higher-order levels of thinking and thereby increasing their ability to learn and apply knowledge in various contexts.

Helping students where they are with respect to their ability to master learning goals or objectives and targeting their beliefs in their ability to master learning objectives is one way formative assessment has the potential to affect the learning process (Brookhart & Durkin, 2003; Edmond, 2010). A second learning strategy outlined by Wiliam (2007) is identifying clear learning goals and criteria for success to share with students. One way to present clear criteria for success is by examining other students' work to help students identify what acceptable work looks like compared to work that shows common errors or misconceptions (Wiliam, 2007).

Presenting formative assessment opportunities as a learning task provides students with each of these opportunities. Black et al. (2004) suggested that such a learning task changes both teachers' and students' attitudes towards learning mathematics by providing students the opportunity to use prior knowledge and providing teachers the opportunity to gather useful information about individual student needs. Building an understanding of prior knowledge shows students that their previous knowledge is valued in the classroom, which is a component of teaching strategies shown to be successful in various grade levels and content areas (Sapon-Shevin, 2013). Implementation of tasks or activities intended to elicit evidence of student understanding is a third key strategy of formative assessment outlined by Wiliam (2007). Meaningful and appropriately challenging tasks can help students understand there are multiple approaches to problems, reach students of various learning styles, and establish a norm of mathematics inquiry (Suh et al., 2011). The use of such activities in the mathematics classroom can help students understand over- or under-simplification of mathematical ideas that students often make, allow students to share different approaches to problem-solving and analysis, and allow teachers to address student misconceptions in real-time in the classroom (Wiliam, 2007).

Black et al. (2004) also suggested that formative assessments provide students with opportunities to revise work based on teacher feedback, which has increased student engagement and deepened student understanding. Giving feedback to help progress student learning is the fourth strategy of formative assessment outlined by Wiliam (2007). It is important that feedback given to students should be descriptive and identify how to improve student learning rather than simply what was incorrect (Wiliam, 2007). Such feedback has been shown to help improve student motivation (Griffin, 2018; Ross & Bergin, 2011; Schunk & Richardson, 2011) and self-efficacy (Schunk & Pajares, 2009; Schunk & Richardson, 2011; Thompson, 2007). Feedback is even more effective when students engage with the work on a cognitive level through error analysis, reflections, and collaborative discussions with peers (Wiliam, 2007). Otherwise, feedback is ineffective and can either diminish student learning or have no impact on it.

Another suggestion of Black et al. (2004) was that formative assessments provide students enough time to process and collaborate on learning tasks during the initial attempt. Collaboration with peers helps students become resources of learning for their peers, which is the fifth key strategy of formative assessments outlined by Wiliam (2007). Collaborative environments allow students to articulate their problem-solving strategies and thought processes, supporting a deeper understanding of mathematical content. Additionally, Wiliam (2007) found that when students give to and receive feedback from each other, the feedback is more critical than that given by teachers. The process helps both the student giving the feedback and the student receiving the feedback (Wiliam, 2007).

Despite the evidence that effective formative assessment can positively influence student achievement, many teachers fail to implement effective formative assessment in their classrooms. According to Black et al. (2004), grading practices and interactions between students and teachers commonly found in today's schools promote performance competition rather than learning collaboration between peers. When feedback is given in the form of numerical grades, students often focus their attention primarily on the numerical score and may disregard any written comments intended to help students identify misconceptions or provide direction for improving their learning (Black et al., 2004; Wiliam, 2007). The numerical grade often leads students to focus on comparing their relative position in the class with other students, which is detrimental to student learning. Another study conducted by McMillan et al. (2010) of teachers' formative assessment practices in middle and high school classrooms revealed teachers rarely use formative assessment for purposes described in literature, such as identifying student weaknesses to improve instruction and providing descriptive feedback to help students progress with their learning.

Analysis of interviews with teachers by McMillan et al. (2010) revealed that formative assessments in courses with high-stakes tests are primarily used to guide remediation efforts rather than to identify students' strengths and weaknesses because teachers believe formative assessments cost valuable instructional time. Efforts to use instructional time efficiently lead teachers to use formative assessment strategies to measure procedural skills rather than conceptual understanding (Yu & Singh, 2018), allowing students to develop superficial mathematical understanding. Such superficial understandings hinder student achievement by preventing students from retaining essential knowledge, applying knowledge to novel situations, and using prior knowledge to construct new learning in future educational endeavors (Seashore, 2015).

Student achievement and motivation may be influenced by helping students better understand learning goals (Black et al., 2004; Wiliam, 2007) and place value on learning mathematics (Swan, 2015) through the use of different formative assessment practices. Implementing FALs in the mathematics classroom is one strategy that may help alter formative assessment practices to reflect key strategies of formative assessment and help teachers promote higher-order thinking.

Formative Assessment Lessons

Learning task characteristics described by Black et al. (2004) closely resembled the central ideas behind one major product of the MAP project known as FALs, which are built upon Wiliam's (2007) formative assessment strategies and intended to influence instructional strategies in the mathematics classroom. FALs, formerly known as classroom challenges, are instructional lessons anchored in the CCSS to emphasize mathematical practices (MARS, 2015a). FALs are intended to help translate the processes described by the CCSS and standards for mathematical practice directly into the classroom (MARS, 2015a). The intentional implementation of FALs during the learning process increases the depth of understanding, reinforces learning, extends learning opportunities, and prepares students for summative assessments (Duffy & Park, 2012; Herman et al., 2015; Research for Action, 2011). Implementing FALs requires teachers to shift their instructional approach away from knowledge presentation directly to students and towards facilitating student understanding while allowing students to struggle with content in a productive manner (Duffy & Park, 2012; Herman et al., 2015).

FALs allow students to complete a learning task through collaboration with peers. Collaboration among peers requires the teacher to group students, preferably in groups of two or three, to help facilitate conversation among students as they work through the FAL (Research for Action, 2011). The collaborative aspect of FALs provides opportunities for students to have vicarious experiences and opportunities for students to experience relatedness in the classroom, which are factors of self-efficacy and motivation, respectively. FALs also offer the benefit of open-ended tasks relevant to student learning with opportunities for regular constructive feedback from teachers and do not limit students in the methods they can use to solve the problem. These components are mentioned by Bobis et al. (2011) as factors contributing to student motivation concerning learning.

Implementing FALs requires significant preparation time on the teacher's part because teachers must learn to shift their thinking from the deliverer of knowledge to the facilitator of knowledge as students struggle with content in a productive manner (Duffy & Park, 2012; Herman et al., 2015). At the high school level, FALs are primarily created for lower-level classes such as Algebra and Geometry, which are courses that require a state test at the end of the year. Pressure to cover content in a timely manner has deterred teachers from implementing FALs because of the preparation involved before implementation (Research for Action, 2011).

There are two types of FALs, each intended to influence student learning in specific ways. The first type of FAL is known as a concept development activity designed to improve understanding by targeting misconceptions students have about the mathematical concepts they are learning and by connecting them to other areas of knowledge (MARS, 2015a). It is recommended that concept development lessons be implemented every few weeks, but these types of FALs can also be used as review or support activities for students as they prepare for summative assessments. The second type of FAL is a problem-solving activity that is intended to help students deepen their mathematical understanding by actively solving novel unstructured problems with real-world and pure mathematical connotations (MARS, 2015a). It is recommended that problem-solving lessons be implemented periodically throughout the year but not as often as concept development lessons.

Regardless of the type of FAL, lesson components typically include the problem to be considered or solved, sample student work, and discussion questions to be used in the classroom (MARS, 2015a), and each lesson has four activities: a pre-assessment, collaborative activity, whole-class discussion, and post-assessment (Research for Action, 2011). The lesson usually begins with students attempting a problem in which teachers then review and return to students for analysis (Seashore, 2015). Usually, teachers use formative assessment to identify misconceptions only to correct student errors before summative assessment opportunities. However, the implementation of FALs provides teachers with information about student strengths and weaknesses with content (Research for Action, 2011) that can be used to alter instruction as the unit progresses. Additionally, implementing FALs can change teachers' formative assessment strategy uses (Wilder, 2015) and expectations of what students can achieve in the mathematics classroom (Research for Action, 2011). FAL implementation has been shown to benefit student learning by activating prior knowledge, promoting active learning, and challenging students to interact with content while discussing thought processes and reasoning strategies with peers (Schoenfeld, 2015). However, these benefits can be thwarted if teachers do not follow the guidelines for FAL implementation and complete all parts of the FAL. In the pilot phase of FAL implementation, only approximately one-third of teachers who implemented FALs completed all four parts of the FAL in their classes due to pressure to stay on pace with their instructional calendar (Research for Action, 2011).

FAL implementation has been shown to be related to increased teacher perceptions of student abilities, engagement, and achievement in mathematics classes (Research for Action, 2011). Despite perceived FAL implementation benefits, many teachers using FALs in the pilot year did not implement FALs according to suggested guidelines due to stress from curriculum requirements, necessity to prepare for high-stakes testing, and time required to properly plan and implement FALS (Research for Action, 2011). Researchers conducted studies during or shortly after the pilot phase (Research for Action, 2011), giving teachers minimal time to become experts at implementing FALs and giving students little experience with learning through FALs. In fact, an analysis of student achievement related to FAL implementation in Algebra 1 classes (Herman et al., 2015) revealed lower student achievement levels than expected. Herman et al. (2015) attributed the low student achievement to the novelty of FALs for both students and teachers during the pilot year.

Researchers have found significant effects on student learning in other studies because of FAL implementation (Herman et al., 2015; Wilder, 2015). Additionally, FALs have many attributes related to practices that increase student motivation, such as teacher-centered and student-centered instruction, modeled and collaborative learning opportunities, and learning from mistakes (Bobis et al., 2011). However, the impact of FALs on student self-efficacy, motivation, and achievement has not been formally researched.

Self-Efficacy

Traditionally, secondary students have been shown to perceive mathematics as a difficult subject (Getachew & Birhane, 2016). Students who experience difficulty in mathematics may lose confidence in themselves and become unmotivated. Lack of confidence can be a contributing factor to a lack of interest and disengagement during class for students (Getachew & Birhane, 2016). This is a major problem in mathematics classes because students must be able to understand, reason, and problem-solve to be successful in mathematics. In order to build these skills, students must be willing to engage in learning processes (Borgonovi & Pokropek, 2019) and be motivated to learn. Engaging students in mathematics class requires teachers to carefully consider how to support students' beliefs in their abilities or self-efficacy.

Helping students learn mathematics requires teachers to consider psychological factors of student learning, such as self-efficacy, as derived from Bandura’s (1997) social learning theory (Nizham et al., 2017). Self-efficacy is a self-regulated learning component affected by several factors, including past personal experiences, known as *mastery experiences*, performance in relation to other peers, known as *vicarious experiences*, encouragements from peers or authority figures, known as *verbal (social) persuasions*, and emotional or physical factors, known as *physiological states* (Stevens et al., 2004; Zimmerman, 2000, 2014). Academic self-efficacy relates to general beliefs about student abilities to complete a task in school (Recber et al., 2018), but self-efficacy can also be subject-specific. Therefore, mathematics self-efficacy relates to students’ beliefs that they can be successful in mathematics or, more specifically, successfully complete individual mathematical tasks.

When presented with a new task, students use self-regulation to judge their abilities to succeed, so higher self-efficacy levels help students believe they can complete a task, leading to greater student achievement (Stevens et al., 2004). Self-efficacy is considered one of the most critical explanations for the difference in student achievement (Recber et al., 2018). Therefore, teachers must understand how to influence students’ self-efficacy in the mathematics classroom because self-efficacy affects students’ educational choices, effort, persistence, and overall views about mathematical content and classes.

Influencing self-efficacy in the classroom requires teachers to understand what they can do to help target the four sources of self-efficacy. Mastery experiences require students to have the opportunity to experience success (Bandura, 1997). Mastery experiences build over time and are often thought to be from previous mathematics courses. However, teachers can also build mastery experiences into their classrooms by allowing students to collaborate with peers or have individual learning experiences in which they experience success with mathematical tasks (Schunk & Pajares, 2009; Schunk & Richardson, 2011; Zimmerman, 2014). Vicarious experiences require students to experience success through other people, such as peers or authority figures (Bandura, 1997). Traditional instruction allows students to vicariously experience success by watching how a teacher successfully solves a problem. A more effective way for students to vicariously experience success is through collaboration with peers (Schunk & Pajares, 2009; Schunk & Richardson, 2011). Seeing that other students in the class can successfully complete a task may lead students to believe they can complete it too because they are on a more comparable level of skill and education than compared to the teacher.

Verbal/social persuasions require students to receive verbal or written encouragement in the form of direction or feedback (Bandura, 1977; Zimmerman, 2014). Research has shown that feedback and self-efficacy are positively related regardless of the type of feedback used (Thompson, 2007). People who are providing verbal persuasions to students should clearly indicate their belief in the students' ability to complete the task (Schunk & Pajares, 2009). However, the chosen task must be attainable, or else the lack of success could diminish the students' self-efficacy regardless of the verbal persuasions. Students may experience verbal persuasions from teachers in the form of written feedback or from peers through collaborative activities. Physiological states require addressing students' emotional states such as fatigue, stress, anxiety, etc.

(Bandura, 1997; Zimmerman, 2014). This source of self-efficacy is much harder to influence in the classroom because it depends on how the student is feeling or reacting to the given task. However, strategies for addressing other sources of self-efficacy such as collaborative opportunities and constructive feedback may also help reduce stress and anxiety for students when these feelings are directly related to mathematics.

Self-efficacy impacts students in various ways. Increased self-efficacy can impact student effort and persistence in mathematics classes, ultimately affecting what students can learn and the careers and classes they choose to pursue (Schunk & Richardson, 2011). Self-efficacy also influences student achievement. Perhaps the most important ways self-efficacy relates to student achievement include student learning strategy use (Stevens et al., 2004; Zimmerman, 2014), student problem-solving strategy use, and student engagement in the learning process (Stevens et al., 2004). Additionally, self-efficacy helps students be resilient to unfavorable outcomes (Fast et al., 2010; Recber et al., 2018).

Given that past performance contributes to self-efficacy (Lopez & Lent, 1992), improving student resilience to unfavorable outcomes by increasing self-efficacy could help struggling students experience greater levels of achievement in mathematics courses and pursue more challenging mathematics courses. Typically, students who struggle with mathematics tend to believe they cannot be successful regardless of the level of effort exerted. These students may even perceive mathematical tasks to be more challenging than intended because decreased self-efficacy can cause students to have narrow thinking when approaching mathematical problems (Zimmerman, 2014). Providing struggling students with opportunities to experience success during the learning process is one way to promote self-efficacy (Siegle & McCoach, 2007). However, addressing self-efficacy in this manner would not only target struggling students but instead could help improve learning for all students in the mathematics classroom. Conversely, implementing instructional strategies or tasks outside the students' ability levels could decrease their self-efficacy if they cannot experience success. When choosing instructional strategies to increase student self-efficacy, teachers should also consider how those strategies foster student interest and target appropriate skill levels (Recber et al., 2018).

Prior research efforts have found that increased self-efficacy levels are related to student achievement increases (Afolabi, 2010; Fast et al., 2010; Lopez & Lent, 1992; Pietsch et al., 2003) and motivation (Borgonovi & Pokropek, 2019). Stevens et al. (2014) found that self-efficacy predicts mathematical success even when student beliefs in their ability do not match students' actual ability to succeed. Low self-efficacy levels can lead to higher anxiety levels because students do not believe they can solve the problem at hand, leading to anxiety about the overall task and mathematical content (Recber et al., 2018). Zimmerman (2000) suggested that teachers direct their efforts at promoting higher self-efficacy levels rather than diminishing anxiety levels. Focusing instructional objectives on problem-solving strategies while allowing students to collaborate and discuss during the learning process could positively influence self-efficacy and reduce anxiety about mathematical content. Research has shown that mathematics self-efficacy predicts student achievement in the mathematics classroom better than other components such as anxiety levels (Recber et al., 2018; Siegle & McCoach, 2007), supporting Zimmerman's suggestion for focusing on student self-efficacy.

Previous studies have been conducted to determine how after-school programs (Cavazos, 2014), mathematical interventions (Kwan, 2016), type of instruction (Lowery, 2018), career academies (Perry, 2017), grouping strategies (Waits, 2016), use of technology such as clickers (Batchelor, 2016), various ways to administer tests (Aherne, 2019), and the presence of a consistent curriculum (Davis & Jones-Martorell, 2018) affect self-efficacy. However, several researchers recognized the need to investigate how to increase students' self-efficacy (Kalaycioglu, 2015) with a focus on specific instructional strategies (Brookhart & Durkin, 2003; Edmond, 2010; McMillan et al., 2010; Stevens et al., 2004). Specifically, researchers stated instructional strategies should include those that offer experience opportunities shown to affect self-efficacy, such as mastery experiences (McMillan et al., 2010) and collaborative activities, which are two FAL components.

Motivation

Another psychological factor that must be considered when helping students learn mathematics is student motivation. Students in mathematics classes often become passive in the learning process as a result of increasingly competitive environments, memorization of processes instead of creative thinking (Bensacon et al., 2015), close supervision of teachers on the problem-solving process, and the emphasis on rewards and punishments for student performance (Niemiec & Ryan, 2009). Research has shown that these practices actually decrease student motivation and can even foster anxiety about learning in students (Durmaz & Akkus, 2016; Niemiec & Ryan, 2009). Additionally, research has shown that a learning environment with a focus on fostering motivation can help students become more resilient to academic failure (Buff, 2019), which can help at-risk learners experience greater levels of achievement if teachers are able to use instructional strategies to motivate them to learn (Naughton, 2016). However, increasing student motivation can help all students, not just those who typically struggle with mathematics. Research has shown that when comparing students with similar ability levels, those with greater levels of motivational constructs obtain greater levels of achievement in the same course (Steinmayr et al., 2019). Therefore, teachers must focus on ways to help foster motivation during the learning process other than simply using rewards and punishments.

Ryan and Deci's (2000) self-determination theory (SDT) provides avenues for motivating students to learn by meeting the three basic needs of autonomy, competence, and relatedness. Previous research has shown that meeting these three basic needs is associated with a decrease in anxiety (Durmaz & Akkus, 2016) and an increase in creative thinking (Niemiec & Ryan, 2009), and persistence (Leon et al., 2015), particularly with concepts that require increased levels of conceptual understanding. With an increased focus on standardized tests, emphasis on participating in advanced placement classes, and increased competition for college admission, it is even more important than ever for students to understand mathematics on a conceptual level rather than procedural knowledge. This indicates that finding instructional strategies that foster motivation by meeting the basic needs outlined in SDT is essential for educators.

There are two types of motivation, namely extrinsic and intrinsic. Extrinsic motivation toward a task occurs when rewards and punishments are present, whereas intrinsic motivation occurs when students are interested in the task at hand (Kolencik, 2014). Previous research has shown that extrinsic motivators such as punishments, hard deadlines, competitions between peers, and assessment solely for evaluation (Ryan & Deci, 2009) can be abused in today's classrooms, resulting in controlling environments and ultimately negatively impacting student motivation (Kaplan, 2018; Kolencik, 2014).

Some researchers identify motivation as either an intrinsic or extrinsic process and treat these motivational constructs separately (Kolencik, 2014). However, SDT outlines motivation as a continuum through which students can move from being extrinsically motivated to becoming intrinsically motivated by becoming autonomous learners when the needs of autonomy, competence, and relatedness are met (Ryan & Deci, 2000). The least autonomous form of extrinsic motivation, considered the most controlling, is external regulation (Ryan & Deci, 2009). Students who are motivated by external regulations are motivated to avoid punishments or receive some sort of reward, and therefore, their motivation is controlled by outside factors. The next form of extrinsic motivation is introjected regulation (Ryan & Deci, 2009). Students motivated by introjected regulation are controlled by anxiety or shame and therefore are motivated by others' perceptions of them or pressure placed on themselves. Students who internalize the values of the task at hand are said to be motivated by identified regulations (Ryan & Deci, 2009). At this point, students are becoming autonomous learners because the motivation is starting to come from within the student rather than being influenced by outside factors. When students internalize the value of the task and believe they have the choice to participate and engage, students have reached integrated regulation (Ryan & Deci, 2009). The more students internalize the motivation, believe they have choices in what they do, and feel connected, the more autonomous students are, and the more intrinsically motivated they become. After students have become intrinsically motivated, continuing to meet these needs for students will theoretically increase intrinsic motivation to higher levels. Conversely, if the needs outlined by SDT are undermined, students will move away from intrinsic motivation and will move toward controlled motivation, and may even become unmotivated (Ross & Bergin, 2011). Results from a study conducted by Kaplan (2018) confirmed that students who experienced environments that support autonomy enjoyed learning more than students who experienced environments with more controlling motivational efforts.

Meeting the needs of students as outlined by SDT requires teachers to first understand what the needs of SDT represent. Autonomy relates to students' need to feel that they have control over the tasks they participate in by choice (Ross & Bergin, 2011). Student autonomy is negatively affected when teachers implement instructional strategies that deny students control during problem-solving (Durmaz & Akkus, 2016; Jones, Uribe-Florez, & Wilkins, 2011). Instead, teachers can increase student autonomy by reducing the emphasis on learning for assessment (Durmaz & Akkus, 2016), help students understand the purpose behind learning tasks, help students understand they have a voice in the learning process, (Niemiec & Ryan, 2009) and provide students with the opportunity or illusion of choice in the learning process (Leon et al., 2015; Ross & Bergin, 2011; Ryan & Deci, 2000). Sometimes, providing student choice in the learning process is not feasible because teachers must ensure students learn specific standards and methods. However, students can be provided with the choice of how to approach a problem or what methods to use. Other ways to promote student autonomy in the classroom include implementing student-centered activities, allowing students to be active and engaged in the learning process, and allowing students the opportunity to use content knowledge to communicate reasoning strategies and problem-solving processes (Ross & Bergin, 2011; Ryan & Deci, 2009).

Competence relates to a student's ability or skill to be successful at a given task (Ryan & Deci, 2000). Much like autonomy, a student's need for competence can be met by creating an environment in which students actively participate in the learning process by presenting their ideas and arguing their thought processes (Durmaz & Akkus, 2016), but should also include having opportunities to expand upon previously learned skills (Niemiec & Ryan, 2009) and participate in challenging tasks that demand higher levels of thinking, offer choices of problem-solving approaches, and vary in difficulty levels to reach students of all ability levels (Bobis et al., 2011; Niemiec & Ryan, 2009; Ross & Bergin, 2011). However, it is essential that teachers consider students' ability levels when choosing what tasks to implement in the classroom. Tasks that are too challenging may decrease motivation because students will not believe they are competent enough to be successful. Tasks that are too easy may not give students satisfaction when mastered (Ross & Bergin, 2011). Specific and descriptive feedback can also help foster competence by allowing students to reflect on their own processes and analyze their work for errors (Griffin, 2018). Specific feedback given in this way can help call students' attention to their mistakes in a productive manner, and further the learning process by providing students with information to help them become more successful (Niemiec & Ryan, 2009). Presenting feedback in this manner helps students understand that making mistakes is an essential part of the learning process.

A trusting and safe learning environment is created when students are encouraged to try new processes without fear of making mistakes. This type of learning environment is crucial for meeting students' needs of relatedness for motivation. Ross and Bergin (2011) indicated that relatedness does not have to occur in the exact moment that learning is happening but instead is something that should be established beginning at the start of the school year. It is essential to create a safe environment where students understand that making mistakes is acceptable and is a crucial part of the learning process. Collaborative environments in which students are encouraged to talk through their ideas together remove the competitive aspect and build trust among peers, which is an important component of relatedness in the educational setting (Durmaz & Akkus, 2016). Teachers can help create a classroom environment that promotes relatedness by establishing guidelines for effective and respectful communication among peers (Ross & Bergin, 2011; Suh et al., 2011). Students often are afraid to answer in mathematics classes because they are either afraid of being wrong or are afraid to have their answers questioned. Helping students to understand that questioning their answer by asking them to articulate their understanding does not imply the answer is necessarily incorrect. Instead, it can encourage students to be more willing to share their thoughts and thereby create an even better classroom environment for fostering relatedness between students and the teacher (Ross & Bergin, 2011).

When any one of these needs is not met, student motivation to learn diminishes. However, implementing one single action to meet the motivational needs of students is not realistic (Ross & Bergin, 2011). Just like in the learning process, meeting students' motivational needs will depend on the students in the classroom and will vary from year to year or even class to class. Therefore, instructional strategies that offer multiple components for addressing motivational needs are ideal. Although SDT identifies needs of autonomy, competence, and relatedness as the need that must be met for motivation to flourish, other research has indicated that some needs may be more important than others. In a study conducted by Durmaz and Akkus (2016), results indicated that autonomy was not as important as competence and relatedness when predicting student achievement, possibly because current instructional methods lack opportunities for autonomy development. In a different study, Buff (2019) found that autonomy and competence were better predictors of student achievement than relatedness.

Motivation and self-efficacy are often discussed together because motivation is a process affected by self-efficacy (Bandura, 1977). Similarly, self-efficacy motivates students related to student competence (Jones et al., 2011). Although often discussed together, motivation and self-efficacy are still separate constructs and should be treated as such.

Summary

Previous studies provided data indicating that when researched separately, formative assessment, self-efficacy, and motivation positively influence student achievement in the mathematics classroom (Black et al., 2004; Brookhart & Durkin, 2003; Edmond, 2010; Recber et al., 2018; Siegle & McCoach, 2007). These results led researchers to suggest future research efforts focus on the effect of specific instructional strategies on student motivational constructs (Brookhart & Durkin, 2003; Edmond, 2010; McMillan et al., 2010; Stevens et al., 2004). However, few research studies investigated the effects of formative instructional strategies on students' self-efficacy and motivation in the mathematics classroom. FALs embody several characteristics identified by researchers as components influencing students' self-efficacy, but the influence of FALs on self-efficacy and motivation has not been researched. FALs are currently implemented in the mathematics classroom. Therefore, research investigating the relationship between FALs, student mathematics self-efficacy, and motivation could further support the implementation of FALs in the mathematics classroom and alter teacher perceptions of implementing these lessons.

CHAPTER III

METHODOLOGY

Information presented in this chapter addresses the research questions to be investigated, the research design implemented, and a description of the population and sample to be included in this study. Additionally, the information presented in this chapter includes a description of data collection methods, instruments for data collection, validity and reliability of instruments, as well as methods for analyzing data collected in this study. Data were collected through student pre-survey and post-survey, student pretest and posttest, teacher logs, and teacher interviews.

Research Questions

1. To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy?

2. To what degree, if any, does FAL implementation affect high school students' motivation?

3. To what degree, if any, does FAL implementation affect student achievement for high school mathematics students?

4. Is there any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation?

5. What are the teachers' perceptions of the overall impact of FAL implementation?

Research Design

The design for this study was an embedded mixed methods design with an emphasis on quantitative data. Creswell and Plano Clark (2007) stated that the embedded design is desirable when "one data set provides a supportive, secondary role in a study based primarily on the other data type" (p.67). There are many variants of the embedded mixed methods design. This study followed the embedded experimental model. The primary characteristic of the embedded experimental model is that qualitative data are embedded within the quantitative design, and the priority of the design is placed on an experimental design (Creswell & Plano Clark, 2007).

The quantitative portion was a combination of quasi-experimental design, including both non-equivalent groups design and pretest-posttest design for self-efficacy, motivation, and achievement. The quasi-experimental design was chosen because class assignments are determined by students' respective high schools, resulting in predetermined classes. Therefore, the random assignment of students was not feasible. The comparison of self-efficacy, motivation, and achievement between students enrolled in classes with FAL implementation and students enrolled in classes without FAL implementation warrants a non-equivalent groups design. The pretest-posttest design was chosen to establish a baseline of student self-efficacy, motivation, and achievement at the beginning of the semester, prior to any FAL implementation for the treatment group. Student self-efficacy, motivation, and achievement measured at the end of the semester, after FAL implementation for the treatment group, were then compared to the baseline for each student.

Survey data were collected from students enrolled in Algebra 1 mathematics classes by administering a single survey that combines two scales to measure student self-efficacy and motivation. This survey was administered to classes in which teachers are implementing FALs, serving as the treatment group, and to classes in which teachers are not implementing FALs, serving as the control group. The survey included student demographic questions, Sources of Middle School Mathematics Self-Efficacy Scale (SMMSE) and Activity Feeling States Scale (AFS), which measured the change in self-efficacy and motivation by first establishing a baseline of self-efficacy and motivation for students in the treatment and control groups (see Appendices A, B, and C). Demographic questions were used to identify age, gender, ethnicity, and whether or not the student is enrolled in more than one mathematics class for the current school year (see Appendix A). The Sources of Middle School Self-Efficacy (SMSSE) Scale was created by Usher and Pajares (2009) to measure self-efficacy (see Appendix B). Permission to use the SMMSE scale was granted by Dr. Usher (see Appendix D). The Activity Feels-States (AFS) Scale was created by Reeve and Sickenius (1994) to measure motivation (see Appendix C). The AFS scale was free to use for research purposes. Survey data were collected at the beginning of the semester, prior to any instruction for both the treatment and control groups, and again at the end of the semester but prior to the administration of the posttest and final exam for the semester.

Student achievement was measured using a researcher-created multiple-choice test addressing skills taught in the spring semester of an Algebra 1 course (see Appendix E). This test was administered in class by the teacher at the beginning of the semester, prior to any instruction for both the treatment and control groups, and again at the end of the semester, after classroom instruction has concluded, after the final collection of survey data, but before the final exam for both the treatment and control groups. The same questions were used for both administrations of the test, but the order in which questions were presented changed for each test administration to avoid memorization (see Appendix F). Average test scores for each student were used to represent student achievement.

Qualitative data were collected to supplement findings from quantitative data collected during this study by analyzing the perceptions of teachers who implemented FALs in their classrooms during the study. The first source of qualitative data was collected concurrently with the quantitative data through teacher logs. Teachers who are implementing FALs in their classrooms were asked to complete monthly logs throughout the duration of the semester. The second source of qualitative data was collected after the collection of quantitative data. At the conclusion of the semester, structured interviews were conducted with each teacher who implemented FALs in their classroom. Questions for both teacher logs and interviews were predetermined and focused on teacher experiences implementing FALs and their perceptions of student experiences, achievement, self-efficacy, and motivation throughout the semester (see Appendices G and H).

Population and Sample

Population

The population primarily impacted by studying the effects of FAL implementation on student self-efficacy and motivation in the high school classroom is high school students in Georgia. In Georgia, there were approximately 449,819 students enrolled in traditional public high schools (GaDOE, 2019b) during the 2018-2019 school year, with grade-level populations of 28% ninth-graders, 26% tenth graders, 23% eleventh graders, and 23% twelfth graders (GaDOE, 2019a). Approximately 49% of students were female, and 51% of students were male (Statistical Atlas, 2018). Various ethnicities were represented in Georgia public high schools, with approximately 16% Hispanic students, 4% Asian, 37% Black, and 43% White (GaDOE, 2019b). Approximately 60.9% of elementary through high school students participated in free or reduced lunch in Georgia, with an average participation rate per school of more than 53% (GaDOE, 2019c).

The accessible population for this study is students enrolled in traditional public high schools in a county in which teachers are currently implementing FALs. One such county in Georgia is County A. Aside from being one of the largest counties in Georgia, County A also houses a diverse population in terms of geographic location, socio-economic status, and ethnicity. County A has 38 schools, of which 7 are high schools (FCS, 2020). County A has other programs that also serve high school students but are conducted as specialized academies or distance learning opportunities. Students enrolled in these programs were not included as part of the accessible population for this study. There were approximately 15,714 high school students enrolled in traditional high schools in County A in the 2019-2020 school year with approximately 26% of the population enrolled in ninth grade (n = 4,086), 26% in tenth grade (n = 4,086), 25% in eleventh grade (n = 3,928), and 23% in twelfth grade (n = 3,614) (GaDOE, 2019a).

The population of County A high school students for the 2019-2020 school year was composed of approximately 50% female and 50% male students (GaDOE, 2019b).

The traditional high school student population was composed of approximately 13% Hispanic, 18% Asian, 4% Black, 62% White, and 3% Multiracial students (GaDOE, 2019b). The average percentage of students participating in free and reduced lunch among the 19 traditional high schools in County A was approximately 13% (GaDOE, 2019c).

Sample

To ensure that student achievement was measured using the same test for each classroom, one school from County A was purposefully selected for participation in this study. The school was chosen based on how comparable the school was to the population of high school students in the state of Georgia. One such school, School A, exists in County A such that the diversity of demographics and level of student mathematics performance is similar to the diversity of demographics and level of student mathematics performance on average for all high school students in the state of Georgia.

School A has a total population of 2,585 students with a student-teacher ratio of 17:1 and a mathematics proficiency level of 55% compared to the state average student-teacher ratio of 16:1 and mathematics proficiency level of 41% in Georgia (Public School Review, 2020). Although the difference in mathematics proficiency levels between school A and the state of Georgia is large, School A was selected because FALs are not currently being implemented in the classrooms. School A has a diverse population of students similar to Georgia, with approximately 5% Asian, 26% Hispanic, 4% Black, 62% White, and 3% Multiracial student populations (GaDOE, 2019b) compared to Georgia's 4% Asian, 15% Hispanic, 37% Black, 40% White, and 4% Multiracial student population (Public School Review, 2020).

Once the school in County A was identified, a second sampling strategy was used for the collection of quantitative data. To help reduce the presence of extraneous variables, teachers working with students enrolled in the same level course and on the same course team were selected based on voluntary participation. The chosen grade level and course for this study were students enrolled in on-level Algebra 1. Accelerated Algebra 1 students were not included in the study because the pacing of the course and the level of information presented in an accelerated course differs from on-level Algebra 1 courses.

The acceptable sample of this study was approximately 672 students enrolled in a public high school in the Southeastern United States during the spring semester of 2021. At the time of this study, special enrollment options were in place for students due to COVID-19, allowing students the choice of attending class in person or attending class online. Students participating in online classes received instruction from different methods via teachers scattered throughout the county compared to students in a face-to-face classroom. Therefore, students attending school via a virtual classroom were excluded from this study. At the beginning of the semester, 46 students completed the pre-survey, and 52 students completed the pretest. At the end of the semester, 22 students completed the post-survey, and 46 students completed the posttest. After pairing student survey attempts for analysis, the resulting sample included a total of 20 students, with 4 students in the control group and 16 students in the treatment group. After pairing student test attempts for analysis, the resulting sample included a total of 44 students with 12 students in the control group and 32 students in the treatment group.

It is important that the supporting qualitative data be collected from teachers actively involved with the implementation of FALs. Therefore, teachers completed monthly logs and attended the post-intervention interview. The decision to collect qualitative data from the teachers rather than the students was made to provide a different aspect of the FAL's impact on student achievement, motivation, and self-efficacy and help interpret the quantitative data.

Description of Intervention

FALs are lessons created to align with specific mathematical concepts and, therefore, should either be used during the unit of instruction in which those concepts are currently being taught or prior to a summative assessment for review purposes. For example, one FAL titled *Classifying Rational and Irrational Numbers* (MARS, 2015a) must be implemented in the instructional unit in which students learn about rational and irrational numbers. Therefore, to ensure FALs align directly with what students are currently learning, the FALs were purposefully selected to address content covered in the Spring semester for Algebra 1 courses at School A. Teachers of mathematics classes with FALs were asked to use two FALs over the course of the semester in their classrooms. It is recommended that FALs be used 2 to 3 times per semester for student learning. Only two FALs were chosen for this study to allow teachers appropriate time to prepare for implementation and review the FAL guidelines, given the likelihood that teachers participating in this study have not implemented a FAL before. Teachers implementing the FALs were given a copy of the guidelines for FAL implementation provided by the MDC (MARS, 2015a) to review at least one month before implementing the first FAL in their classrooms. The teacher guidelines provided by the MDC are described in Appendix I.

Students enrolled in classes serving as the treatment group began each FAL by completing the pre-assessment task provided in the FAL guidelines (MARS, 2015a). This pre-assessment was not the pretest used for measuring student achievement but instead was an important part of the FAL intended to help guide teachers as they prepared for the whole-class discussion at the beginning of the FAL task and prepared to help students during the FAL task. An example of a pre-assessment task taken from the FAL for Representing Quadratic Functions Graphically can be found in Appendix J. The pre-assessment task typically takes between 10 and 20 minutes to administer depending on the selected FAL and should be administered prior to the day the FAL task is implemented. The pre-assessment was administered before the implementation of the FAL to allow teachers to take the pre-assessment tasks and provide written feedback on each student's assessment. The FAL guidelines offered a table of common misconceptions and suggested questions for teachers to use when providing feedback on students' pre-assessment tasks (MARS, 2015a). However, feedback on pre-assessment tasks should only include comments and questions but no numerical grade. Omitting a numerical grade helped students focus on the feedback and directed responses instead of whether they failed the assessment.

The teacher began the FAL implementation during the next class period by leading a whole-class introduction to the collaborative group activity. The whole-class discussion was started by the teacher posing a question for students to answer related to the pre-assessment task. These questions were intended to direct student attention towards the primary goal of the activity and helped provoke student discussions during the collaborative portion of the task (MARS, 2015a).

After the whole-class discussion, students were separated into groups as determined by the teacher to complete the collaborative activity portion of the FAL. Students used their understanding from previous instruction during the unit, the pre-assessment, and the whole-class discussion to work together to complete the collaborative activity. One such FAL, Representing Quadratic Function Graphically, required students to match equations of quadratic functions and graphs of quadratic functions presented as domino cards. A copy of the directions for matching dominos and a portion of the dominos used in this task are presented in Appendix K. During this time, the teacher circulated the room, listening to student discussions, prompting students with questions to help students progress, and monitoring student discussions to identify strengths or misconceptions present during the activity. At the conclusion of the collaborative activity, the teacher led another whole-class discussion to wrap up the activity. At this time, the class discussed various approaches to the task and strategies used during the task (MARS, 2015a). This portion of the FAL should help students focus on the methods used to solve the problems rather than the actual solutions to the problem (MARS, 2015a). The FAL task, including the whole-class introduction, collaborative activity, and whole-class discussion after the collaborative activity should take approximately 60 to 110 minutes to complete, depending on the chosen FALs, if done in a single class period. Exact times may vary depending on the needs of the students. If a single class period of 90 minutes is not possible, the FAL task may be split into two or more shorter class periods.

After the whole-class discussion, students participated in an individual post-assessment at the end of the collaborative activity. Similar to the pre-assessment, the post-assessment task was not used to measure student achievement but instead was used to help the teacher and students gauge what they have learned from participating in the FAL task. Depending on the FAL chosen, the post-assessment can be a reflection on the methods used in the task and later discussed with the whole class or a reflection of their work on the pre-assessment (MARS, 2015a). If time permits, the post-assessment can be given on the same day as the collaborative task, or the following day. From the pre-assessment to the completion of the post-assessment, the FAL should take approximately 2-3 class periods to complete (MARS, 2015a).

Student self-efficacy and motivation were measured once at the beginning of the semester, before any FALs were implemented, to set a baseline of motivation and self-efficacy. Student self-efficacy and motivation were then measured again at the end of the semester, after FALs were implemented, but before the posttest was administered approximately 19 weeks later. Details of how self-efficacy and motivation were measured are listed in the instrumentation section below.

Instrumentation

Quantitative

Two instruments were used to collect quantitative data for this study. Students were asked to provide their student number, but not name, so the data from each administration of each instrument could be paired for analysis. Students reported demographic information through the survey for further analysis. Demographic questions to be included at the beginning of the survey can be found in Appendix A.

Additional analyses may be run to understand the impact of the demographic variables affecting the results of FALs implementation. The first instrument was a survey composed of one scale to measure student mathematics self-efficacy and one scale to measure student motivation. Student mathematics self-efficacy was measured using the SMSSE Scale (Usher & Pajares, 2009) (see Appendix B). This scale was chosen because the questions on the scale address each source of self-efficacy as identified in Bandura's (1977) self-efficacy theory, namely mastery experiences, vicarious experiences, social persuasion, and physiological state. The scale consists of 24 total questions on which students will rate the level of truth behind each statement using a Likert scale (1 = *definitely false* to 6 = *definitely true*). Six of the scale questions are intended to measure mastery experiences (Q2, 14, 15, 16, 19, 23), six scale questions are intended to measure vicarious experiences (VA: Q1, 8; VP: 12, 24; VS: 4, 17), six scale questions are intended to measure social persuasion (Q6, 10, 11, 18, 20, 21), and six scale questions are intended to measure physiological state (Q3, 5, 7, 9, 13, 22) with regards to mathematics class. A copy of the self-efficacy scale is provided in Appendix B. Permission to use this self-efficacy scale was granted by Dr. Usher (see Appendix D). This scale was converted to an online format to help make the survey administration easier and less disruptive for students.

Student motivation was measured using the Activity Feels-States Scale (AFS) created by Reeve and Sickenius (1994). This scale was chosen because the questions on the scale address each basic need as defined in Ryan and Deci's (2000) self-determination theory, namely autonomy, relatedness, and competence. The scale consists of 12 total questions to which students rate their agreement with each statement via a

Likert scale survey (1 = *strongly disagree* to 7 = *strongly agree*). Three of the scale questions are intended to measure student autonomy (Q4, 8, 12), three scale questions are intended to measure student competence (Q1, 7, 11), and three scale questions are intended to measure student relatedness while completing a task (Q2, 5, 10). For this study, the mathematical task described in the instructions is identified as solving math problems in Algebra 1 class. The other three questions on the scale are considered to be filler questions and are not included when scoring (Q3, 6, 9). A copy of the AFS scale is given in Appendix C. This AFS scale is free to use for research purposes. This scale was converted to an online format to help make the survey administration easier and less disruptive for students.

Student achievement was measured using a researcher-created test (see Appendix E). Test questions were obtained from Savvas enVision A|G|A Common Core resources (SAVVAS Learning Company, 2020), Georgia End of Course resources for test preparation (GaDOE, 2004; Winking, 2013), and Georgia Milestone resources for test preparation (Georgia Cyber Academy, 2015; GaDOE, 2019d). The test was administered as a pretest at the beginning of the Spring semester, prior to any formal instruction, and again as a posttest at the end of the Spring semester, prior to the administration of the final exam for Algebra 1. The final exam for Algebra 1 was not used as the posttest for this study because students might be exempt from the final exam if their course average was a 90 or above after instruction had concluded for the semester. The same questions were used for each test administration, but the order in which questions appeared differed for the pretest and posttest administrations (see Appendix F). Questions chosen for the test were multiple-choice questions created to measure students' abilities to apply skills taught in the Spring semester of an Algebra 1 course. Each question has one correct answer accompanied by three distractors for a total of four answer choices per question. The pretest has an additional answer choice of "I do not know" to deter students from guessing on the pretest and therefore misrepresenting their achievement for the baseline measure. Both tests were administered in an online format in the traditional classroom setting to help make the test administration easier and less disruptive for students.

Qualitative

Two instruments were used to collect qualitative data for this study. The first instrument was monthly logs to be completed by teachers who implement FALs in their classroom during the study. Logs were presented with structured questions for teachers to answer via an online format. The online format was chosen to make the completion of the logs easier and less time-consuming for teachers. Questions included in the first log were intended to understand teacher preparation for FALs, anticipation of FAL implementation, and thoughts on how FAL implementation may affect teacher perceptions of students and students themselves. Questions included in logs 2 - 4 were intended to understand instructional strategies used each month and teachers' perceptions of the impact of chosen instructional strategies on students. If a FAL was implemented during any of these months, teachers were asked to answer additional questions regarding FAL implementation and its impact on students. Questions included in the fifth log were intended to understand teachers' reflections on FAL implementation throughout the semester and the potential impact of FALs on students' achievement, self-efficacy, and motivation as assessed by the teacher.

The second instrument is a post-intervention interview conducted with each teacher who implemented FALs during the study. The interview was structured with predetermined questions regarding the teacher's experience preparing for FALs, the teacher's experience implementing FALs, thoughts on future FAL implementation, and the impact FALs had on students with regards to overall response, achievement, self-efficacy, and motivation. Interviews were conducted face-to-face at the teacher's school at a time suitable for each teacher during post-planning. The interview with Teacher 1 was conducted in her classroom and lasted approximately 21 minutes. The interview with Teacher 2 was conducted in a classroom at the school and lasted approximately 24 minutes.

Validity and Reliability

Quantitative

The pretest-posttest administration of the survey composed of the self-efficacy and AFS scales reduced the threat to internal validity for both surveys. The Sources of Middle School Mathematics Self-efficacy (SMMSE) Scale was constructed and analyzed by Usher and Pajares (2009) to produce a scale that measured each of the four sources as outlined by Bandura's (1977) self-efficacy theory: mastery experiences, vicarious experiences, social persuasion, and physiological state. The original SMMSE scale consisted of 84 items and was analyzed through a series of three phases by administering the survey to three different samples of middle school students. Methods of analysis throughout the three phases include item review by stakeholders in education, exploratory factor analysis, item review by respected self-efficacy scholars, and confirmatory factor analysis (Usher & Pajares, 2009), resulting in a 24-item scale. Analysis of the scale revealed four factors, namely mastery experiences, vicarious experiences, social persuasion, and physiological state, with Cronbach alpha measurements of .88, .84, .88, and .87, respectively (Usher & Pajares, 2009). Construct validity of the scale was evaluated by finding the correlation coefficients between individual items and the four measures of self-efficacy as well as between the four subscales of the SMMSE scale representing each construct of self-efficacy and the four measures of self-efficacy (Usher & Pajares, 2009). Usher and Pajares (2009) found that each item and each subscale correlated well with the four sources of self-efficacy. Since the creation of the SMMSE scale, many researchers have used this scale to measure self-efficacy in various populations, including elementary school students (Cavazos, 2014; Thomas, 2013), middle school students (Cavazos, 2014; Freed, 2013; Thomas, 2013; Usher et al., 2019), high school students (Freed, 2013; Usher et al., 2019), and college students (Locklear, 2012).

The AFS was created by Reeve and Sickenius (1994) to help provide a survey that produces a quantifiable measure of motivation as represented by the constructs of Self Determination Theory: self-determination (autonomy), relatedness, and competence. The original survey was tested across five samples of undergraduate students and revealed an average Cronbach's alpha of .61, .75, and .90 for the subscales of self-determination, relatedness, and competence, respectively (Reeve & Sickenius, 1994). Although the Cronbach alpha measurement for self-determination was not high, Reeve and Sickenius (1994) suggested that the low measure could be attributed to the multidimensionality of self-determination. External validity of the AFS was evaluated by finding the correlation coefficients between each construct of the AFS and related constructs. Reeve and

Sickenius (1994) found that each subscale correlated well with associated constructs. Since the creation of the AFS, many researchers have used this scale to measure motivation in various populations, including elementary school students (Mischo, 2015), middle school students (Jang et al., 2012), and high school students (Kaplan, 2018; Reeve & Tseng, 2011), and college students (Jang et al., 2016; Lee, 2017; Reeve et al., 2003).

The 37-question test was designed using questions obtained from the SAVVAS enVision A|G|A Common Core resources (SAVVAS Learning Company, 2020), Georgia End of Course Test resources (GaDOE, 2004; Winking, 2013), and Georgia Milestone Test resources (Georgia Cyber Academy, 2015; GaDOE, 2019d). The SAVVAS enVision resources are included in a program purchased by some counties for mathematics teachers to use for instructional purposes (SAVVAS Learning Company, 2020). The Georgia End of Course resources include a diagnostics test provided by an experienced math teacher (Winking, 2013), who has been teaching mathematics for 27 years, and a previous version of the Georgia End of Course test released by the GaDOE (2004). The Georgia Milestone resources include end-of-course test prep materials (Georgia Cyber Academy, 2015) and a study guide produced by the GaDOE (2019d). The test was analyzed to align questions to state standards and identify each question's DOK level (see Appendix E). The same questions were used for both the pretest and posttest. To prevent the memorization of question items and answers, the order in which questions were presented was different for each test administration (see Appendix F).

The primary threats to the study are lack of participation from the sample and representativeness of the sample. To minimize the threat of representativeness, I chose a sample that contained diverse populations represented, such as gender, socio-economic levels, and ethnicities. Choosing a large school in the state of Georgia allowed for a diverse population. A large school also allowed for a large enough accessible population to minimize the threat of a small sample size even if some participants choose not to participate. I also worked with teachers to make it clear to students that survey results would not affect their grade in any way to prevent students from guessing on surveys in an attempt to receive a higher score and to elicit genuine responses from students.

Qualitative

Unequal sample sizes between quantitative and qualitative data produce a threat to the validity of results (Creswell, 2014). The triangulation of data between teacher logs, teacher interviews, and quantitative data helped reduce the threat of validity posed by unequal sample sizes. Additionally, logs and interviews were presented in a structured format with predetermined questions. Formatting the qualitative instruments in this way helped ensure teachers who provided qualitative data were answering the same questions about the same constructs. Developing predetermined questions also helped prevent bias that I could introduce in the way a question was phrased.

Efforts to ensure the reliability of results from qualitative data include careful transcription and cross-checking of codes used to analyze research. All interviews were transcribed using the digital transcription service Otterai. After interviews were transcribed, interviews were listened to alongside reading the transcript. Any errors in the transcript as a result of digital transcription were manually corrected. A codebook was created before analyzing the qualitative data based on constructs related to the research questions, including FALs, self-efficacy, motivation, and student achievement. The codebook was cross-checked by an outside researcher who served as an impartial coder. The impartial coder is a former graduate student who successfully completed a mixed methods research study through the University of Chattanooga for her Master's degree. The impartial coder reviewed approximately 30 percent of the data, including one interview and one group of teacher logs. After the outside researcher coded the interview and group of logs, codes were compared. The intercoder agreement was measured by calculating the percent of codes that match the two coders. Creswell (2014) stated that a desirable intercoder agreement for qualitative reliability data is an agreement greater than or equal to 80%. Initially, the intercoder agreement percentage was 78.7%. After reconciliation, the intercoder agreement percentage was 92.2%.

Data Collection Procedure

Quantitative

Participants' agreement to participate in this study was obtained before the study implementation, including Student Assent Form (see Appendix L), Parental Consent Forms (see Appendix M), and Teacher Consent Forms (see Appendix N). IRB approvals were obtained before data collection (see Appendices O and P). Data were collected in the same manner for the first two research questions. To minimize the number of times students were surveyed, student mathematics self-efficacy and motivation were administered as a single survey composed of the self-efficacy and AFS scales. This survey was first administered at the beginning of the Spring semester to all Algebra 1 students participating in the study and again at the end of the semester, approximately 19 weeks later. The survey administration in this manner was consistent with protocols for the pretest and posttest design chosen for this study.

Students ranked how true or false various statements were that related to the four sources of self-efficacy on the self-efficacy portion of the survey using a Likert scale (1 = *definitely false* to 6 = *definitely true*). Similarly, Students ranked their motivation on a Likert scale (1 = *strongly disagree* to 7 = *strongly agree*) designed to measure the three basic needs as defined in self-determination theory: autonomy, competence, and relatedness.

Student responses to the survey were separated according to the classes in which students were enrolled so that measures of self-efficacy and motivation could be calculated for the treatment group, students enrolled in classes with FAL implementation, and the control group, students enrolled in classes without FAL implementation. Within each group, student responses were separated according to questions related to self-efficacy and questions related to motivation. Calculating an average score for self-efficacy questions and motivation questions separately for each administration of the survey for both the treatment and control groups gave a single continuous measurement of self-efficacy and motivation for each student. The values for the survey results acquired at the beginning of the semester, before FAL implementation for the treatment group, and the survey results acquired at the end of the semester, after FAL implementation for the treatment group, were then compared for analysis for both the control and treatment groups. Students were asked to provide their student number as part of the survey so that a unique identifier was available to pair data from each survey administration. However, no student names were provided in the survey, and no student numbers were reported to ensure confidentiality for participants.

Data for the third research question were collected by administering a test to all Algebra 1 classes participating in the study. Test data collection was administered once at the beginning of the semester as a pretest, before any formal instruction for the Spring semester, and before any FAL implementation for the treatment group. Then, the same test was administered at the end of the Spring semester as a posttest, after formal instruction had concluded for the semester and after the second administration of the survey. The order in which the questions were presented was changed for the second test administration to prevent memorization of answers from the pretest to the posttest. To minimize interference with student learning in this study, the data collection date for measuring student achievement on the posttest depended on the teachers' instructional calendars. Students were asked to provide their student number on both the pretest and posttest so that a unique identifier could be used to pair self-efficacy scores, motivation scores, and test scores for each student for analysis.

Qualitative

Qualitative data were collected through teacher logs and interviews. Teachers who implemented FALs in their classrooms during the study were asked to complete monthly logs with pre-determined questions. Each log was presented in an online format, and teachers were able to submit their answers directly through Qualtrics. Questions presented in teacher log 1 primarily focused on FAL preparation, teachers' anticipation of FAL implementation, and how teachers believed FALs would affect their students. Questions presented in teacher log 2 primarily focused on what instructional strategies were implemented, how teachers believed the instructional strategies affected students in terms of motivation, self-efficacy, and achievement, and how students' motivation, self-efficacy, and achievement compared to the previous month. Additional questions presented in teacher log 2 included questions related to FAL implementation. Teachers were instructed to only answer questions related to FAL implementation if a FAL was implemented during that month. Questions presented in teacher logs 3 and 4 were identical to the questions presented in teacher log 2. Questions presented in teacher log 5 primarily focused on the effects of FAL implementation on teachers and students, how teacher expectations of FAL implementation compared to their beliefs at the beginning of the semester, and teacher opinions on future FAL implementation. A complete list of questions presented in each log is provided in Appendix G.

Additional qualitative data were collected at the end of the semester through in-person interviews conducted during post-planning. Interviews were conducted in a room of the teacher's choosing at the teacher's school. These interviews were structured with a list of predetermined questions focused on topics including preparation for FAL implementation, the process of implementing FALs in the classroom, effects of FAL implementation on teachers, effects of FAL implementation on students with regards to self-efficacy, motivation, and achievement, and future FAL implementation. Each interview lasted approximately 21 to 24 minutes and was recorded using the voice memos app on an iPad. A complete list of questions asked during each interview is provided in Appendix H.

Data Analysis

The same population was used to collect data for all four research questions. However, different data were collected for each research question using different instruments, and data analysis varied from one research question to another. Quantitative data were collected for research questions 1 and 2 via the administration of a survey. Additional quantitative data were collected for research question 3 via the administration of an assessment. Qualitative data were collected via teacher logs and interviews to help interpret findings and explain results gathered from quantitative data.

Research Question 1: To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy? A *t*-test was the most appropriate test for answering the first research question because self-efficacy data were analyzed the mean gain scores from pre-survey to post-survey for both the treatment and control groups separately. Survey questions related to the self-efficacy scale were used to measure student self-efficacy. The results of the *t*-test analysis helped determine whether there was a statistically significant difference in student self-efficacy between groups after FAL implementation. Relevant qualitative data from teacher logs and interviews were supplemented to help interpret the results for this research question.

Research Question 2: To what degree, if any, does FAL implementation affect high school students' motivation? A *t*-test was the most appropriate test for answering the second research question because motivation data were analyzed the mean gain scores from pre-survey to post-survey for both the treatment and control groups separately. Survey questions related to the AFS scale were used to measure student motivation. The results of *t*-test analysis helped determine whether there was a statistically significant difference in student motivation between groups after FAL implementation. Relevant qualitative data from teacher logs and interviews were supplemented to help interpret the results for this research question.

Research Question 3: To what degree, if any, does FAL implementation affect student achievement for high school mathematics students? A *t*-test was the most appropriate test for answering the third research question because student achievement data was analyzed the gain scores from pretest to posttest for both the treatment and control groups separately. Student achievement was measured using a locally created summative assessment administered as a posttest at the end of the semester and an equivalent summative assessment administered as a pretest at the beginning of the semester. The results of the *t*-test analysis helped determine whether there was a statistically significant difference in student achievement between groups after FAL implementation. Relevant qualitative data from teacher logs and interviews were supplemented to help interpret the results for this research question.

Research Question 4: Is there any relationship between students' mathematics self-efficacy, motivation, achievement, and FAL implementation? A correlation analysis was the most appropriate test for answering the fourth research question because data were analyzed to see if there was a relationship between self-efficacy, motivation, and achievement for both the treatment and control groups. Survey questions related to the self-efficacy scale were used to measure self-efficacy, and survey questions related to the AFS scale were used to measure motivation. Student achievement was measured using a researcher-created test. The results of the correlation analysis helped determine whether a relationship exists and the strength of the relationship between students' mathematics self-efficacy, motivation, achievement, and FAL implementation. Relevant qualitative data from teacher logs and interviews were supplemented to help interpret the results for this research question.

Research Question 5: What are the teachers' perceptions of the overall impact of FAL implementation? Relevant qualitative data from teacher logs and interviews were supplemented to help interpret results from surveys and tests for each research question. Qualitative data from teacher logs and interviews were analyzed through directed content analysis. This approach was used because the research questions in this study were based on existing theories in research, which was a characteristic of directed content analysis (Hsieh & Shannon, 2005). Initial codes were developed by identifying key characteristics and terms from literature. Bandura's (1977) theory of self-efficacy, Ryan and Deci's (2000) self-determination theory of motivation, student achievement, and FALs served as the primary themes for codes identified from the literature. Codes overlapping between the primary themes were put into a separate category and identified as overlapping constructs. Other codes were derived directly from teacher responses. Some of these codes were added to existing themes, and others were grouped together as separate themes and identified as instructional strategies. After codes were identified, data were coded using line-by-line coding. Due to the limited amount of qualitative data gathered in this study, manual coding was done. After all data were coded, data were then separated according to the theme and code with which it aligned and summarized for interpretation.

Summary

Chapter 3 describes the proposed research design, potential setting, and participants. The intended intervention and instruments for gathering data were also discussed, along with the validity and reliability of the proposed instruments. Additionally, procedures for data collection and analysis were discussed.

Chapter IV

RESULTS

This chapter details the study's results, which were analyzed using SPSS version 28 for this embedded experimental study that examined the effect of FAL implementation on student self-efficacy, motivation, and achievement in the high school mathematics classroom. Both quantitative and qualitative data were collected to answer the following research questions. Quantitative data were collected through student surveys on self-efficacy and motivation, and tests on math achievement. Qualitative data from teacher logs and interviews were supplemented to help interpret students' survey and test results.

1. To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy?

2. To what degree, if any, does FAL implementation affect high school students' motivation?

3. To what degree, if any, does FAL implementation affect student achievement for high school mathematics students?

4. Is there any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation?

5. What are the teachers' perceptions of the overall impact of FAL implementation?

Results for Research Question 1

Quantitative Data

Research question one examined if FAL implementation affected high school students' mathematics self-efficacy. In total, eleven students completed the pre-survey in the control group, but only four completed the post-survey. Thirty-five participants completed the pre-survey in the treatment group, but only eighteen completed the post-survey. In order to ensure the accuracy of data comparison, only the responses of participants who completed both pre- and post-survey were kept. This created four survey completers in the control group and sixteen in the treatment group for the final results (see Table 1).

Table 1

Demographic Data for Pre- and Post-Survey

Category		Treatment	Control
Gender	Male	8 (50%)	2 (50%)
	Female	8 (50%)	2 (50%)
Ethnicity	White	14 (87.5%)	2 (50%)
	African American/Black	1 (6.25%)	0 (0%)
	Asian/Asian American	0 (0%)	1 (25%)
	Hispanic/Latino(a)	1 (6.25%)	0 (0%)
	Native American	0 (0%)	0 (0%)
	Mixed Ethnicity	0 (0%)	1 (25%)
	Other	0 (0%)	0 (0%)
Other Math Course	Yes	1 (6.25%)	1 (25%)
	No	15 (93.75%)	3 (75%)

According to Table 1, the treatment group had eight males (50%) and eight females (50%) who completed both pre- and post-survey. The majority of survey completers in the treatment group were White (87.5%), with one Black (6.25%) and one Hispanic (6.25%). Approximately 6.25 percent of participants (n = 1) in the treatment group were taking another math course in addition to Algebra 1 at the implementation time of this research. The control group had two males (50%) and two females (50%)

who completed both pre- and post-survey. The majority of survey completers in the control group were also White (50%), with one Asian (25%) and one mixed ethnicity (25%). In the control group, only one survey completer was taking another math course in addition to Algebra 1 at the implementation time of this research.

The self-efficacy scale includes six questions for mastery experiences (Q2, 14, 15, 16, 19, 23), six questions for vicarious experiences (VA: Q1, 8; VP: Q12, 24; VS: Q4, 17), six questions for social persuasion (Q6, 10, 11, 18, 20, 21), and six questions for physiological state (Q3, 5, 7, 9, 13, 22). Mean gain scores were computed to show the difference between the post- and pre-survey scores. A positive mean gain score indicates an increase from the pre-survey to the post-survey and vice versa. Appendix Q includes all descriptive data for self-efficacy by question (e.g., mean, standard deviation, gain); Appendix R presents the *t*-test result by question.

Mastery Experiences

According to Table 2 and Table 3, the overall mean gain score on mastery experiences of the treatment group was positive, slightly greater than the control group ($M_T = .02$, $M_C = -.13$). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = .38$, $p = .712$. There were six questions related to mastery experiences (Q2, 14, 15, 16, 19, 23). The positive mean gain scores appeared in Q15, 19, and Q23 for the treatment group and in Q15 for the control group. The mean gain scores of Q2, 16, 19, and 23 for the treatment group were slightly greater than the control group.

Question 2 asked students if they perceived they could make excellent grades on math tests. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = -.06, M_C = -.50), the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was not significant, $t(18) = .78$, $p = .443$. In response to Question 14 about students' feelings about doing well on math assignments, a decrease showed for both treatment and control groups (M_T = -.25, M_C = -.25). No significant difference was found for Question 14, $t(18) = .00$, $p = 1.000$. An increase from pre-survey to post-survey appeared on Question 15 for both treatment and control groups. However, the mean gain score of the treatment group was slightly lower than the control group (M_T = .13, M_C = .75) for this item regarding if students perceived they have always been successful with math. This difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -1.63$, $p = .121$. Question 16 asked students if they got good grades in math on their last report card. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = -.38, M_C = -.50), the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was insignificant, $t(3) = .14$, $p = .896$. An increase from pre-survey to post-survey showed on Question 19 for the treatment group. Question 19 asked students if they perceived they did poorly in math even when studying hard. This item was reverse scored (ex., an answer of 1 becomes 6, an answer of 2 becomes 5, etc.). The mean gain score of the treatment group was slightly greater than the control group (M_T = .19, M_C = .00), but no significant difference was found between these two, $t(18) = .24$, $p = .811$. The largest increase related to mastery experiences for the treatment group showed in Question 23, which measured students' feelings about doing well on even the most difficult math assignments (M_T = .50, M_C = -.25). However, again, the difference in yield between these two was not large enough to be considered significant, $t(18) = 1.39$, $p = .181$.

Table 2

Mean Gain Scores for Mastery Experiences

#	Comp.	Question	Treat. Gain	Ctrl. Gain
ME ---			0.02	-0.13
Q2	ME	I make excellent grades on math tests.	-0.06	-0.50
Q14	ME	I do well on math assignments.	-0.25	-0.25
Q15	ME	I have always been successful with math.	0.13	0.75
Q16	ME	I got good grades in math on my last report card.	-0.38	-0.50
Q19	ME^	Even when I study very hard, I do poorly in math.	0.19	0.00
Q23	ME	I do well on even the most difficult math assignments.	0.50	-0.25

Note. ME = Mastery Experiences; ^ Reverse-scored item; *. The mean difference is significant at the .05 level

Table 3

t-test Results for Mastery Experiences

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
ME --	0.02	0.61	-0.13	1.03	0.38	18	0.712	0.21
Q2	-0.06	1.00	-0.50	1.00	0.78	18	0.443	0.44
Q14	-0.25	0.68	-0.25	1.26	0.00	18	1.000	0.00
Q15	0.13	0.62	0.75	0.96	-1.63	18	0.121	-0.91
Q16	-0.38	0.72	-0.50	1.73	0.14	3	0.896	0.13
Q19^	0.19	1.22	0.00	2.00	0.24	18	0.811	0.14
Q23	0.50	1.03	-0.25	0.50	1.39	18	0.181	0.78

Note. ME = Mastery Experiences; ^ Reverse-scored item; *. The mean difference is significant at the .05 level

Vicarious Experiences

According to Table 4 and Table 5, the overall mean gain score on vicarious experiences of the treatment group was negative, slightly lower than the control group (M_T = -.36, M_C = -.16). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = -.57$, $p = .579$. There were six questions related to vicarious experience from adults (Q1, 8), from peers (Q12, 24), and from self (Q4, 17). The positive mean gain scores only appeared in Q1 and Q12 for the control group. Only the mean gain score of Q8 for the treatment group was slightly greater than the control group (M_T = .00, M_C = -.50).

Questions 1 and 8 were related to the vicarious experience students received from adults. The overall mean gain score on vicarious experiences from adults was negative for the treatment group (M_T = -.13, M_C = -.13). The control group had the same result. Question 1 asked students if seeing adults did well in math pushed them to do better. The mean gain score of the treatment group was slightly lower than the control group (M_T = -.25, M_C = .25), and the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.90$, $p = .380$. Conversely, in response to Question 8, students could picture themselves solving the problem the same way when they saw how their math teacher solved a problem, and the mean gain score of the treatment group was slightly higher than the control group (M_T = .00, M_C = -.50). However, no significant difference between treatment and control groups was found for Question 8, $t(18) = .66$, $p = .517$.

Questions 12 and 24 were related to the vicarious experience students received from peers. The overall mean gain score on vicarious experiences from peers was negative for the treatment group was negative and slightly lower than the control group (M_T = -.41, M_C = -.13). Question 12 asked students if seeing kids did better in math pushed them to do better. The mean gain score of the treatment group was slightly lower than the control group (M_T = -.31, M_C = .25), and the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.83$, $p = .415$. In response to Question 24, students could see themselves solving the problem the same way when they saw another student solve a math problem. The mean gain score of the treatment group for Q24 was negative, equal to the control group (M_T = -.50, M_C = -.50), with no significant result, $t(18) = .00$, $p = 1.000$.

Questions 4 and 17 were related to the vicarious experience students received from themselves. The overall mean gain score on vicarious experiences from self was negative for the treatment group was negative and slightly lower than the control group (M_T = -.53, M_C = -.25). Question 4 asked students if they imagined themselves working through challenging problems successfully. The mean gain score of the treatment group was slightly lower than the control group (M_T = -.69, M_C = -.50), and the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.40$, $p = .691$. Similarly, in response to Question 17, students competed with themselves in math, and the mean gain score of the treatment group was slightly lower than the control group (M_T = -.37, M_C = .00). The mean gain score was negative, which indicated a decrease from pre-survey to post-survey. No significant difference between treatment and control groups was found for Question 17, $t(18) = -.54$, $p = .596$.

Table 4

Mean Gain Scores for Vicarious Experiences

#	Comp.	Question	Treat. Gain	Ctrl. Gain
VE ---			-0.36	-0.16
VA ---			-0.13	-0.13
Q1	VA	Seeing adults do well in math pushes me to do better.	-0.25	0.25
Q8	VA	When I see how my math teacher solves a problem, I can picture myself solving the problem the same way.	0.00	-0.50
VP ---			-0.41	-0.13
Q12	VP	Seeing kids do better than me in math pushes me to do better.	-0.31	0.25
Q24	VP	When I see another student solve a math problem, I can see myself solving the problem the same way.	-0.50	-0.50
VS ---			-0.53	-0.25
Q4	VS	I imagine myself working through challenging problems successfully.	-0.69	-0.50
Q17	VS	I compete with myself in math.	-0.37	0.00

Note. VE = Vicarious Experience; VA = Vicarious Experience from Adults; VP = Vicarious Experience from Peers; VS = Vicarious Experience from Self; ^Reverse-scored item

Table 5
t-test Results for Vicarious Experiences

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
VE --	-0.36	0.60	-0.16	0.58	-0.57	18	0.579	-0.32
VA --	-0.13	0.72	-0.13	1.03	0.00	18	1.000	0.00
Q1	-0.25	0.86	0.25	1.50	-0.90	18	0.380	-0.50
Q8	0.00	1.41	-0.50	1.00	0.66	18	0.517	0.37
VP --	-0.41	1.05	-0.13	0.48	-0.51	18	0.614	-0.29
Q12	-0.31	1.25	0.25	0.96	-0.83	18	0.415	-0.47
Q24	-0.50	1.41	-0.50	0.58	0.00	18	1.000	0.00
VS --	-0.53	0.74	-0.25	0.87	-0.66	18	0.518	-0.37
Q4	-0.69	0.87	-0.50	0.58	-0.40	18	0.691	-0.23
Q17	-0.37	1.26	0.00	1.15	-0.54	18	0.596	-0.30

Note. VE = Vicarious Experience; VA = Vicarious Experience from Adults; VP = Vicarious Experience from Peers; VS = Vicarious Experience from Self; ^Reverse-scored item; *. The mean difference is significant at the .05 level

Social Persuasions

According to Table 6 and Table 7, the overall mean gain score on social persuasions of the treatment group was positive but slightly lower than the control group (M_T = .24, M_C = .96). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = -1.43$, $p = .169$. There were six questions related to social persuasions (Q6, 10, 11, 18, 20, 21). The positive mean gain scores appeared in all items for the treatment group and in all items for the control group except for Q21 (M_C = .00). Among these six items, only the mean gain scores of Q21 for the treatment group were slightly greater than the control group.

Question 6 asked students if people have told them they have a math talent. The mean gain score of the treatment group was positive but slightly lower than the control group (M_T = .31, M_C = .75). The difference in mean gain score between treatment and control groups was insignificant, $t(18) = -.57$, $p = .577$. Similarly, in response to Question 10 about if they have been praised for their math ability, an increase showed for both treatment and control groups ($M_T = .13$, $M_C = .50$). No significant difference was found for Question 10, $t(18) = -.39$, $p = .700$. An increase from pre-survey to post-survey appeared on Question 11 for both treatment and control groups. However, the mean gain score of the treatment group was slightly lower than the control group ($M_T = .06$, $M_C = .75$) for this item regarding if students' math teachers had told them that they were good at learning math. This difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.87$, $p = .394$. Question 18 asked students if other students have told them that they're good at learning math. The mean gain score of the treatment group was positive but slightly lower than the control group ($M_T = .19$, $M_C = 1.50$). The difference in mean gain score between treatment and control groups was not significant, $t(18) = -1.55$, $p = .139$. Another increase from pre-survey to post-survey showed on Question 20 for both treatment and control groups. Question 20 asked students if their classmates liked to work with them in math because of their math ability. The mean gain score of the treatment group was lower than the control group ($M_T = .13$, $M_C = 2.25$), and this difference was found statistically significant, $t(18) = -2.60$, $p = .018$. Among these six items, only the mean gain scores of Q21 for the treatment group were slightly greater than the control group. Question 21 asked students if adults in their family had told them they were good math students ($M_T = .63$, $M_C = .00$). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = .87$, $p = .396$.

Table 6

Mean Gain Scores for Social Persuasions

#	Comp.	Question	Treat. Gain	Ctrl. Gain
P ---			0.24	0.96
Q6	P	People have told me that I have a talent for math.	0.31	0.75
Q10	P	I have been praised for my ability in math.	0.13	0.50
Q11	P	My math teachers have told me that I am good at learning math.	0.06	0.75
Q18	P	Other students have told me that I'm good at learning math.	0.19	1.50
Q20	P	Classmates like to work with me in math because they think I'm good at it.	0.13	2.25
Q21	P	Adults in my family have told me what a good math student I am.	0.63	0.00

Note. P = Social Persuasions; ^ Reverse-scored item

Table 7

t-test Results for Social Persuasions

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
P --	0.24	0.91	0.96	0.84	-1.43	18	0.169	-0.80
Q6	0.31	1.30	0.75	1.71	-0.57	18	0.577	-0.32
Q10	0.13	1.78	0.50	1.29	-0.39	18	0.700	-0.22
Q11	0.06	1.34	0.75	1.71	-0.87	18	0.394	-0.49
Q18	0.19	1.64	1.50	0.58	-1.55	18	0.139	-0.87
Q20	0.13	1.54	2.25	0.96	-2.60*	18	0.018	-1.45
Q21	0.63	1.02	0.00	2.16	0.87	18	0.396	0.49

Note. P = Social Persuasions; ^ Reverse-scored item; *. The mean difference is significant at the .05 level

Physiological States

According to Table 8 and Table 9, the overall mean gain score on physiological states of the treatment group was negative, slightly greater than the control group (M_T = -.58, M_C = -1.00). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = .97$, $p = .347$. There were six questions related to physiological states (Q3, 5, 7, 9, 13, 22). All six items were reverse scored (ex., an answer of 1 becomes 6, an answer of 2 becomes 5, etc.). The positive mean gain scores appeared on Q5 and 9 for the treatment group. The mean gain scores of Q3, 5, 7, 9, 13, and 22 for the treatment group were slightly greater than the control group.

Question 3 asked students if their whole body becomes tense when they have to do math. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = -.19, M_C = -.75), the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was not significant, $t(18) = .72$, $p = .481$. Similarly, in response to Question 5 about students' feelings about being in math class making them feel stressed and nervous, an increase showed for treatment and a decrease for control groups (M_T = .13, M_C = -.25). No significant difference was found for Question 5, $t(18) = .53$, $p = .600$. Question 7 asked students if doing math work took all of their energy. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = -.19, M_C = -.75), the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was insignificant, $t(3) = .85$, $p = .406$. An increase from pre-survey to post-survey showed on Question 9 for the treatment group. Question 9 asked students if they started to feel stressed-out as soon as they began their work. The mean gain score of the treatment group was slightly greater than the control group (M_T = .50, M_C = -.25), but no significant difference was found between these two, $t(18) = 1.03$, $p = .318$. Question 13 asked students if their minds went blank and they're unable to think clearly when doing their math work. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = -.25, M_C = -.75), the score was negative, which indicated a decrease from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was not significant, $t(18) = .50$, $p = .624$. Question 22 asked students if they got depressed when they thought about learning math. The mean gain score of the treatment group was neither positive nor negative, but slightly greater than the control group (M_T = .00, M_C = -.25). No significant difference was found between these two, $t(18) = .42$, $p = .682$.

Table 8

Mean Gain Scores for Physiological States

#	Comp.	Question	Treat. Gain	Ctrl. Gain
PH ---			-0.58	-1.00
Q3	PH^	My whole body becomes tense when I have to do math.	-0.19	-0.75
Q5	PH^	Just being in math class makes me feel stressed and nervous.	0.13	-0.25
Q7	PH^	Doing math work takes all of my energy.	-0.19	-0.75
Q9	PH^	I start to feel stressed-out as soon as I begin my work.	0.50	-0.25
Q13	PH^	My mind goes blank and I am unable to think clearly when doing my math work.	-0.25	-0.75
Q22	PH^	I get depressed when I think about learning math.	0.00	-0.25

Note. PH = Physiological State; ^ Reverse-scored item

Table 9

t-test Results for Physiological States

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
PH --	-0.58	0.81	-1.00	0.56	0.97	18	0.347	0.54
Q3^	-0.19	1.52	-0.75	0.50	0.72	18	0.481	0.40
Q5^	0.13	1.36	-0.25	0.50	0.53	18	0.600	0.30
Q7^	-0.19	1.22	-0.75	0.96	0.85	18	0.406	0.48
Q9^	0.50	1.37	-0.25	0.96	1.03	18	0.318	0.57
Q13^	-0.25	1.61	-0.75	2.50	0.50	18	0.624	0.28
Q22^	0.00	1.15	-0.25	0.50	0.42	18	0.682	0.23

Note. PH = Physiological State; ^ Reverse-scored item; *. The mean difference is significant at the .05 level

Qualitative Data

Teachers reported fluctuations in student self-efficacy throughout the semester and mentioned various factors that they believed affected students' self-efficacy. Teacher's comments on changes in student self-efficacy and influences of self-efficacy, including mastery experiences, vicarious experiences, social persuasions, and physiological states are presented in this section.

Overall Student Self-Efficacy

Shortly after the start of the semester, both teachers reported a decrease in self-efficacy from first semester and the early weeks of second semester (Log 2). However, when discussing self-efficacy in Log 3, both teachers reported an increase in student self-efficacy and attributed this change in self-efficacy to the implementation of the quadratic function FAL in February. As the semester progressed, both teachers reported uncertainty in changes in self-efficacy, stating that self-efficacy levels had either decreased or remained unchanged (Log 4). Despite the fluctuations reported in self-efficacy throughout the semester, both teachers believed that FALs helped increase students' self-efficacy. When discussing students' self-efficacy in the interview at the end of the semester, Teacher A said, "I believe that FAL implementation increased my student … self-efficacy" and that she didn't believe FALs were the cause of a decrease in anyone's self-efficacy. Teacher B also stated in her interview that she believed FALs increased her students' self-efficacy; however, she also discussed challenges with students' self-efficacy regarding the initial implementation of FALs. In her interview, Teacher B specifically mentioned students who were initially confused by the terminology used in FALs and said that the students had low confidence in their abilities. However, after beginning the FAL, the students realized they knew what to do, which ultimately improved their confidence in themselves.

Mastery Experiences

Primary sources of mastery experiences reported by teachers included instruction in previous courses, instruction in previous units, and completing individual practice problems. Both teachers agreed that students appeared to have increased self-efficacy when students were attempting content based on topics they had previously mastered (Log 4) and that students struggled with content that presented new concepts of which students had no prior knowledge (Log 2).

Teacher A reported in Log 2 that she believed "overall practice with the material contributed the most to students' self-efficacy" and that more opportunities to master content through practice would be the best way to increase students' self-efficacy. However, Teacher A also expressed concerns about the self-efficacy of students who had not previously mastered the content related to FALs chosen for implementation (Log 1). Teacher B believed that a short warm-up or mini-lesson would help provide mastery experiences for students who previously struggled with the content (Log 4). Both teachers agreed that separating content into smaller pieces, or chunking content, would allow students more opportunities to have mastery experiences with the Algebra 1 content, leading to increased self-efficacy.

Vicarious Experiences

Teachers described various situations in which students vicariously experienced success, including through peer collaboration and teacher-led instruction. Both teachers described typical classroom instruction in which students had opportunities to listen to the teacher explain procedures and model example problems while teaching the content related to FALs (Log 3). Teacher B stated that she thought “direct instruction and step-by-step break down allowed for students to understand the procedure of factoring better.” Teacher A stated in her interview that matching cards during the FAL was the easiest part for students but also that “once they were given an example seeing what they need to be doing, they were able to fully do the matching.” Both teachers also described situations in which students were able to collaborate and work out examples with peers both during the FAL and outside of FAL implementation (Log 3). Teacher A stated that “watching students work in groups and rely on each other to come to conclusions” was enjoyable for her during the FAL. Teacher B agreed that collaboration is beneficial when she stated in her interview that “it would be best to provide more practice time for students as groups” to improve students’ self-efficacy.

Social Persuasions

Both teachers described situations in which they had to use social persuasions to encourage students during the FAL. Teacher A reported that, while some students readily engaged in the FAL, other students only participated after she encouraged them to get started (Interview). She also stated in the interview that she had to stay near those students "to encourage them to even move the cards around and start talking about them" during the card sort activity. Teacher B stated in Log 2 that she was continuously encouraging students to persevere in solving longer problems as students continued learning about multi-step problems. Later, in her interview, Teacher B stated that, during the FAL, she told students to "just try your best" and "it's ok, you may get this wrong, but it's ok."

Physiological States

Teachers described several instances throughout the semester in which physiological states affected students. At the beginning of the semester, Teacher A expressed concern in Log 1 about students feeling uncomfortable with FAL implementation because of how much it differed from typical classroom instruction and later stated in Log 5 that she initially did not think students would be responsive to FALs. Teacher B had similar views and stated in Log 5 that she initially believed students would be hesitant to participate in FALs for the same reasons. As the semester progressed, Teacher B stated in Log 5 that students became "overwhelmed with the workload" in terms of multi-step problems and longer problems not related to FALs. However, both teachers expressed that their students seemed confused at the initial FAL implementation because it was something they had not seen before. After the second implementation, Teacher A expressed in her interview that she believed her students would "enjoy doing something different than the guided notes" while teacher B expressed in Log 5 that she believed students would be more comfortable with FALs if they were implemented earlier and more regularly throughout the year.

Results for Research Question 2

The activity feeling states scale includes three questions for autonomy (Q4, 8, 12), three questions for competence (Q1, 7, 11), and three questions for relatedness (Q2, 5, 10). Questions 3, 6, and 9 are filler items that are not scored. Mean gain scores were computed to show the difference between the post- and pre-survey scores. A positive mean gain score indicates an increase from the pre-survey to the post-survey and vice versa. Appendix S includes all descriptive data for motivation by question (e.g., mean, standard deviation, gain); Appendix T presents the *t*-test result by question.

Quantitative Data

Autonomy

According to Table 10 and Table 11, the overall mean gain score on autonomy of the treatment group was negative, slightly lower than the control group (M_T = -.25, M_C = .00). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = -.41$, $p = .690$. There were three questions related to autonomy (Q4, 8, 12). The only positive mean gain scores appeared in Q12 for the control group. Only the mean gain scores of Q4 for the treatment group were slightly greater than the control group.

Question 4 asked students if they felt free while participating in their math class. Although the mean gain score of the treatment group was slightly greater than the control group (M_T = .00, M_C = -.50), the score was neither positive nor negative, which indicated no increase from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was not significant, $t(18) = .66$, $p = .517$. In response to Question 8 about whether they were doing what they wanted to be doing in the math class, a decrease showed for both treatment and control groups (M_T = -.50, M_C = -.25). No significant difference was found for Question 8, $t(18) = -.44$, $p = .666$. Question 12 asked students if they felt free to decide for themselves what to do in the math class. The mean gain score of the treatment group was negative and slightly lower than the control group (M_T = -.25, M_C = .75). The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.94$, $p = .362$.

Table 10

Mean Gain Scores for Autonomy

			Treat.	Ctrl.
#	Comp.	Question	Gain	Gain
Autonomy			-.25	.00
Q4		Free	.00	-0.50
Q8		I'm doing what I want to be doing	-.50	-0.25
Q12		Free to decide for myself what to do	-.25	.75

Table 11

t-test Results for Autonomy

Comp.	Treatment Gain *M*	Treatment Gain *SD*	Control Gain *M*	Control Gain *SD*	*t*	*df*	*p*	*Cohen's d*
Autonomy	-0.25	1.08	0.00	1.22	-0.41	18	.690	-0.23
Q4	0.00	1.37	-0.50	1.29	0.66	18	.517	0.37
Q8	-0.50	0.97	-0.25	1.26	-0.44	18	.666	-0.24
Q12	-0.25	1.98	0.75	1.50	-0.94	18	.362	-0.52

Note. *. The mean difference is significant at the .05 level

Competence

According to Table 12 and Table 13, the overall mean gain score on competence of the treatment group was positive, slightly higher than the control group (M_T = .06, M_C = -.25). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = .73$, $p = .475$. There were three questions related to competence (Q1, 7, 11). The positive mean gain scores appeared in Q1 and Q11 for the treatment group and Q11 for the control group. The mean gain scores of Q1 and Q7 for the treatment group were slightly greater than the control group.

Question 1 asked students if they felt capable while participating in their math class. The mean gain score of the treatment group was slightly greater than the control group (M_T = .06, M_C = -.75), and the score was positive, which indicated an increase from pre-survey to post-survey. The difference in mean gain score between treatment and control groups was not significant, $t(18) = 1.67$, $p = .113$. In response to Question 7 about if they felt competent while participating in their math class, a decrease showed for both treatment and control groups (M_T = -.13, M_C = -.50). No significant difference was found for Question 7, $t(18) = .57$, $p = .574$. Question 11 asked students if they felt their skill were improving in the math class. The mean gain score of the treatment group was positive and slightly lower than the control group ($M_T = .25$, $M_C = .50$). The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -.37$, $p = .714$.

Table 12

Mean Gain Scores for Competence

#	Comp.	Question	Treat. Gain	Ctrl. Gain
Competence			.06	-.25
Q1		Capable	.06	-.75
Q7		Competent	-.13	-.50
Q11		My skills are improving	.25	.50

Table 13

t-test Results for Competence

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
Competence	0.06	0.78	-0.25	0.69	0.73	18	.475	0.41
Q1	0.06	0.77	-0.75	1.26	1.67	18	.113	0.93
Q7	-0.13	1.20	-0.50	1.00	0.57	18	.574	0.32
Q11	0.25	1.29	0.50	0.58	-0.37	18	.714	-0.21

Note. *. The mean difference is significant at the .05 level

Relatedness

According to Table 14 and Table 15, the overall mean gain score on relatedness of the treatment group was positive but slightly lower than the control group ($M_T = .02$,

$M_C = .33$). However, the difference in yield between these two was not large enough to be considered significant, $t(18) = -.55$, $p = .591$. There were three questions related to relatedness (Q2, 5, 10). The positive mean gain scores appeared in Q2 for the treatment group and Q2 and Q10 for the control group. The mean gain scores of all questions about relatedness for the treatment group were slightly lower than the control group.

Question 2 asked students if they felt they belonged and if the people here cared about them while participating in their math class. The mean gain score of the treatment group was positive but slightly greater than the control group ($M_T = .19$, $M_C = .25$). The difference in mean gain score between treatment and control groups was not significant, $t(18) = -.09$, $p = .929$. In response to Question 5 about if they felt involved with close friends while participating in their math class, a decrease showed for the treatment group ($M_T = -.06$, $M_C = .00$). No significant difference was found for Question 5, $t(18) = -.06$, $p = .951$. Question 10 asked students if they felt emotionally close to the people around them in the math class. The mean gain score of the treatment group was negative and slightly lower than the control group ($M_T = -.06$, $M_C = .75$). The difference in mean gain score between treatment and control groups was insignificant, though, $t(18) = -1.03$, $p = .316$.

Table 14

Mean Gain Scores for Relatedness

#	Comp.	Question	Treat. Gain	Ctrl. Gain
Relatedness			.02	.33
Q2		I belong and the people here care about me	.19	.25
Q5		Involved with close friends	-.06	.00
Q10		Emotionally close to the people around me	-.06	.75

Table 15

t-test Results for Relatedness

Comp.	Treatment Gain *M*	Treatment Gain *SD*	Control Gain *M*	Control Gain *SD*	*t*	*df*	*p*	*Cohen's d*
Relatedness	0.02	1.09	0.33	0.61	-0.55	18	.591	-0.31
Q2	0.19	1.28	0.25	0.96	-0.09	18	.929	-0.05
Q5	-0.06	1.91	0.00	0.82	-0.06	18	.951	-0.04
Q10	-0.06	1.39	0.75	1.50	-1.03	18	.316	-0.58

Note. *. The mean difference is significant at the .05 level

Qualitative Data

Initially, teachers expressed concern about student motivation because of FAL implementation. Both teachers expressed the concern that students would be less motivated because they were accustomed to direct instruction and not a student-centered instructional approach. However, teachers reported fluctuations in student motivation over the course of the semester. Teacher's comments on changes in student motivation and effects on motivation such as autonomy, competence, and relatedness were presented in this section.

Overall Student Motivation

Shortly after the start of the semester, both teachers reported a decrease in motivation from first semester and the early weeks of second semester. The teachers attributed this decrease in motivation to the introduction of material that was new to students and for which students had no background knowledge to build on (Log 2). However, when discussing motivation in Log 3, both teachers reported an increase in student motivation and attributed this change in motivation to the implementation of a

FAL in February. As the semester progressed, both teachers reported a decrease in student motivation again. In Log 4, Teacher A commented on the decrease in student motivation, saying, "with it being close to the end of the semester, students tend to lose motivation, especially after spring break." Similarly, in the interview with Teacher B, she commented on the decrease in student motivation towards the end of the semester, saying that "since it [the FAL] was at the end of the school, their motivation was just gone." When Teacher B was asked if she thought the decrease in motivation was in relation to the implementation of the FAL, she said she believed it was not and that it was likely due to other factors with the end of the school year. Despite the fluctuations in student motivation throughout the semester, both teachers believed that FAL implementation had a positive influence on student motivation.

Autonomy

Prior to FAL implementation, teachers disagreed on whether FAL implementation would help students be autonomous learners. Teacher A believed that FALs would help students become independent problem-solvers. In contrast, Teacher B believed that independence might cause a lack of motivation since students were accustomed to direct instruction (Log 1). After FAL implementation, teacher A confirmed her belief that students became more independent in the learning process (Log 5) because the FAL allowed students to explore the material on their own whereas they are normally guided by the teacher during direct instruction (Interview). Teacher A stated during her interview that she believed her students "felt like they had more freedom and more responsibility of the content themselves."

Competence

Before implementing FALs, teachers expressed concern with students who were not competent with the material covered in the task; however, teachers also expressed hope that the use of the FAL would help build competence for these students. Both teachers expressed their belief that students felt the most competent dealing with concepts for which they had prior knowledge. Teacher A believed students' prior experience with these topics helped students feel more confident with the material and therefore be motivated to complete tasks, answer questions in class, and attempt more difficult content (Log 4). Similarly, Teacher B reported that background knowledge allowed students to be more confident and therefore be more eager to learn about the topic (Log 4). Although both teachers believed that instructional strategies such as breaking information into smaller sections would help build student competence (Log 2), both teachers expressed that participation in FALs also helped students build their confidence. Teacher A stated during her interview that after FAL implementation, she saw "willingness to answer questions, the desire, the confidence in these students just increased tremendously."

Relatedness

Both teachers commented on different ways to influence relatedness in the classroom, including collaboration and a safe learning environment where students can make mistakes. Initially, Teacher B expressed in Log 1 that the pre-assessment portion of the FAL would help students learn from their mistakes. Later, in Log 2, she described a scenario in which she was talking with students and encouraged them to answer a question whether they were correct or not. Teacher A focused on collaboration between students. Teacher A expressed her belief that motivating students was difficult because students are not accustomed to collaborating (Log 2) but later stated that she believed collaboration would help students become more motivated (Log 3). However, during her interview, Teacher A reported difficulty in student motivation because her low-achieving students, who "have no desire to work with others" shut down on her during the FAL because they did not want to be involved while other students were excited about the FAL because it was a fun activity for them.

Results for Research Question 3

Quantitative Data

Research question three examined if FAL implementation affected high school students' achievement. In total, 13 students completed the pretest in the control group, but only 12 completed the posttest; 39 students completed the pretest in the treatment group, but only 34 completed the posttest. In order to ensure the accuracy of data comparison, only the responses of participants who completed both pretest and posttest were kept. This created 12 test completers in the control group and 32 in the treatment group for the final results. The pass rates for pretest and posttest by question were presented in Appendix U. Pass rate referred to the number of students who passed the question among their group. The pass rate increased from the pretest to the posttest on most items for the treatment group except for Q17, 20, 23, 26, and 36; The pass rate increased from the pretest to the posttest on most items for the control group except for Q12, 17, 20, 26 and 34 and 36. The treatment group had a slightly higher pass rate on 27 out of 37 test items than the control group. They had a slightly lower pass rate on Q13, 14, 18, 19, 23, 25, 28, 32, 35, and 37 than the control group. The treatment group's overall mean gain test score was positive, slightly greater than the control group (M_T = 28.46, M_C = 22.75). However, the difference in yield between these two was not large enough to be considered significant, $t(42) = .92$, $p = .364$.

Qualitative Data

Teachers made several comments in their log entries and interviews related to student achievement. Teachers' comments related to student achievement with respect to changes in students' achievement, content knowledge, skills necessary for success in mathematics, and evidence of students' achievement were presented below.

Evidence of Achievement

At the beginning of the semester, prior to FAL implementation, teachers explained how they believed FAL implementation might affect student achievement in Log 1. Teacher A expressed her belief that FALs would help her track student progress using the pretest and posttest results. Teacher B reported that she would be able to see students' conceptual understanding from a connection made within the FAL and that she would be able to understand students' ability and growth from watching students complete the FAL. After FAL implementation, both teachers reported during their interviews that students were actually able to complete the activity and were able to give explanations for why they matched the cards the way they did. Teacher A stated that, although she still believed her high-performing students showed the most achievement, she was able to determine where her students were struggling with the content as a result of the FAL (Interview). Teacher A believed that being able to identify students' strengths and weaknesses would be beneficial because she could focus on how to "bring students' struggles to where their strengths are, so they can do better on summative assessments" (Interview). Teacher B believed that she saw "more conceptual understanding in the FALs rather than just direct instruction" and that FALs allowed her to assess both procedural and conceptual understanding (Interview). Teachers also believed that the feedback (Teacher B, Log 1) and collaboration between students (Teacher A, Interview) helped increase student achievement by allowing students to learn from their mistakes and answer questions with each other during the FAL.

Achievement

When measuring student achievement, both teachers reported fluctuations in student achievement throughout the semester. Teacher A and Teacher B reported in Log 2 that student achievement seemed to be lower than first semester and the first few weeks of second semester. Both teachers attributed the decrease in student achievement to the introduction of new material with which students had no previous experience. After the first FAL implementation, both teachers reported an increase in student achievement in Log 3, followed by uncertainty in whether student achievement had increased or remained the same in Log 4 near the end of the semester. Despite the fluctuations in student achievement, both teachers reported belief that FAL implementation increased student achievement overall in Log 5 at the end of the semester. Teacher B expressed in Log 5 that she believed FAL implementation positively affected student achievement by allowing them the opportunity to "explain and express their understanding of mathematical concepts." Although both teachers reported belief that student achievement increased for students during the interviews at the end of the semester, Teacher A believed that her middle-performing students showed the most improvement, whereas Teacher B believed that her high-performing students showed the greatest improvement in terms of achievement. However, Teacher B also reported in her interview that her ELL students benefitted from the FAL because they were able to remember the visual representations presented in the FAL when confronted with visual representations on assessments later in the course.

Content Knowledge

Teachers believed that FALs would affect students' content knowledge by increasing understanding of content, increasing comprehension of vocabulary (Teacher A, Log 1), and bringing deeper connections among concepts (Teacher B, Log 1). Both teachers believed instructional strategies such as direct instruction, chunking material, and guided notes helped students understand procedures for completing math problems. However, teachers believed that FALs helped improve content knowledge in other ways. Teacher B stated that FALs helped students improve their content knowledge through "practice explain(ing) their conceptual understanding" and by assisting them to "bridge together their conceptual understanding with their procedural fluency" (Log 5). Teacher A believed that FALs helped students "helped with student independence and increased higher-order thinking throughout the concepts that they were implemented on" (Log 5). Teacher A also reported in her interview that she noticed students had a better grasp on quadratic functions and that the card sorts in the FALs would help her students visually interpret information which would help deepen their content knowledge.

Skills

Teachers believed that FALs represented skills necessary for mathematical success, including higher-order thinking skills, problem-solving, and articulating thought processes. At the beginning of the semester, both teachers believed that FALs would require students to use higher-order thinking skills (Log 1). After FAL implementation, both teachers agreed that FAL helped students articulate their thought processes by "explain [explaining] to each other the conceptual purpose of each type of function instead of just explaining what the function is" (Teacher A, Log 2) and explaining "mathematics procedurally but also conceptually" (Teacher B, Log 2). Teachers believed that students would be more successful in mathematics by problem-solving independently (Teacher B, Log 1) and articulating their understanding (Teacher A, Interview) not just to their peers but also to people outside of the classroom (Teacher B, Interview).

Results for Research Question 4

Quantitative Data

Research question four examined if there was any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation. Pearson correlation coefficient was computed to assess the linear relationship among students' mathematics self-efficacy, motivation, and achievement between treatment and control groups. In order to ensure the accuracy of data comparison, only the responses of participants who completed both surveys and tests were kept. This created three completers in the control group and twelve in the treatment group for the final results. Table 16 indicates that only one significant correlation was found between the overall mean gain score on self-efficacy and motivation for the control group, $r(3) = 1.00$, $p = .011$. However, no significant correlations were found among the treatment group's overall mean gain score on self-efficacy, motivation, and achievement.

Table 16

Pearson Correlations among Overall Self-Efficacy, Overall Motivation, and Overall Achievement

Group	Variable	Overall Gain Self-Efficacy	Overall Gain Motivation	Overall Gain Achievement
Control	Overall Gain Self-Efficacy	1	1.00*	0.623
	Overall Gain Motivation	1.00*	1	0.637
	Overall Gain Achievement	0.623	0.637	1
Treatment	Overall Gain Self-Efficacy	1	0.161	-0.020
	Overall Gain Motivation	0.161	1	0.316
	Overall Gain Achievement	-0.020	0.316	1

Note. * The mean difference is significant at the .05 level

More specifically, Pearson correlation coefficient was computed to assess the linear relationship among subcomponents of students' mathematics self-efficacy, motivation, and achievement between treatment and control groups. Significant correlations were found in mean gain score for the control group between (1) mastery experiences and competence, $r(3) = 1.00$, $p = .000$ and (2) achievement and social persuasions, $r(3) = .998$, $p = .039$. Significant correlations were found for the treatment group between (1) social persuasions and mastery experiences, $r(12) = .632$, $p = .028$ and (2) autonomy and physiological states, $r(12) = -.582$, $p = .047$.

Table 17

Pearson Correlations among Subcomponents of Self-Efficacy, Subcomponents of Motivation, and Overall Achievement

Group		ME	VE	P	PH	A	C	R	Achv.
Ctrl.	ME	1	0.277	0.910	0.500	0.693	**1.000****	0.971	0.882
	VE	0.277	1	-0.146	0.971	0.885	0.277	0.038	-0.207
	P	0.910	-0.146	1	0.096	0.332	0.910	0.983	.998*
	PH	0.500	0.971	0.096	1	0.971	0.500	0.277	0.034
	A	0.693	0.885	0.332	0.971	1	0.693	0.500	0.273
	C	**1.000****	0.277	0.910	0.500	0.693	1	0.971	0.882
	R	0.971	0.038	0.983	0.277	0.500	0.971	1	0.970
	Achv.	0.882	-0.207	**.998***	0.034	0.273	0.882	0.970	1
Treat.	ME	1	-0.070	**.632***	0.295	0.196	0.336	0.432	-0.058
	VE	-0.070	1	0.404	0.444	-0.204	0.183	0.156	0.172
	P	**.632***	0.404	1	0.378	-0.068	-0.005	0.543	-0.186
	PH	0.295	0.444	0.378	1	**-.582***	0.509	0.223	0.030
	A	0.196	-0.204	-0.068	**-.582***	1	0.143	0.443	0.209
	C	0.336	0.183	-0.005	0.509	0.143	1	0.221	0.137
	R	0.432	0.156	0.543	0.223	0.443	0.221	1	0.321
	Achv.	-0.058	0.172	-0.186	0.030	0.209	0.137	0.321	1

Note. ME = Mastery Experiences; VE = Vicarious Experience; P = Social Persuasions; PH = Physiological State; **Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Qualitative Data

Teachers described ways that they believed student self-efficacy, motivation, and achievement were related to FAL implementation. Both teachers reported in Log 5 that they believed FAL implementation had a positive relationship with students' self-efficacy, motivation, and achievement.

When discussing the relationship between self-efficacy and FAL implementation, both teachers reported in Log 3 that they observed an increase in self-efficacy and attributed this change to FAL implementation. During the interviews at the end of the semester, both teachers maintained the belief that FAL implementation increased their students' self-efficacy. In Log 3, Teacher A stated that she believed "the FAL implemented in February helped increase student self-efficacy with much of the material presented in March." In Log 5, Teacher B stated she believed "the FALs increases… students' achievement, motivation, and self-efficacy because it gave them a chance to explain and express their understanding of mathematical concepts." Although there were fluctuations in students' self-efficacy throughout the semester, both teachers expressed the belief that FAL implementation had a positive relationship with self-efficacy.

When discussing the relationship between FAL implementation and motivation, teachers initially expressed concern that FAL implementation may decrease student motivation because it would deviate from normal classroom instruction (Log 1). However, in Log 3, both teachers reported an increase in student motivation and attributed this change to the implementation of the first FAL. During the interviews at the end of the semester, Teacher B stated, "I know in the first FAL that we did, they [students] probably… their motivation increased" and Teacher A reported that after FAL implementation, she saw "willingness to answer questions, the desire, the confidence in these students increased tremendously." Both teachers expressed their belief that participation in FALs helped build students' confidence. This is important because in Log 4, Teacher B stated that "when students are confident answering questions… I feel that they are more motivated to complete the assignments and answer questions out loud in class." Although teachers reported fluctuations in motivation throughout the semester, both teachers expressed the belief that FAL implementation had a positive relationship with student motivation.

When discussing the relationship between FAL implementation and student achievement, teachers reported an increase in student achievement after FAL implementation (Log 3). After FAL implementation, both teachers reported that students were able to complete the activity and were able to give explanations for how they matched cards during the card sort activity (Interviews). Teachers believed that feedback (Teacher B, Log 1), collaboration between students (Teacher A, Interview), and opportunities for students to articulate their understanding (Log 5) during the FAL positively affected student achievement. After FAL implementation, teachers agreed that FALs helped students articulate their thought processes by "explain [explaining] to each other the conceptual purpose of each type of function instead of just explaining what the function is" (Teacher A, Log 2) and explaining "mathematics procedurally but also conceptually" (Teacher B, Log 2). Teacher A also reported in her interview that she noticed students had a better grasp on quadratic functions and that the card sort in the FAL would deepen students' content knowledge by providing them the opportunity to visually interpret information. Overall, teachers expressed the belief that the implementation of FALs had a positive relationship with student achievement.

Results for Research Question 5

Results for research question 5 were mainly from the qualitative data about teachers' perceptions of the overall impact of FAL implementation. The data were collected from teacher logs and interviews. Teachers described their experiences related to preparing FALS and implementing FALs in the classroom. Teachers also gave information about how they thought FALs affected their students and what they might do if implementing FALs in the future.

FAL Preparation

Teachers reported that FAL preparation takes more time than preparation required for typical classroom instruction. In Log 5, Teacher A stated that FALs "take quite a bit of time before a FAL is implemented to fully prepare for a lesson" but also that "the more you prepare, the more effective FAL implementation is."

Teachers reported that preparing for FAL implementation was similar to how they would typically prepare for classroom instruction with respect to preparing materials ahead of time, making copies for students, identifying intended learning objectives for students, and aligning the chosen activity with the intended learning objectives. When discussing similarities in the interview, Teacher A stated that "picking out the correct formative assessment lesson and seeing if it aligned with the standard was similar to how I would normally prepare for a class."

Conversely, teachers reported differences in preparing for FAL implementation compared to typical classroom instruction. Differences reported by teachers include the amount of work it takes to prepare the materials and the amount of time it takes for teachers to go through the FAL instructions to be fully prepared to facilitate the task. Both teachers stated that they not only had to prepare specific materials for the FAL but also had to be comfortable guiding students through the activity and preparing feedback to give to students after the pre-assessment. The additional preparation of going through the activity themselves took more time than what would typically be required for classroom instruction. Teacher B emphasized how taking the time to decide how to group students prior to implementing the activity was an additional factor to consider when preparing for classroom instruction. However, when discussing the differences during the interview, Teacher B said, “I think it’s just more time-consuming on my part, but I think with more preparation, it would be fine.”

During the interviews, both teachers stated that the teaching guide was a helpful component for implementing FALs. Teachers said that the guide was helpful in terms of understanding what a formative assessment lesson was and the purpose for using them in the classroom. Teachers also stated that the guide helped them understand the different components involved in a FAL, what to do when implementing the task, and a timeline to follow for FAL implementation. Teacher A emphasized how the teacher guide was especially helpful in providing prompted questions for the pre- and post-assessment feedback, while Teacher B emphasized how helpful the teacher guide was in providing sample questions and student responses as a foundation to build from when implementing the task in the classroom.

FAL Implementation

In Log 1, both teachers expressed concerns about implementing FALs in the classroom. Teacher A stated she worried “about the time the FAL take(s) in class due to the time constraints with EOCs” whereas teacher B noted that it was possible that “the schedule will be affected due to weather since the FAL will be implemented during the Winter.”

However, in the log entries, both teachers made it clear that two FALs were implemented over the course of the spring semester. The first FAL was implemented in February, and the second FAL was implemented in May. During the interviews, both teachers stated they had full time for implementation and were able to implement all parts of the first FAL, including the pre-assessment, collaborative task, and post-assessment. However, teachers reported challenges with implementing the second FAL due to changes in the school schedule. During her interview, Teacher A reported challenges with the pre-assessment. She reported shortening the pre-assessment and giving feedback in class rather than individually to each student. Teacher B reported difficulties giving feedback on the post-assessment during her interview. She said being able to give the post-assessment but inability to provide feedback due to a change in the local school schedule. Other challenges to FAL implementation reported by both teachers included engaging students with a change in the routine nature of the class and being able to group students in a way that would allow them to work well together during COVID-19.

Effects of FAL Implementation

Despite the challenges to FAL implementation, both teachers reported positive effects of FAL implementation on their students. In Log 1, Teacher A expressed her belief that implementing the chosen FALs would help students use higher-order thinking skills. In contrast, Teacher B expressed the belief that implementation would help increase her understanding of students' abilities from the pre- and post-assessments. Both teachers agreed that the implementation of FALs helped grow students' understanding. During her interview, Teacher B stated that she saw "more conceptual understanding in the FALs rather than just direct instruction." Both teachers also reported that students were actively engaged, using higher-order thinking, and showing increased student interaction in the classroom during FALs, which provided a more student-centered and hands-on approach to learning. In Log 5, Teacher B stated, "usually my lessons are direct instruction heavy, but the FALs allowed for the discussions to be student-focused and student-led." Additionally, both teachers reported an increase in student achievement, motivation, and self-efficacy after implementing the first FAL and looked favorably upon the visual representation of quadratic functions and data comparisons used in the selected FALs. Teachers also reported additional effects on student learning and performance that was specific to their respective classrooms. During the interview, Teacher B reported an increase in confidence among her students because of being able to match the cards together and complete the activity even though the FAL used different or more difficult terminology than what was typically used in class. Teacher A reported a deeper understanding of content knowledge among her students during her interview and noted that the depth of knowledge emphasized by FALs might help her students carry the understanding to future years.

Although teachers reported many benefits of implementing FALs in the classroom, not all students were affected in the same way. For example, Teacher B reported some students showing a lack of interest in the activity because it deviated from the normal classroom routine, while other students were excited about the new type of instruction. Similarly, Teacher A reported a lack of excitement about the FALs among her students who are typically independent workers and stated that she had to offer those students more encouragement to complete the FAL than other students in the class.

Future FAL Implementation

Teachers A and B both stated they are interested in implementing FALs in the future in their classrooms. However, both teachers said they would change the time they begin implementing FALs and how frequently they would implement FALs throughout the semester. Teacher B stated she would want to "start at the beginning of the year, just to get them used to it" during her interview and that she would want to be "more consistent in the implementation of FALs" in Log 5. Teacher A reported in Log 5 that she would like to "increase the amount of FALs implemented" because she believes "the more exposure to this instructional strategy, the better." Teachers had differing opinions on how they might change FALs for future implementation regarding times allotted for specific components of the FAL. During the interviews, Teacher A reported a desire to shorten interaction times during the collaborative activity because her students would deviate from the focus of the activity, whereas Teacher B reported a desire to lengthen times for the collaborative activity to allow students more time to discuss their findings.

Summary

Research Question 1

Quantitative Data

RQ 1 results showed that the overall mean gain score on mastery experiences of the treatment group was positive, slightly greater than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were six questions related to mastery experiences (Q2, 14, 15, 16, 19, 23). Q19 was reverse scored. The positive mean gain scores appeared in Q15, 19, and Q23 for the treatment group and in Q15 for the control group. The treatment group had a slightly greater mean gain score in four out of six questions than the control group (Q2, 16, 19, and 23) related to mastery experiences. No significant differences were found for individual questions.

RQ 1 results showed that the overall mean gain score on vicarious experiences of the treatment group was negative, slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were six questions related to vicarious experience from *adults* (Q1, 8), from *peers* (Q12, 24), and from *self* (Q4, 17). The overall mean gain score on vicarious experiences from *adults* was negative for the treatment group. The control group had the same result. The overall mean gain score on vicarious experiences from *peers* was negative for the treatment group was negative and slightly lower than the control group. The overall mean gain score on vicarious experiences from *self* was negative for the treatment group was negative and slightly lower than the control group. The positive mean gain scores only appeared in Q1 and Q12 for the control group. The treatment group had a slightly greater mean gain score in only one out of six questions than the control group (Q8) related to vicarious experiences. No significant differences were found for individual subcomponents and questions.

RQ 1 results showed that the overall mean gain score on social persuasions of the treatment group was positive but slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were six questions related to social persuasions (Q6, 10, 11, 18, 20, 21). The positive mean gain scores appeared in all questions for the treatment group and in all questions for the control group except for Q21 ($M_C = .00$). The treatment group had a slightly greater mean gain score in only one out of six questions than the control group (Q21) related to social persuasions. No significant differences were found for individual questions.

RQ 1 results showed that the overall mean gain score on physiological states of the treatment group was negative, slightly greater than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were six questions related to physiological states (Q3, 5, 7, 9, 13, 22). All six items were reverse scored (ex., an answer of 1 becomes 6, an answer of 2 becomes 5, etc.). The positive mean gain scores appeared on Q5 and 9 for the treatment group. The treatment group had a slightly greater mean gain score in all six questions than the control group (Q3, 5, 7, 9, 13, and 22) related to physiological states. No significant differences were found for individual questions.

Qualitative Data

Teachers reported fluctuations in student self-efficacy throughout the semester. Initially, teachers reported a decrease in student self-efficacy from first semester and the early weeks of second semester followed by an increase in self-efficacy attributed to the implementation of the quadratic function FAL. However, at the end of the semester, teachers reported uncertainty about whether self-efficacy had decreased or remained unchanged. Despite the fluctuations in self-efficacy reported throughout the semester, teachers believed that FAL implementation helped increase students' self-efficacy. Additionally, Teacher A stated she did not believe FALs were the cause of any decrease in students' self-efficacy. Teacher B reported challenges with students' self-efficacy regarding the initial implementation of FALs related to terminology used in the activity and student confidence in their abilities. However, she also reported that student confidence in their abilities seemed to increase after students began the FAL and realized they knew what to do.

Primary sources of mastery experiences reported by teachers included instruction from previous courses, instruction from previous units, and completing individual practice problems. Both teachers agreed that students had increased self-efficacy when attempting problems based on prior knowledge and that students struggled with content based on concepts with which students did not have prior experience. Both teachers agreed that opportunities to master content through practice would increase student self-efficacy, especially with content that students had not previously mastered. Additionally, both teachers agreed that separating content into smaller pieces would increase student self-efficacy by allowing more opportunities for mastery experiences.

Primary sources of vicarious experiences reported by teachers included peer collaboration and teacher-led instruction. Both teachers described situations in which students had opportunities to listen to explanations of procedures and watch example problems modeled by the teacher during typical classroom instruction of content related to FALs. Both teachers also described situations in which students were given the opportunity to work together to solve problems during and outside of the FAL. Additionally, Teacher B reported that she believed more time for collaboration between students would be beneficial for improving students' self-efficacy.

The primary source of social persuasion reported by teachers was the encouragement given to students. Both teachers agreed that students needed encouragement at various points during the learning process. Teacher A reported the need to encourage students to begin participating in the FAL and to continue working throughout the card sort activity. Teacher B reported the need to encourage students to persevere in the problem-solving process and to encourage students to work even if they may solve the problem incorrectly.

Teachers described several instances throughout the semester in which physiological states affected students. These instances included students feeling uncomfortable with the change in instruction caused by the introduction of FALs, students feeling confused when initially faced with FALs, and students feeling overwhelmed with new content requiring multiple steps to solve. Initially, teachers reported belief that students would either not be responsive to FALs or would be hesitant to participate in FALs. However, at the end of the semester, Teacher A reported that she believed students would enjoy the change in classroom instruction while Teacher B reported that she believed students might be more comfortable with FALs if they were implemented earlier and more regularly throughout the school year.

Research Question 2

Quantitative Data

RQ2 results showed that the overall mean gain score on autonomy of the treatment group was negative, slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were three questions related to autonomy (Q4, 8, 12). The only positive mean gain scores appeared in Q12 for the control group. The treatment group had a slightly greater mean gain score in only one out of three questions than the control group (Q4) related to autonomy. No significant differences were found for individual questions.

RQ2 results showed that the overall mean gain score on competence of the treatment group was positive, slightly higher than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were three questions related to competence (Q1, 7, 11). The positive mean gain scores appeared in Q1 and Q11 for the treatment group and Q11 for the control group. The treatment group had a slightly greater mean gain score in two out of three questions than the control group (Q1 and 7) related to competence. No significant differences were found for individual questions.

RQ2 results showed that the overall mean gain score on relatedness of the treatment group was positive but slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. There were three questions related to relatedness (Q2, 5, 10). The positive mean gain scores appeared in Q2 for the treatment group and Q2 and Q10 for the control group. The mean gain scores of all questions about relatedness for the treatment group were slightly lower than the control group. No significant differences were found for individual questions.

Qualitative Data

Teachers reported fluctuations in student motivation throughout the semester. Initially, teachers reported a decrease in student motivation from first semester and the early weeks of second semester followed by an increase in student motivation following the first implementation of a FAL. The initial decrease in student motivation was attributed to the introduction of content with which students had no previous experience. However, at the end of the semester, teachers also reported a decrease in student motivation. Teachers attributed the decrease in motivation at the end of the semester to outside influences including the end of the school year. Additionally, Teacher B stated she did not believe FALs were the cause of any decrease in student motivation at the end of the semester. Despite the fluctuations in motivation reported throughout the semester, both teachers believed that FAL implementation had a positive influence on student motivation.

Initially, teachers disagreed on whether FAL implementation would help students be autonomous learners. Teachers agreed that FALs would require more independence from students. However, Teacher A believed the increased independence would help students embrace being independent learners while Teacher B believed that the increased independence would cause students to lose motivation. At the end of the semester, Teacher A confirmed her belief that students would become more independent in the learning process and stated that she believed students had more freedom, more responsibility, and a chance to explore the content on their own.

Before implementing FALs, teachers expressed concern with students who lacked competence with the material covered in the FAL. However, teachers also expressed hope that FAL implementation would help build competence for these students. Both teachers agreed that prior knowledge helped students feel more confident with the material. Teacher A reported that prior knowledge helped students be more motivated to learn while Teacher B reported that prior knowledge helped students be more eager to learn about the topic. Both teachers also reported they believed that breaking information into smaller sections and participation in FALs would help build student confidence.

Primary methods for influencing relatedness reported by teachers included collaboration and creating a safe learning environment in which students can make mistakes. Teacher A reported that motivating students was difficult because they were not accustomed to collaborating or did not want to work together, while other students were excited about the FAL because it was fun for them. Teacher B initially expressed her belief that the use of a pre-assessment and post-assessment during the FAL would help students learn from their mistakes but later described a scenario in which she encouraged students to answer questions whether or not they were correct.

Research Question 3

Quantitative Data

RQ3 results showed that the pass rate increased from the pretest to the posttest on most items for the treatment group except for Q17, 20, 23, 26, and 36; The pass rate increased from the pretest to the posttest on most items for the control group except for Q12, 17, 20, 26 and 34 and 36. The treatment group had a slightly higher pass rate on 27 out of 37 test items than the control group except for Q13, 14, 18, 19, 23, 25, 28, 32, 35, and 37. The treatment group's overall mean gain test score was positive, slightly greater than the control group. However, the difference in yield between these two was not large enough to be considered significant.

Qualitative Data

Teachers' comments regarding student achievement primarily related to changes in student achievement, content knowledge, skills necessary for success in mathematics, and evidence of achievement. Prior to FAL implementation, teachers believed the use of FALs in the classroom would help them track student progress from pretest to posttest, see students' conceptual understanding from connections made within the FAL, and understand students' ability and growth from watching students participate during the FAL. After FAL implementation, both teachers reported that students were able to complete the FAL and explain their reasoning during the card sort activity. Additionally, Teacher A reported that the FAL helped her determine where her students were struggling with the content whereas Teacher B reported that the FAL helped her assess students' procedural and conceptual understanding. Both teachers also agreed that allowing students the opportunity to learn from feedback given on the pre- and post-assessment and allowing students the opportunity to answer questions with each other through collaboration during the FAL helped increase student achievement.

Teachers reported fluctuations in student achievement throughout the semester. Initially, teachers reported a decrease in student achievement from first semester and the first few weeks in second semester followed by an increase in student achievement after the first FAL implementation. At the end of the semester, teachers reported uncertainty in whether student achievement had increased or remained unchanged. Teachers attributed the initial decline in student achievement to the introduction of new material of which students had no previous experience. Despite the fluctuations in student achievement, both teachers agreed that they believed FAL implementation increased student achievement overall. However, teachers disagreed on what students showed the most improvement regarding achievement. Teacher A reported that her middle-performing students showed the most improvement, whereas Teacher B reported that he high-performing students showed the greatest improvement. Additionally, Teacher B reported that her ELL students benefitted from the FAL because students were able to remember visual representations presented in the FAL when confronted with similar visual representations on assessments later in the course.

At the beginning of the semester, teachers believed that FALs would affect students' content knowledge by increasing understanding of content, increasing comprehension of vocabulary, and bringing deeper connections among concepts. Teachers believed instructional strategies such as direct instruction, chunking material, and guided notes helped students understand procedural fluency with math problems. However, teachers also believed that FALs would help improve content knowledge in other ways, such as practice explaining conceptual understanding, increasing the use of higher-order thinking, and allowing students the opportunity to visually interpret information.

Initially, teachers believed that FALs would require students to use higher-order thinking skills. After FAL implementation, teachers both teachers agreed that FALs helped students articulate their thought processes. Teachers agreed that higher-order thinking and articulation are skills required in FALs which are also necessary for success in mathematics. Teachers also believed that students would be more successful in mathematics by problem-solving independently and articulating their understanding to peers and people outside of the classroom.

Research Question 4

Quantitative Data

Several significant correlations were discovered in the RQ4 results. First, A significant correlation was found between the overall mean gain score on self-efficacy and motivation for the control group. However, no significant correlations were found among the overall mean gain score on self-efficacy, motivation, and achievement for the treatment group. Second, significant correlations were found in the mean gain score for the control group between (1) mastery experiences and competence (positive) and (2) achievement and social persuasions (positive). Third, significant correlations were found for the treatment group between (1) social persuasions and mastery experiences (positive) and (2) autonomy and physiological states (negative).

Qualitative Data

Teachers' perceptions of relationships between student self-efficacy, motivation, and achievement primarily involved their relationship with FAL implementation. Teachers reported a positive relationship between FAL implementation and self-efficacy, between FAL implementation and motivation, and between FAL implementation and student achievement.

Teachers reported an increase in student self-efficacy during the semester and attributed this change to FAL implementation. Teachers expressed the belief that FAL implementation increased student self-efficacy, motivation, and achievement overall. Teachers also expressed the belief that FALs provided students opportunities to express understanding of mathematical concepts through explanations which ultimately impacted student self-efficacy. Although teachers reported fluctuations in self-efficacy, both teachers expressed the belief that FAL implementation had a positive relationship with student self-efficacy.

Teachers initially expressed concern that FAL implementation may have a negative relationship with motivation because students would be deviating from typical classroom instruction. However, both teachers reported an increase in student motivation and attributed this change to the implementation of the first FAL. Teachers expressed the belief that FAL implementation increased student motivation in terms of desire to participate, student confidence, and willingness to participate in the classroom. Although teachers reported fluctuations in motivation, both teachers expressed the belief that FAL implementation had a positive relationship with student motivation.

Finally, teachers also reported an increase in student motivation after FAL implementation. Teachers reported that students were able to complete the activity during the FAL and were able to provide explanations for how they matched cards during the card sort. Teachers believed that feedback, collaboration between students, and opportunities for students to articulate their understanding during the FAL positively affected student achievement. After FAL implementation, teachers agreed that FALs helped students articulate their understanding in both procedural and conceptual ways. Teachers reported observing better grasps on quadratic functions and deeper content knowledge from visual representations of information. Overall, teachers expressed the belief that the implementation of FALs had a positive relationship with student achievement.

Research Question 5

Teachers' perceptions of FAL implementation primarily addressed preparing FALs, implementing FALs, effects of FALs on students, and implementing FALs in the classroom in the future. Teachers agreed preparing for FAL implementation requires more time than typical classroom instruction. Similarities between preparing for FALs and preparing for typical instruction reported by teachers included preparing materials ahead of time, making copies for students, identifying intended learning objectives for students, and aligning the chosen activity with the intended learning objectives. Differences between preparing for FALs and preparing for typical instruction include amount of work needed to prepare materials, amount of time needed to go through the FAL instructions to be fully prepared to facilitate the task, and deciding how to group students prior to implementing the activity. Both teachers agreed that the teaching guide was helpful in preparing to implement FALs. Teachers reported that the teaching guide was primarily beneficial in helping them understand the different components of FALs, what to do when implementing the FAL, and a timeline to follow for FAL implementation. Additionally, Teacher A reported that the prompted questions for pre- and post-assessment feedback were especially helpful while Teacher B emphasized how helpful the sample questions provided in the teacher guide were when implementing the task in the classroom.

At the beginning of the semester, both teachers expressed concerns about FAL implementation regarding the semester's schedule. Teacher A expressed concerns about being able to implement the FAL and still teach the required content in time for the EOC at the end of the semester while Teacher B expressed concern about changes in the schedule due to inclement weather during winter months. However, both teachers made it clear that they were able to implement two FALs over the course of the spring semester. The first FAL was implemented in February, and the second FAL was implemented in May. Both teachers reported having enough time to implement all components of the first FAL including the pre-assessment, collaborative task, and post-assessment, but that they struggled to implement all parts of the second FAL. Teacher A struggled to give the allotted time for the pre-assessment and had to provide feedback as a class rather than providing individual feedback whereas Teacher B reported an inability to give feedback on the post-assessment. Other challenges to FAL implementation reported by both teachers included student engagement as a result of the change in routine and grouping students in a way that they would work well together during COVID-19.

Despite challenges to FAL implementation, both teachers reported positive effects of FAL implementation on their students. Both teachers agreed that implementing FALs helped grow student understanding, increase student engagement among students, required higher-order thinking skills, increased student interaction, and provided a more student-centered and hands-on approach to learning. Additionally, both teachers agreed that student self-efficacy, motivation, and achievement increased after implementing the first FAL. However, Teacher B reported that her students seemed more confident after being able to complete the activity, while Teacher A reported a deeper understanding of content knowledge among her students after FAL implementation. Although teachers reported the benefits of FAL implementation, some students were not interested in the FAL and had to be encouraged, while others were excited to participate in a new activity.

Teachers agreed that they would be interested in implementing FALs in their classrooms in the future. However, both teachers stated they would change how early they begin implementing FALs and how frequently they would implement FALs throughout the school year. However, teachers had differing opinions on how they would alter times allotted for specific components of the FAL during FAL implementation. Teacher A reported a desire to shorten interaction times during the collaborative activity whereas Teacher B reported a desire to lengthen collaborative times during the FAL.

Chapter V

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Information presented in this chapter includes a summary of the related literature, methodology, and findings of this study. Additionally, a discussion of findings with respect to current literature is also provided. Limitations of the study, implications of FAL implementation, and directions for future research are discussed.

Related Literature

Students in the United States have consistently performed lower than students in other high-achieving countries for many years (Hushman & Marley, 2015; OECD, 2019), bringing students' academic performance in the United States to the attention of many policymakers. Poor performance in mathematics has led researchers, theorists, and educators to focus on investigating factors affecting mathematics achievement (Yu & Singh, 2018), such as a common curriculum across states (Seashore, 2015; Research for Action, 2011), various instructional strategies (Edmond, 2010; Wiginton, 2013; Yu & Singh, 2018), and teacher training (Siegle & McCoach, 2007). Low performance in mathematics is not only concerning for educators but also for employers of STEM-related careers because skills needed for success in mathematics are also important skills for success in today's economy. Employers of STEM-related careers have found that a gap exists between skills applicants need and skills applicants have when applying for these careers (Lazio & Ford, 2019).

One effort to improve skills necessary for success in mathematics and student achievement is the introduction of Common Core State Standards (Seashore, 2015). A primary focus of the common core standards is helping students reach higher levels of thinking and application, known as standards of mathematical practice. The introduction of Common Core standards led to the creation of instructional strategies and learning tasks to help teachers address standards of mathematical practice in the classroom (Duffy & Park, 2012), one of which was Formative Assessment Lessons, developed by the Mathematics Design Collaborative (Bill and Melinda Gates Foundation, 2017). FALs were designed to help students connect concepts to prior knowledge or synthesize learning near the end of an instructional unit (Bill and Melinda Gates Foundation, 2017; MARS, 2015a). Previous research has shown that teachers believe the use of FALs improves students' math knowledge, math skills, problem-solving skills (Research for Action, 2011), and student achievement (Wilder, 2015). However, periodic implementation of FALs calls to question the impact FALs can have on students (Seashore, 2015).

Success in high school mathematics not only requires students to build skills necessary for success, but also requires students to engage in the learning process (Borgonovi & Pokropek, 2019; Yurniwati & Hanum, 2017). Willingness to engage in the learning process is affected by many factors, including student self-efficacy and motivation to learn (Recber et al., 2018; Siegle & McCoach, 2007). Previous research has revealed that higher levels of self-efficacy are related to higher levels of student achievement and motivation (Brookhart & Durkin, 2003; Kwan, 2016; Stevens et al., 2004; Zimmerman, 2000). FALs provide structured tasks with achievable goals, opportunities for collaboration among peers, feedback from peers and instructors, and self-reflection which relate to components of self-efficacy as outlined by Bandura (1997). Additionally, FALs are appropriately challenging tasks which require students to apply their learning and persevere during the problem-solving process during collaboration with peers, which previous research has shown can improve students' self-efficacy (DeThomas, 2017; Fast et al., 2010; Fidan, 2017; Kwan, 2016).

Research has shown that student self-efficacy and motivation are positively related to each other (Stevens et al., 2004) and that some teachers believe FAL implementation can increase student engagement in the mathematics classroom (Research for Action, 2011). Research has revealed that extrinsic motivation can decrease student interest and motivation to learn (Niemiec & Ryan, 2009) and that activities meant to foster intrinsic motivation may help students be more equipped for problem-solving and applying knowledge, ultimately improving student achievement (Durmaz & Akkus, 2016; Leon et al., 2015). The intended use and structure of FALs offer challenging tasks, student-centered approaches to instruction, collaboration among peers, carefully constructed feedback, and opportunities to revisit work which may help address components of Ryan and Deci's (2000) Self Determination Theory of motivation. Research has shown that meeting students' needs in these ways helps students be more prepared for problem-solving and ultimately helps students be more successful in the mathematics classroom (Buff, 2019; Griffin, 2018).

Educators must focus on influencing self-efficacy and motivation through carefully chosen instructional strategies. However, even the most effective instructional strategies do not affect student learning if students are unmotivated and have low self-efficacy (Bandura, 1997; Ryan & Deci, 2000, 2009). Implementing FALs offers students the opportunity to receive traditional and student-centered instruction at different times in an instructional unit, which research has shown is more desirable for helping students be more successful in the mathematics classroom (Winginton, 2013; Yu & Singh, 2018).

Initial research on FAL implementation was conducted shortly after FALs were first piloted in the classroom and resulted in evidence of significant effects on student knowledge of concepts (Wilder, 2015) but low effects on student achievement (Herman et al., 2015). Researchers identified the effects of specific instructional strategies on student self-efficacy (Brookhart & Durkin, 2003; Edmond, 2010; McMillan et al., 2010; Stevens et al., 2004) and the effects of instructional strategies on student motivation (Yu & Singh, 2018) as areas in need of further research. Therefore, the primary focus of this study was to determine the impact, if any, of FAL implementation on student self-efficacy, motivation, and achievement in the mathematics classroom.

Methodology

The purpose of this study was to add to the research base of information regarding the impact of instructional strategies on student self-efficacy, motivation, and achievement by answering the following research questions.

1. To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy?

2. To what degree, if any, does FAL implementation affect high school students' motivation?

3. To what degree, if any, does FAL implementation affect student achievement for high school mathematics students?

4. Is there any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation?

5. What are the teachers' perceptions of the overall impact of FAL implementation?

The design for this study was an embedded mixed methods design following the embedded experimental model. The quantitative portion of this design was a combination of quasi-experimental design, including both non-equivalent groups and pretest-posttest design. A baseline of student self-efficacy and motivation was established for both treatment and control groups at the beginning of the semester by administering a single survey that combined two scales. Student self-efficacy and motivation were then measured again at the end of the semester. Scales used in the survey included the Sources of Middle School Mathematics Self-Efficacy Scale (SMMSE) and the Activity Feeling States Scale (AFS). Both scales were reliable instruments.

A baseline of student achievement was also established for both treatment and control groups by administering a researcher-created multiple-choice test at the beginning of the semester. Student achievement was then measured again at the end of the semester for comparison. Questions on both test administrations remained the same and addressed skills taught in the spring semester of and Algebra 1 course, but the order of questions was changed from pretest to posttest.

Student participants were selected via a voluntary sampling method. At the end of the semester, the sample population who completed both administrations of the survey included a total of 20 students, with four students in the control group and 16 students in the treatment group. The sample population who completed both tests included a total of 44 students, with 12 students in the control group and 32 students in the treatment group. Supporting qualitative data were collected from two teachers who implemented FALs in their classrooms via monthly log entries throughout the semester and post-intervention interviews at the end of the semester.

Summary of Findings

A brief summary of the findings for each research question is presented below. A more detailed summary of the findings of this study is presented in Chapter 4.

Research Question 1: To what degree, if any, does FAL implementation affect high school students' mathematics self-efficacy? The effect of FAL implementation on high school students' self-efficacy was tested. To answer this research question, a *t*-test was conducted on the change in mean score for self-efficacy between treatment and control groups. Qualitative data from teacher logs and interviews were used to provide a deeper understanding of the results.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on mastery experiences of the treatment group was positive and slightly greater than the control group. However, the difference in yield between these two was not large enough to be considered statistically significant. The treatment group had a slightly greater mean gain score in four out of six questions than the control group (Q2, 16, 19, and 23) related to mastery experiences. No significant differences were found for individual questions. Analysis of qualitative data revealed that sources of mastery experiences reported by teachers included instruction from previous courses, instruction from previous units, and completing individual practice problems. Teachers agreed that students had increased self-efficacy when attempting problems based on prior knowledge and that students struggled when attempting problems based on concepts with which students had no previous experience. Teachers also agreed that opportunities to master content through practice and chunking material would help improve students' self-efficacy by allowing more opportunities for students to have mastery experiences.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on vicarious experiences of the treatment group was negative and slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered statistically significant. The overall mean gain score on vicarious experiences from *adults* was negative for both the treatment and control groups. The overall mean gain score on vicarious experiences from *peers* was negative for the treatment group and slightly lower than the control group. The overall mean gain score on vicarious experiences from *self* was negative for the treatment group and slightly lower than the control group. The treatment group had a slightly greater mean gain score in only one out of six questions than the control group (Q8) related to vicarious experiences. No significant differences were found for individual subcomponents and questions. Analysis of qualitative data revealed that sources of vicarious experiences reported by teachers included peer collaboration and teacher-led instruction. Teachers described situations in which students had opportunities to listen to teacher explanations and see example problems worked out by teachers during teacher-led instruction. Additionally, teachers described situations in which students were given opportunities to collaborate during and outside of the FAL and reported the belief that increased collaboration would be beneficial for improving student self-efficacy.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on social persuasions of the treatment group was positive but slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered statistically significant. The treatment group had a slightly greater mean gain score in only one out of six questions than the control group (Q21) related to social persuasions. No significant differences were found for the individual question. Analysis of qualitative data revealed that the primary source of social persuasions reported by teachers was student encouragement. Teachers agreed that students needed encouragement at various points during the FAL, including getting started, working throughout the card sort activity, and persevering through solving challenging problems. Teachers also described situations in which they needed to encourage students to work even if they may solve the problem incorrectly.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on physiological states of the treatment group was negative but slightly greater than the control group. However, the difference in yield between these two was not large enough to be considered statistically significant. The treatment group had a slightly greater mean gain score in all six questions than the control group (Q3, 5, 7, 9, 13, and 22) related to physiological states. No significant differences were found for individual questions. Analysis of qualitative data revealed several situations throughout the semester in which physiological states affected students. Reported instances included students feeling uncomfortable with the change in instruction caused by the introduction of FALs, students feeling confused when initially faced with FALs, and students feeling overwhelmed with new content requiring multiple steps. Teachers initially believed students would either not be responsive or would be hesitant to participate in FALs. However, after FAL implementation, teachers reported that some students enjoyed the change in instruction whereas other students may be more comfortable with FALs if implemented earlier and more often throughout the semester.

Overall, analysis of qualitative data revealed that teachers believed student self-efficacy fluctuated throughout the semester. Challenges with students' self-efficacy were reported during the initial FAL implementation, primarily related to terminology used in the activity and initial student confidence in their abilities. However, teachers believed that the increase in student self-efficacy near the beginning of the semester could be attributed to the first implementation of a FAL and did not believe that any decrease in self-efficacy was related to FAL implementation. Instead, teachers reported that they believed FAL implementation helped increase students' confidence in their abilities and their overall self-efficacy.

Research Question 2: To what degree, if any, does FAL implementation affect high school students' motivation? The effect of FAL implementation on high school students' motivation was tested. To answer this research question, a *t*-test was conducted on the change in mean score for motivation between treatment and control groups. Qualitative data from teacher logs and interviews were used to provide a deeper understanding of the results.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on autonomy of the treatment group was negative and slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. The treatment group had a slightly greater mean gain score in only one out of three questions than the control group (Q4) related to autonomy. No significant differences were found for individual questions. Analysis of qualitative data revealed that teachers initially disagreed on whether FAL implementation would help students become more autonomous learners although they agreed that FAL implementation would require more independence from students during the learning process. After FAL implementation, teachers reported the belief that students were more independent in the learning process, had more freedom, had more responsibility, and had a chance to explore content on their own.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on competence of the treatment group was positive and slightly higher than the control group. However, the difference in yield between these two was not large enough to be considered significant. The treatment group had a slightly greater mean gain score in two out of three questions than the control group (Q1 and 7) related to competence. No significant differences were found for individual questions. Analysis of qualitative data revealed that initially, teachers were concerned about FAL implementation for students who lacked competence with material addressed in the FALs but also that teachers were hopeful FAL implementation would help build competence for these students. Teachers reported that prior knowledge helped students be more motivated and eager to learn. Additionally, teachers reported they believed that breaking information into smaller sections and participating in FALs would help build student confidence.

Quantitative analysis of student responses to the survey revealed that the overall mean gain score on relatedness of the treatment was positive but slightly lower than the control group. However, the difference in yield between these two was not large enough to be considered significant. The mean gain scores of all questions about relatedness for the treatment group were slightly lower than the control group. No significant differences were found for individual questions. Analysis of qualitative data revealed that teachers believed collaboration and creating a safe learning environment in which students can make mistakes during FALs influenced relatedness for students. Teachers reported having to encourage students who did not want to collaborate and described scenarios in which teachers had to encourage students to answer questions even if the answer they gave might be incorrect.

Overall, analysis of qualitative data revealed that teachers believed student motivation fluctuated throughout the semester. However, teachers attributed decreases in motivation to the introduction of new content or outside factors and did not believe that any decrease in motivation was related to FAL implementation. Instead, teachers reported that they believed FAL implementation had a positive influence on student motivation.

Research Question 3: To what degree, if any, does FAL implementation affect student achievement for high school mathematics students? The effect of FAL implementation on high school students' math achievement was tested. To answer this research question, a *t*-test was conducted on the change in mean score for math achievement between treatment and control groups. Qualitative data from teacher logs and interviews were used to provide a deeper understanding of the results.

Quantitative analysis of student test performance revealed that students in the treatment group had a slightly higher pass rate on 27 out of the 37 test items than students in the control group. Students' mean gain test scores in the treatment group were also slightly greater than students in the control group. However, the difference in yield between these two was not large enough to be statistically significant.

Although quantitative data did not show statistically significant differences in student achievement for students in the treatment group, qualitative data analysis revealed teachers believed FAL implementation increased student achievement overall. Teachers reported that students were able to complete the FAL and explain their reasoning during the card sort activity. Teachers also reported that FALs allowed students to use higher-order thinking skills and articulate their understanding, skills necessary for success in mathematics. Both teachers agreed that allowing students the opportunity to learn from feedback given on the preassessment, feedback given on the post-assessment, visual representations presented in the FAL, and opportunities to collaborate with peers during the FAL helped increase student achievement, particularly for high- and middle-performing students. Although teachers reported beliefs that FAL implementation positively impacted student achievement, teachers also reported fluctuations in student achievement throughout the semester. Teachers attributed the fluctuations in student achievement to the introduction of new, more challenging material with which students had no prior experience.

Research Question 4: Is there any relationship among students' mathematics self-efficacy, motivation, achievement, and FAL implementation? The effect of FAL implementation on high school motivation was tested. To answer this research question, a correlation analysis was conducted among overall self-efficacy, motivation, and achievement and among subcomponents of self-efficacy, subcomponents of motivation, and overall achievement. Qualitative data from teacher logs and interviews were used to provide a deeper understanding of the results.

Quantitative data analysis revealed several significant correlations. A significant positive correlation was found between the overall mean gain score on self-efficacy and motivation for the control group. No significant correlation was found among the overall mean gain score on self-efficacy, motivation, and achievement for the treatment group. Significant positive correlations were found for the mean gain score for the control group between mastery experiences and competence and between achievement and social persuasions. A significant positive correlation was found in the mean gain score for the treatment group between social persuasions and mastery experiences. A significant negative correlation was found in the mean gain score for the treatment group between autonomy and physiological states.

Analysis of qualitative data revealed that teachers believed that a positive relationship exists between FAL implementation and self-efficacy, between FAL implementation and motivation, and between FAL implementation and student achievement. Teachers reported an increase in self-efficacy and motivation and attributed this change to FAL implementation. Despite fluctuations in student self-efficacy and motivation throughout the semester, teachers expressed the belief that FAL implementation had a positive relationship with self-efficacy and motivation. Similarly, teachers expressed the belief that opportunities for feedback, articulating understanding, and collaboration with peers contributed to a positive relationship between FAL implementation and student achievement.

Research Question 5: What are the teachers' perceptions of the overall impact of FAL implementation? Teacher perceptions of the impact of FAL implementation on instructional planning and students were evaluated. To answer this research question, qualitative data from teacher logs and interviews were analyzed.

Teachers reported that preparing for FAL implementation required more time than preparing for typical classroom instruction. Preparing for FALs required teachers to take more time to prepare materials, go through the FAL to be fully prepared for facilitating the task, and deciding how to group students prior to implementing the activity. However, teachers also identified similarities between preparing for FALs and preparing for typical classroom instruction, including preparing materials ahead of time, making copies for students, identifying intended learning objectives, and aligning the chosen activity with the intended learning objectives. Teachers agreed that the teaching guide was a helpful tool for FAL implementation because it helped them understand different components of FALs, how to implement FALs, and what timeline to follow for FAL implementation. Additionally, teachers reported that the prompts and sample questions provided in the teacher guide were beneficial for FAL implementation.

Teachers were able to implement two FALs during the spring semester, despite being concerned about amount of time available during the semester due to winter weather and the scheduled state end-of-course exam. When implementing the first FAL, teachers were able to implement all components and provide feedback. However, when implementing the second FAL, teachers reported having to alter the timeline for the pre-assessment, resort to whole-class feedback rather than individual feedback on the pre-assessment, or forego feedback on the post-assessment altogether. Other challenges of

FAL implementation reported by teachers included student engagement during the activity and grouping students for a productive work environment, especially in the midst of COVID-19.

Despite challenges with FAL implementation at the end of the semester, teachers agreed that implementing FALs seemed to have a positive effect on students in terms of student understanding, active engagement among students, use of higher-order thinking skills, student interaction, student-centered learning, and hands-on learning. Separately, teachers reported positive influences of FAL implementation on student confidence and depth of content knowledge. Additionally, teachers agreed that student self-efficacy, motivation, and achievement seemed to increase after FAL implementation. However, teachers also reported that while some students seemed excited to participate in FALs, others were not interested and had to be encouraged to participate.

Teachers agreed that they would be interested in implementing FALs in their classrooms in the future but also noted changes they would make for future use. For example, teachers reported they would like to begin implementing FALs earlier and more frequently throughout the school year. Additionally, teachers reported that they would adjust times given for components of FALs, such as the collaborative task, to fit their students' needs.

Discussion of Findings

Although no statistically significant differences were found in the mean gain scores between treatment and control groups for self-efficacy, motivation, and overall student achievement, findings revealed a number of positive outcomes from implementing FALs in the high school mathematics classroom. In addition, several correlations were found to be significant related to self-efficacy, motivation, and overall student achievement between groups.

Self-Efficacy

No significant differences were found between treatment and control groups related to self-efficacy, but the treatment group did have a slightly greater mean gain score than the control group in four questions for mastery experiences, one question for vicarious experiences, one question for social persuasions, and six questions for physiological states. Qualitative data also showed that teachers perceived FAL implementation helped increase student self-efficacy. This result is consistent with previous research that revealed tasks such as FALs, which provide structured tasks which achievable goals, collaborative opportunities, frequent feedback, and self-reflection, positively influence students' mathematics self-efficacy (DeThomas, 2017; Fidan, 2017; Kwan, 2016). When presented with a new task, higher self-efficacy levels help students believe they can complete a task (Stevens et al., 2004). Results of this study supported Stevens et al. (2004) by revealing that FAL implementation increased students' beliefs that they would do well even on the most difficult math assignments.

Researchers have stated that mastery experiences are important for building students' self-efficacy (McMillan et al., 2010). Based on the qualitative results of this study, teachers reported that FAL implementation allowed students to attempt a problem on their own during the pretest but then to collaborate with peers, which are important opportunities for mastery experiences (Schunk & Pajares, 2009; Schunk & Richardson, 2011; Zimmerman, 2000). Quantitative results of this study regarding questions related to mastery experiences revealed that students who participated in FAL implementation felt that studying harder helped them do better in math and that they do well even on the most difficult math assignments. These results indicate that students would be more likely to attempt challenging problems because they believe they would do well. This was consistent with previous research, which stated that students in appropriately challenging classrooms would have higher levels of self-efficacy (Fast et al., 2010; Kwan, 2016) and that students with higher levels of self-efficacy would be more likely to partake in challenging tasks (Bandura, 1977; Zimmerman, 2000). These results indicated that the inclusion of FALs in the mathematics classroom might increase students' self-efficacy by allowing for mastery experiences outside of typical individual practice and help increase collaborative opportunities between peers.

Based on the results of this study, FAL implementation also appeared to help students picture themselves solving problems correctly when provided the opportunity to experience success through their teacher. Vicarious experiences through *adults* is an important factor of Bandura's (1977) self-efficacy theory. In this study, teachers reported modeling how to perform the card sort activity during the FAL before allowing students to begin. Teachers believed that modeling the activity helped students feel more confident about being able to begin the activity. These results suggested that the inclusion of FALs in the classroom might allow students to vicariously experience success through methods other than traditional instruction.

Verbal, or social, persuasion is another important component of Bandura's (1977) self-efficacy theory. Previous research has shown that providing positive and specific feedback can help increase students' self-efficacy (Bandura, 1977; Thompson, 2007; Zimmerman, 2014). FAL implementation influenced students' self-efficacy by means of social persuasion. Students reported increased levels of being told they have a talent for math, being praised for their math abilities, being told they were good at math from students and teachers, and feeling that classmates liked to work with them because of their math ability. However, increases in responses for these sources of social persuasions were lower than students who did not participate in FALs. Students who participated in FALs did report feeling that adults in their family told them they were good at math more so than students who did not participate in FALs. Although this form of social persuasions did not come from the teacher, Thompson (2007) stated that any form of feedback can positively influence students' self-efficacy. Additionally, teachers described several situations in which they clearly indicated their belief in students' ability to complete the task during the FAL, which is an important component of verbal persuasion, according to Schunk and Pajares (2009). These results indicated that FALs might positively influence students' self-efficacy by providing opportunities for social persuasion.

Finally, FAL implementation influenced students' self-efficacy by means of addressing physiological states. Physiological states are often the most difficult form of self-efficacy to address in the classroom (Zimmerman, 2000). Students who participated in FALs appeared to feel less stressed and nervous when beginning math work. However, students reported increased levels of tension, energy depletion, inability to think clearly, and depression when learning math. Although, reported increases in these physiological states were not as high for students who participated in FALs when compared to students who did not participate in FALs. Teachers also reported seeing greater levels of confidence among students when participating in FALs. These results suggested that the inclusion of FALs in the classroom might help students be more comfortable and might help diminish feelings of anxiety and stress when faced with mathematics tasks. This was consistent with findings from Zimmerman (2000) who stated that physiological states should not be addressed directly but should be indirectly addressed by targeting students' self-efficacy.

Although no statistically significant differences were found in the mean gain scores between treatment and control groups for self-efficacy, positive outcomes from this study showed that FAL implementation might influence students' self-efficacy. Teachers reported that several challenges were presented during this school year regarding grouping students, student attendance, and local school scheduling changes due to the COVID-19 pandemic. The limitations on the number of students grouped, the duration for which students could be grouped, and the deviation from typical school schedules might have impacted the effect of FAL implementation on students.

Motivation

Students in mathematics classes are often passive learners because traditional instructional techniques allow them to memorize processes instead of instilling creative thinking (Bensacon et al., 2015) and to rely heavily on supervision of the teacher, rewards, or punishments for motivation (Niemic & Ryan, 2009). No significant differences were found between treatment and control groups related to motivation, but the treatment group did have a slightly greater mean gain score than the control group in one question for autonomy and two questions for competence. In addition, teachers believed that FAL implementation improved student motivation by meeting the needs of motivation outlined by Ryan and Deci (2000). Specifically, FAL implementation might improve motivation by addressing the needs of autonomy, competence, and relatedness.

According to Ryan and Deci (2000), students need to take control of the learning process to be motivated in the classroom. Although qualitative results of this study did not show evidence in teacher perceptions that FAL implementation increased student autonomy, students who participated in FALs showed a slightly greater feeling of freedom while participating in math class than students who did not participate in FALs. Teachers also reported that some students seemed more excited about participating in the FAL and enjoyed learning. These results are consistent with Kaplan (2018) who found that students who experienced environments that support autonomy enjoyed learning more than students who experienced environments with more controlling efforts. Teachers mentioned that students were able to solve problems and explain different approaches to solutions during the collaborative activity. Having the opportunity to choose different approaches to problem-solving and believing they have a voice in the learning process helps promote autonomy and thereby increases student motivation (Durmaz & Akkus, 2016; Jones et al., 2011; Niemiec & Ryan, 2009). Finally, teachers reported that students had increased opportunities to articulate their problem-solving processes and understanding during FALs which is another important method for fostering autonomy in the mathematics classroom (Ross & Bergin, 2011; Ryan & Deci, 2009). These results suggested that the inclusion of FALs in the mathematics classroom might help promote student autonomy, which in turn increases student motivation.

Ryan and Deci (2000) also stated that students need to believe they are competent in mathematics to be motivated in the classroom. Based on the quantitative result, students who participated in FALs showed a slightly greater feeling of being capable and competent while participating in math class than those who did not. Analysis of qualitative data revealed that teachers believed FALs allowed students to become active in the learning process and that FALs presented challenging but achievable tasks which are important for fostering student competence (Seifert & Sutton, 2017). Teachers also reported that students became more active in the learning process during FAL implementation and that they had opportunities to discuss their thought processes with their peers. These are desirable components of instruction meant to foster student competence in the classroom (Durmaz & Akkus, 2016). In addition, students felt that their skills are improving after FAL implementation. However, the increase in responses for this source of competency was slightly lower than students who did not participate in FALs. Teachers stated that FALs were challenging for students because students were forced to use higher-order thinking skills and because the tasks offered challenging activities that built on content learned earlier in the unit or school year. These results described components of instructional tasks identified in previous research as ideal components for fostering competence and therefore improving student motivation (Bobis et al., 2011; Niemiec & Ryan, 2009; Ross & Bergin, 2011). Finally, teachers reported that the use of FALs helped them increase the amount of feedback given to students through the use of the preassessment, post-assessment, and the card sort activity. Teachers described situations in which they were able to provide specific feedback targeted towards individual students and specific feedback targeted to the whole class or groups of students so that students could reflect on their performance from preassessment to post-assessment. Specific feedback given to students in a way that allows them to reflect on their own understanding helps students become more competent and more motivated in the learning process (Griffin, 2018; Niemiec & Ryan, 2009). These results indicated that FAL implementation might improve student motivation by helping students feel competent in the mathematics classroom.

Finally, Ryan and Deci (2000) stated that students are motivated when they feel respected and that they belong in a classroom. Quantitative results of this study showed that FAL implementation slightly increased students' feeling of belonging and feeling that people cared about them while participating in math class. This result suggested that FAL implementation might help satisfy students' need for relatedness in the classroom. However, it is important to note that these feelings did not improve as much for students who participated in FALs compared to those who did not. Analysis of qualitative data revealed that teachers believed that the collaborative opportunities in the FAL allowed students the opportunity to work together, which helped them be more excited about learning and more motivated to complete the task. These findings were consistent with suggestions made by Seifert and Sutton (2017) to facilitate relatedness in the classroom. Additionally, teachers reported observing students be more willing to engage in class discussions and answer questions after FAL implementation. This results from meeting the need for relatedness to motivate students, according to Ross and Bergin (2011). These results indicated that the inclusion of FALs in the classroom might help foster a safe learning environment in which the need for relatedness was met, improving student motivation.

Although no statistically significant differences were found in the mean gain scores between treatment and control groups for motivation, positive outcomes from this study showed that FAL implementation might influence students' motivation by meeting the needs of self-determination theory. Ryan and Deci (2000) stated that meeting the needs of autonomy, relatedness, and competence in the classroom provides the ideal opportunity for increased motivation. Results of this study indicated that the inclusion of FALs in the classroom might help meet these needs and therefore increase student motivation. Teachers reported that the students became less motivated as the semester progressed, but that they did not believe FAL implementation was a cause for the decrease in motivation. Additionally, teachers reported several challenges during this school year regarding grouping students, student attendance, and local school scheduling changes due to the COVID-19 pandemic. The limitations on the number of students grouped, the duration for which students could be grouped, and the deviation from typical school schedules may have impacted the effect of FAL implementation on students.

Achievement

No significant differences were found related to achievement, but students who participated in FALs appeared to have greater pass rates on the majority of questions on the math assessment compared to students who did not participate in FALs. These quantitative results were further supported by teacher comments made in logs and interviews in which teachers reported the belief that FAL implementation increased student achievement, content knowledge, and depth of understanding. These results were consistent with previous research which has shown that teachers believe FAL implementation improves students' math skills, knowledge (Research for Action, 2011), and understanding (Wilder, 2015). In this study, teachers also reported the belief that the opportunity for students to have traditional instruction in addition to student-centered approaches offered with FAL implementation helped improve student achievement, which was consistent with the findings from other researchers (Schoenfeld, 2015; Wiginton, 2013; Yu & Singh, 2018).

Additionally, the lack of statistical significance in quantitative results for overall student achievement was consistent with teacher perceptions from initial research conducted during the pilot phase of FAL implementation (Research for Action, 2011) in which teachers reported low effects on student achievement. However, teacher responses given in this study through log entries and interviews suggested that students' conceptual understanding and depth of knowledge of specific math concepts had improved. These comments were consistent with research conducted by Wilder (2015) who reported significant effects on students' knowledge of specific concepts in the mathematics classroom.

Although no statistically significant differences were found in the mean gain scores between treatment and control groups for achievement, positive outcomes from this study showed that FAL implementation might influence students' achievement by means of test performance, content knowledge, and skills necessary for mathematical success. Teachers reported several challenges presented during this school year regarding grouping students, student attendance, and local school scheduling changes due to the COVID-19 pandemic. The limitations on the number of students grouped, the duration for which students could be grouped, and the deviation from typical school schedules might have impacted the effect of FAL implementation on students.

Relationships among Self-Efficacy, Motivation, Achievement, and FAL Implementation

Based on the quantitative results of this study, there was no significant relationship among students' overall self-efficacy, motivation, and achievement for the treatment group. However, there was one significant positive relationship between self-efficacy and motivation for the control group, which was consistent with research from Brookhart and Durkin (2003), Kwan (2016), Stevens et al. (2004), and Zimmerman (2000). Qualitative results revealed that teachers perceived several relationships between FAL implementation and each construct of self-efficacy, motivation, and achievement separately. In log entries and interviews, both teachers agreed that they believed FAL implementation had a positive relationship with self-efficacy and motivation separately, despite fluctuations in students' self-efficacy and motivation throughout the semester. Teachers also reported belief that FAL implementation was positively related to student achievement throughout the semester. These results were consistent with early research on FAL implementation (Research for Action, 2011) and indicated that the use of FALs might positively influence students in the mathematics classroom.

More specifically, there were significant results in the relationships between subcomponents of self-efficacy and subcomponents of motivation for both students who participated in FALs and for students who did not. A positive relationship was shown between mastery experiences and competence for students who did not participate in FALs. This relationship is consistent with information presented by Ryan and Deci (2000). Additionally, this relationship was further confirmed by teacher logs and interviews in which teachers expressed belief that an increase in self-efficacy helped students feel more confident and believe they had the skills necessary to complete the task. A positive relationship was also found between achievement and social persuasions for students who did not participate in FALs. This relationship is not surprising because social persuasion is a subcomponent of self-efficacy, and previous research has shown that increased self-efficacy leads to higher levels of student achievement (Zimmerman, 2000).

A positive relationship was shown between social persuasions and mastery experiences for students who participated in FALs. This positive relationship was further confirmed by teacher logs and interviews in which teachers reported that some students would successfully complete problems and the task after receiving encouragement from teachers. Alternatively, a negative relationship was shown between autonomy and physiological states. Relationships between components of self-efficacy and components of motivation as outlined by self-determination theory have been mentioned in previous research by Ryan and Deci (2000). This quantitative fining was aligned with the qualitative result. Initially, teachers disagreed on whether FAL implementation would help students be autonomous learners. They agreed that FALs would require more independence from students. However, Teachers A and B had different opinions about autonomy. Teacher A believed the increased independence helped students embrace being independent learners, but Teacher B believed that the increased independence would cause students to lose motivation. They described several instances throughout the semester in which physiological states affected students. These instances included students feeling uncomfortable with the change in instruction caused by the introduction of FALs, students feeling confused when initially faced with FALs, and students feeling overwhelmed with new content requiring multiple steps to solve.

Teacher's Perceptions of Impact of FAL Implementation

Based on the results of this study, teachers believed that FAL implementation was more time-consuming than typical classroom instruction in terms of preparation. These results were consistent with early research conducted on FAL implementation in the high school mathematics classroom (Research for Action, 2011). However, contrary to teacher reports provided by Research for Action (2011), both teachers in this study believed that FAL preparation was still manageable and stated that time needed for preparation would not deter them from implementing them again in the future.

Teachers in this study reported the belief that FAL implementation helped students reach deeper levels of knowledge, increased student achievement on assessments, and helped reinforce concepts taught via traditional instruction earlier in the unit. This was consistent with the intended results of implementing FALs in the classroom presented in previous research (Duffy & Park, 2012; Herman et al., 2015; Research for Action, 2011). Teachers also mentioned certain aspects of FALs that they enjoyed seeing in the classroom, such as collaboration among peers and hearing students explain different approaches to solving problems. These aspects were mentioned by Bobis et al. (2011) as factors contributing to student motivation in the classroom. Additionally, teachers reported believing that FALs helped their students be more active in the learning process, use prior knowledge from previous math classes and units, encouraged collaboration, and encouraged discussion among peers. These benefits of FAL implementation have also been recognized in previous research (Schoenfeld, 2015) in which FAL implementation was said to benefit student learning by activating prior knowledge, promote active learning, and challenge students to interact with the content while discussing thought processes and reasoning strategies with peers.

Teachers in this study reported belief that FAL implementation helped them identify strengths and weaknesses in their students that may have been missed with traditional instruction, which is consistent with the intention for FAL implementation in the classroom (Research for Action, 2011). Additionally, teachers reported in end of year interviews that their experience with FAL implementation would alter how they use formative assessment and provide feedback to students in the future. These changes in teacher practices are consistent with early research on FAL implementation (Research for Action, 2011).

Research has also shown that improper implementation of FALs by not completing all components may lessen the effects of FAL implementation on students (Research for Action, 2011). However, both teachers in this study agreed that all parts of each FAL were implemented but that some parts of the second FAL had to be altered due to the school schedule and course timeline. The alterations made to FAL components could have affected the impact FALs had on students. Additionally, previous research that revealed lower effects on student achievement than expected contributed to the results to novelty of FALs for both teachers and students (Herman et al., 2015). FALs were also a new instructional strategy for teachers and students in this study because it was important that students did not have previous experience with FALs. However, teachers at the selected school also did not have previous experience with implementing FALs. The results of this study indicated that teachers perceived FALs as a useful tool for students and teachers, but the novelty of FALs to teachers and students might have influenced the effect FALs had on students in this study.

Overall, the results of this study indicated positive teacher perceptions about FAL implementation and the effects of FAL implementation on students despite insignificant quantitative data results. It is important to note that when each FAL was implemented in the classroom, all students who were present on the day of implementation participated in the FAL. Therefore, teacher perceptions provided in this study include observations made of all students who participated in the FAL. However, quantitative data collected in this study only represented students who elected to participate and were able or willing to complete both the surveys and tests. Therefore, the limited number of students who participated in quantitative data collection and the inability to isolate students who elected to participate in quantitative data collection from other students during FAL implementation may have limited the quantitative results of this study.

Limitations of the Study

The study was limited to students enrolled in Algebra 1 at a single high school in northern Georgia. The limited sample size made it more difficult to generalize findings to larger populations. Additionally, class rosters were determined by the local school, preventing randomization of participants to the treatment and control groups.

Another limitation of this study is that data collection was done during the school year following a shut-down of face-to-face instruction as a result of the COVID-19 pandemic. The selected county allowed students to choose between face-to-face instruction at the beginning of the semester and then allowed students to revisit their decision at the end of the first semester. Since permission for participation in this study was gathered from students and parents at the end of first semester, some students who elected to participate in the study were no longer enrolled in face-to-face instruction at the time of data collection. Additionally, some students who were enrolled in face-to-face instruction were not able to participate because they were enrolled in virtual learning during first semester and therefore, permission to participate in the study could not be obtained before data collection began. The COVID-19 pandemic also changed protocols necessary in school for student health and safety. These protocols required students to be quarantined if they either contracted or were exposed to COVID-19 which potentially affected the number of students who were able to complete all administrations of the surveys and assessment, possibly contributing to the limited sample size at the conclusion of data collection.

Other confounding variables may have influenced the findings of this study. Confounding variables that may have been present in this study include whether students were enrolled in additional math classes, whether a student was repeating Algebra 1, and whether students were attending tutoring sessions outside of class. However, selecting teachers who plan instruction together through frequent collaboration, administering surveys and assessments in a pretest-posttest design over a short period of time, and comparing results between a treatment and control group helped deter the effects of confounding variables in this study. Additionally, the COVID-19 pandemic brought challenges to the classroom and students' personal lives which could have affected student achievement as measured by assessments. The COVID-19 pandemic offered the potential for students to be absent for extended periods of time throughout the semester due to illness or exposure, leaving students to learn content via videos available online instead of in class with other students. Similarly, changes in school and personal lives of students as a result of the COVID-19 pandemic may have affected student responses regarding self-efficacy and motivation as measured by survey administrations. Many changes were made to school and classroom environments, including social distancing, encouragement of masks, etc., to help stop the spread of COVID which could have affected students.

Another limitation of this study is the use of a researcher-created test. Using locally created assessments would likely eliminate posttest scores for high-performing students because the chosen county allowed students with a course average of 90 or greater at the end of spring semester to be exempt final exams. Therefore, a researcher-created test was used, which included carefully chosen questions addressing spring semester content gathered from resources intended to prepare students for the state Algebra 1 end-of-course exam.

Implications for FAL Implementation and Future Research

The results of this study demonstrated the impact that FAL implementation might have on the high school mathematics classroom. Although there were no statistically significant differences in self-efficacy, motivation, and achievement between students who participated in FALs and those who did not, this study did have some positive descriptive data from surveys and tests, and qualitative data from teacher logs and interviews. This could conclude that including FALs as an instructional strategy might positively impact students' self-efficacy, motivation, and achievement. When students have increased levels of self-efficacy and motivation, they also have higher levels of achievement. Therefore, the inclusion of FALs in the classroom might be a useful tool for teachers to help improve mathematics achievement and affect students in a way helping them become more successful in future courses.

Additionally, the results of this study have shown how the inclusion of FALs in the classroom might impact teachers' perceptions of students. Teachers in this study were surprised to find how well their students were able to do with the FALs even though some students required more encouragement than others. The inclusion of FALs as an instructional tool allowed teachers another method for assessing students in which they were able to identify misconceptions they may have missed on traditional formative assessments such as quizzes. These results showed that FAL implementation in the classroom might have a positive effect on students and teachers, which would lead to more successful and impactful mathematics classroom instruction.

The number of FALs implemented in this study was limited due to the study's time frame, school schedules related to COVID-19, and pending state exams. Previous research has called into question the periodic implementation of FALs (Seashore, 2015). Therefore, it is important that teachers begin looking at available FALs at the beginning of the school year so that FALs can be implemented more regularly to achieve maximum benefits.

There are several opportunities for future research based on the results of this study. Future research should include a larger sample size of students. The larger sample size could be from a single school or include students from multiple schools within the same county. A larger sample size would be recommended to allow for a more rigorous analysis of quantitative data between treatment and control groups as well as a more reliable comparison for correlations among student self-efficacy, motivation, and achievement. In the current study, the sample size provided a limited understanding of how FAL implementation might affect students because a small portion of students elected to participate, and even fewer students were able to finish both administrations of the surveys and tests. Including a larger sample size or ensuring that all participants complete administrations of the surveys and tests would allow for the opportunity to more accurately interpret the results of quantitative analyses and would provide a deeper understanding of how FAL may affect students.

In the post-pandemic world of education, future research could also include both students enrolled in face-to-face instruction and students who are enrolled in virtual instruction. The inclusion of students in both learning environments would allow for comparisons of FAL implementation between learning environments. Additionally, participation in virtual classrooms seems to be increasing. Therefore, it would be beneficial to understand what effects, if any, FAL implementation would have on students who attend class online rather than in person.

Additionally, future research should include a longer timeline for implementation. This study was limited to a single semester. Prior research (Research for Action, 2011) and qualitative data gathered from teachers in this study suggested that FALs should be implemented earlier in the school year. Collecting data over the course of a school year rather than a single semester would allow for more consistent and more frequent FAL implementation, which could provide more reliable data for comparison.

Future research should include student perceptions of the effects of FALs on self-efficacy, motivation, and achievement. Qualitative data gathered from this study only represented teacher perceptions of the effects of FAL implementation. However, perceptions of teachers and perceptions of students may not necessarily align. Collecting qualitative data from either teachers and students or just students would provide a different perspective of the effect of FAL implementation on students in the mathematics classroom.

Finally, future research could include grade levels other than Algebra 1. Currently, Algebra 1 is the only mathematics class that requires an end-of-course test in the state of Georgia. However, FALs are available for Geometry and Algebra II as well. The inclusion of students in higher grade levels would allow for comparison of effects of FAL implementation across different mathematics classes and would provide a deeper understanding of how FAL implementation affects mathematics students as they progress through high school.

Conclusion

For many high school students, particularly students pursuing careers in STEM fields, performing well in mathematics classes is crucial to success in high school post-high school endeavors. Therefore, it is important that educators have the necessary tools to not only use instructional strategies to target understanding but also to implement strategies that target underlying constructs affecting student achievement, such as self-efficacy and motivation.

This study examined students' self-efficacy, motivation, and achievement in response to formative assessment lesson implementation in the high school Algebra 1 classroom. Results from this study suggested that FAL implementation might affect students by targeting subcomponents of self-efficacy and motivation as well as student achievement. Results from this study also suggested that FAL implementation might affect teachers by challenging them to move from traditional instructional techniques to instruction focusing on students and providing more opportunities for student inquiry.

More research is needed to investigate the impact FALs can have on students in the high school mathematics classroom. Conducting this study in the midst of COVID-19 led to several limitations and multiple avenues for future research. Future studies could focus on increasing the number and frequency of FALs implemented, increasing the number of students participating in the study, and including student perceptions of effects of FAL implementation to gain a deeper understanding of how FALs affect high school mathematics students.

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Appendix A

Survey Demographics Questions

Survey Demographics Questions

1. Please select your gender:
    a. Male
    b. Female

2. Please select your ethnicity:
    a. White
    b. African American/Black
    c. Asian/Asian American
    d. Hispanic/Latino(a)
    e. Native American
    f. Mixed Ethnicity
    g. Other

3. Are you enrolled in another math class other than Algebra 1? (For example, support math, geometry, algebra II, AMDM, etc.)
    a. Yes
    b. No

Appendix B

Sources of Middle School Mathematics Self-Efficacy Scale

Middle School Mathematics Self-Efficacy Scale

Directions: Tell us how true or false each statement is for you.

1	2	3	4	5	6
Definitely False	**Mostly False**	**A little bit False**	**A little bit True**	**Mostly True**	**Definitely True**

1	Seeing adults do well in math pushes me to do better. (VA)	1	2	3	4	5	6
2	I make excellent grades on math tests. (ME)	1	2	3	4	5	6
3	My whole body becomes tense when I have to do math. (PH*)	1	2	3	4	5	6
4	I imagine myself working through challenging problems successfully. (VS)	1	2	3	4	5	6
5	Just being in math class makes me feel stressed and nervous. (PH*)	1	2	3	4	5	6
6	People have told me that I have a talent for math. (P)	1	2	3	4	5	6
7	Doing math work takes all of my energy. (PH*)	1	2	3	4	5	6
8	When I see how my math teacher solves a problem, I can picture myself solving the problem the same way. (VA)	1	2	3	4	5	6
9	I start to feel stressed-out as soon as I begin my work. (PH*)	1	2	3	4	5	6
10	I have been praised for my ability in math. (P)	1	2	3	4	5	6
11	My math teachers have told me that I am good at learning math. (P)	1	2	3	4	5	6
12	Seeing kids do better than me in math pushes me to do better. (VP)	1	2	3	4	5	6
13	My mind goes blank and I am unable to think clearly when doing my math work. (PH*)	1	2	3	4	5	6
14	I do well on math assignments. (ME)	1	2	3	4	5	6
15	I have always been successful with math. (ME)	1	2	3	4	5	6
16	I got good grades in math on my last report card. (ME)	1	2	3	4	5	6
17	I compete with myself in math. (VS)	1	2	3	4	5	6
18	Other students have told me that I'm good at learning math. (P)	1	2	3	4	5	6
19	Even when I study very hard, I do poorly in math. (ME*)	1	2	3	4	5	6
20	Classmates like to work with me in math because they think I'm good at it. (P)	1	2	3	4	5	6
21	Adults in my family have told me what a good math student I am. (P)	1	2	3	4	5	6

22	I get depressed when I think about learning math. (PH*)	1	2	3	4	5	6
23	I do well on even the most difficult math assignments. (ME)	1	2	3	4	5	6
24	When I see another student solve a math problem, I can see myself solving the problem the same way. (VP)	1	2	3	4	5	6

ME, Mastery Experiences; VA, Vicarious Experience from Adults; VP; Vicarious Experience from Peers; VS, Vicarious Experience from Self; P, Social Persuasions; PH, Physiological State; * Reverse-scored item

Appendix C

Activity Feeling States Scale

Activity Feeling States Scale

Consider your experience while participating in your math class. For each item below, circle a number near 7 if you strongly agree that solving math problems in class makes you feel that way. Circle a number near 1 if you strongly disagree that solving math problems in class makes you feel that way. If you agree and disagree equally with the item, then circle a number near 4.

Participating in my math class makes me feel...

	Strongly Disagree 1	2	3	Agree & Disagree Equally 4	5	6	Strongly Agree 7
1. Capable (C)	1	2	3	4	5	6	7
2. I belong and the people here care about me (R)	1	2	3	4	5	6	7
3. Stressed (Filler)	1	2	3	4	5	6	7
4. Free (A)	1	2	3	4	5	6	7
5. Involved with close friends (R)	1	2	3	4	5	6	7
6. Pressured (Filler)	1	2	3	4	5	6	7
7. Competent (C)	1	2	3	4	5	6	7
8. I'm doing what I want to be doing (A)	1	2	3	4	5	6	7
9. Uptight (Filler)	1	2	3	4	5	6	7
10. Emotionally close to the people around me (R)	1	2	3	4	5	6	7
11. My skills are improving (C)	1	2	3	4	5	6	7
12. Free to decide for myself what to do (A)	1	2	3	4	5	6	7

Scoring Key:
Autonomy – Mean (Free, I'm doing what I want to be doing, Free to decide for myself what to do)
Competence – Mean (Capable, Competent, My skills are improving)
Relatedness – Mean (I belong and the people here care about me, Involved with close friends, Emotionally close to the people around me)
Notes: "Stressed", "Pressured", and "Uptight" are filler items that are not scored.

Appendix D

Permission for the SMMSE Scale

Permission for the SMMSE Scale

From: Usher, Ellen L. <ellen.usher@uky.edu>

Sent: Monday, July 6, 2020 4:49 PM

To: Leah M Owens <lowens@valdosta.edu>

Cc: Ford, Calah J. <calah.ford@uky.edu>

Subject: RE: Request for Permission - Sources of Middle School Mathematics Self-Efficacy Scale

Delivered From External Sender

Dear Leah,

Thanks for your email and your thoughtful description of your dissertation work. This looks very interesting. You certainly have my permission to use the sources of self-efficacy items. I would love to know what you find.

I'm also copying Calah Ford on this message. Calah is a doctoral student working with me, and she's at a similar stage in her work. I think you two might have some overlapping interests, so I thought it would be neat to put you in touch.

Best wishes on your work!

Ellen Usher
Professor and Program Chair, Educational Psychology
Director, P20 Motivation and Learning Lab

Appendix E

Pretest and Posttest Questions

Pretest and Posttest Questions

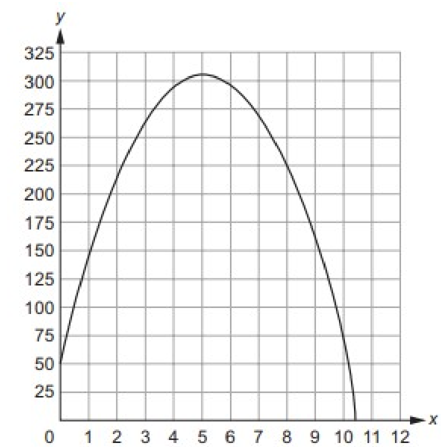
Standard	Question Number	DOK Level	Assessment Question
MGSE9-12.A.SSE.2 Use the structure of an expression to rewrite it in different equivalent forms.	1	III	Which of the following is equivalent to $ns^3 + n^2s$? A. $ns(s^2 + 1)$ B. $\mathbf{ns(s^2 + n)}$ C. $ns(s^2 + s)$ D. $ns^2(s + n)$
MGSE9-12.A.SSE.2 Use the structure of an expression to rewrite it in different equivalent forms.	2	III	What polynomial equals $(x + 6)(2x - 3)$? A. $\mathbf{2x^2 + 9x - 18}$ B. $2x^2 + 12x + 3$ C. $x^2 + 8x - 9$ D. $x^2 - 11x + 6$
MGSE9-12.A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.	3	III	Which expression is a factor of $4x^2 + 10x + 6$? A. $2(x + 3)$ B. $\mathbf{2x + 3}$ C. $4(x + 3)$ D. $4x + 3$

MGSE9-12.A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.	4	III	Which of the following is a factor of $6x^2 - 13x + 5$? A. $x + 1$ B. $\mathbf{2x - 1}$ C. $3x + 1$ D. $6x - 1$
MGSE9-12.A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.	5	III	What is the factored form of $f(x) = x^2 + 8x + 15$ that reveals the zeros of the function? A. $(x + 4)(x + 2)$ B. $\mathbf{(x + 3)(x + 5)}$ C. $(x + 2)(x + 6)$ D. $(x + 1)(x + 15)$
MGSE9-12.A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.	6	III	What is the equivalent form of $f(x) = x^2 + 8x + 15$ that reveals the minimum value of the function? A. $\mathbf{(x + 4)^2 - 1}$ B. $(x + 3)^2$ C. $(x + 2)^2 + 3$ D. $(x + 1)^2 + 8$
MGSE9-12.A.SSE.2 Use the structure of an expression to rewrite it in different equivalent forms.	7	III	Which expression represents $y^4 - 36$ in factored form? A. $(y^2 + 4)(y^2 - 9)$ B. $(y^2 + 4)(y - 3)(y + 3)$ C. $\mathbf{(y^2 + 6)(y^2 - 6)}$ D. $(y^4 - 36)(y + 1)$

MGSE9-12.A.SSE.2 Use the structure of an expression to rewrite it in different equivalent forms.	8	III	What is the factored form of $5n^3 - 10n^2 + 3n - 6$? A. $\mathbf{(5n^2 + 3)(n - 2)}$ B. $30n^3$ C. $(5n^3 + 3)(n - 2)$ D. $10n(n^2 - 6)$
MGSE9-12.A.REI.4b Solve quadratic equations by inspection (e.g., for x2 = 49), taking square roots, factoring, completing the square, and the quadratic formula, as appropriate to the initial form of the equation (limit to real number solutions).	9	III	If $x^2 + 13x + 30 = 0$, what are the possible values of x? A. -5 and -6 B. $\mathbf{-3}$ **and** $\mathbf{-10}$ C. 3 and 10 D. 5 and 6
MGSE9-12.A.REI.4b Solve quadratic equations by inspection (e.g., for x2 = 49), taking square roots, factoring, completing the square, and the quadratic formula, as appropriate to the initial form of the equation (limit to real number solutions).	10	III	What values of x satisfy $x^2 + 2x = 24$? A. $-6, -4$ B. $\mathbf{-6, 4}$ C. $6, -4$ D. $6, 4$
MGSE9–12.N.RN.2 Rewrite expressions involving radicals using the properties of exponents. (i.e.,	11	III	Which number equals $3\sqrt{56}$? A. $\mathbf{6\sqrt{14}}$ B. $12\sqrt{7}$

simplify and/or use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots)			C. $15\sqrt{6}$ D. $8\sqrt{28}$
MGSE9-12.A.REI.4 Solve quadratic equations in one variable.	12	III	Solve the equation by finding square roots: $8(x^2-1)=24$ A. $1.41, -1.41$ B. $5.7, -5.7$ C. $\mathbf{2, -2}$ D. $4.1, -4.1$
MGSE9-12.N.RN.3 Explain why the sum or product of rational numbers is rational; why the sum of a rational number and an irrational number is irrational; and why the product of a nonzero rational number and an irrational number is irrational.	13	I	Which sum is rational? A. $\pi+18$ B. $\boldsymbol{\sqrt{25}+1.75}$ C. $\sqrt{3}+5.5$ D. $32\sqrt{10}$
MGSE9–12.N.RN.2 Rewrite expressions involving radicals using the properties of exponents. (i.e., simplify and/or use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots)	14	II	Which of the following is equivalent to $\frac{\sqrt{27}}{\sqrt{3}}$? A. $\mathbf{3}$ B. $3\sqrt{2}$ C. $3\sqrt{3}$ D. 9
MGSE9–12.N.RN.2	15	II	What number equals $8\sqrt{7}+4\sqrt{7}-3\sqrt{7}$

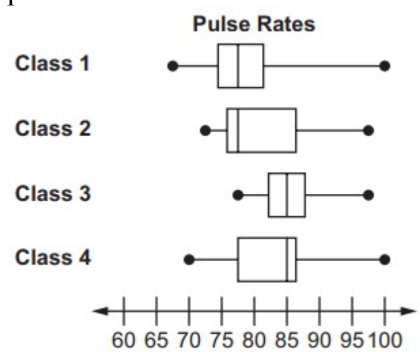
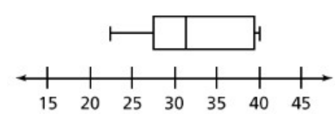
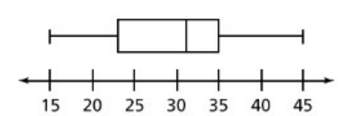
Rewrite expressions involving radicals using the properties of exponents. (i.e., simplify and/or use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots)			A. $\mathbf{9\sqrt{7}}$ B. $15\sqrt{7}$ C. $16\sqrt{7}$ D. $9\sqrt{21}$
MGSE9–12.N.RN.2 Rewrite expressions involving radicals using the properties of exponents. (i.e., simplify and/or use the operations of addition, subtraction, and multiplication, with radicals within expressions limited to square roots)	16	II	Which of these is equivalent to this expression? $(2\sqrt{8})(\sqrt{20})$ A. $2\sqrt{28}$ B. 5 C. $\mathbf{8\sqrt{10}}$ D. $32\sqrt{10}$
MGSE9-12.A.REI.4b Solve quadratic equations by inspection (e.g., for x2 = 49), taking square roots, factoring, completing the square, and the quadratic formula, as appropriate to the initial form of the equation (limit to real number solutions).	17	IV	What methods would you use to solve the quadratic equation $-2x^2 + 8x + 13 = 0$? A. **Quadratic formula or graphing; the equation cannot be factored, and the leading coefficient is not equal to 1** B. Factoring or graphing; the equation can be factored, and the leading coefficient is and integer C. Quadratic formula or factoring, the equation can be factored, and the leading coefficient is not equal to 1 D. Quadratic formula; the equation cannot be factored, and the leading coefficient is an integer
MGSE9-12.A.REI.4 Solve quadratic equations in one variable.	18	II	What are the solutions of $2x^2 + 3x = 6$? Use the quadratic formula. A. $x = \frac{3\pm\sqrt{57}}{4}$

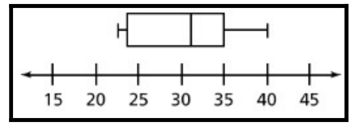
			B. $\boldsymbol{x = \frac{-3 \pm \sqrt{57}}{4}}$ C. $x = \frac{-3 \pm \sqrt{57}}{2}$ D. $x = \frac{3 \pm \sqrt{57}}{2}$
MGSE9–12.A.REI.4a Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2$ = q that has the same solutions.	19	II	Which of these is the result of completing the square for $x^2 + 8x - 30$? A. $(x + 4)^2 - 30$ **B.** $\boldsymbol{(x + 4)^2 - 46}$ C. $(x + 8)^2 - 30$ D. $(x + 8)^2 - 94$
MGSE9-12.F.IF.4 Using tables, graphs, and verbal descriptions, interpret the key characteristics of a function which models the relationship between two quantities. Sketch a graph showing key features including: intercepts; interval where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.	20	II	The graph shows the height, y, in meters, of a rocket above sea level in terms of the time, t, in seconds, since it was launched. The rocket landed at sea level.  What does the x-intercept represent in this situation? A. The height from which the rocket was launched **B. The time it took the rocket to return to sea level** C. The total distance the rocket flew while it was in flight D. The time it took the rocket to reach the highest point in its flight

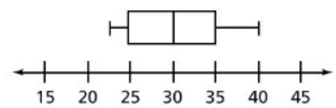
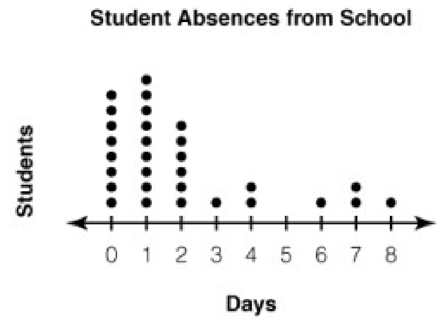
<table>
<tr><td>MGSE9-12.S.ID.2
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, mean absolute deviation) of two or more different data sets.</td><td>21</td><td>III</td><td>Shelby will take a total of 6 tests. On the first 5 tests her scores were: 80, 85, 73, 78, 90. If she wants a mean grade of 80, what does Shelby have to score on her 6th test?

A. **74**
B. 80
C. 84
D. 90</td></tr>
<tr><td>MGSE9-12.S.ID.2
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, mean absolute deviation) of two or more different data sets.</td><td>22</td><td>II</td><td>Use the chart to answer the question.
<table><tr><th colspan="2">Hospital Volunteer Hours</th></tr><tr><th>Name</th><th>Hours Worked</th></tr><tr><td>Jan</td><td>104</td></tr><tr><td>Amy</td><td>98</td></tr><tr><td>Tom</td><td>120</td></tr><tr><td>Chris</td><td>105</td></tr><tr><td>Stephanie</td><td>102</td></tr></table>What is the median number of hours these students worked?

A. 100
B. 103
C. **104**
D. 120</td></tr>
<tr><td>MGSE9-12.S.ID.2
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, mean absolute deviation) of two or more different data sets.</td><td>23</td><td>IV</td><td>This table shows dogs' weights at a competition. Which measure of the weights has the greatest value?
<table><tr><th>Dogs' Weights (pounds)</th></tr><tr><td>35, 22, 31, 23, 35, 22, 30, 35, 40</td></tr></table>
A. Mean
B. Median
C. **Mode**
D. Range</td></tr>
<tr><td>MGSE9-12.S.ID.2
Use statistics appropriate to the shape of the data distribution to</td><td>24</td><td>III</td><td>This table shows the admission price for various movie theatres in the metro-Atlanta area.
<table><tr><th colspan="5">Movie Theater Prices</th></tr><tr><td>$9.00</td><td>$12.00</td><td>$9.75</td><td>$8.25</td><td>$11.25</td></tr></table></td></tr>
</table>

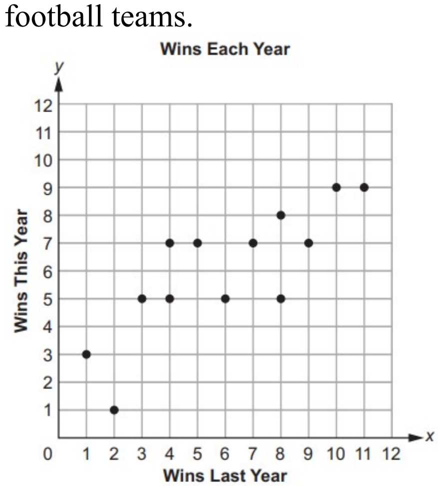
compare center (median, mean) and spread (interquartile range, mean absolute deviation) of two or more different data sets.			Which is the mean absolute deviation? A. **\$1.26** B. \$6.30 C. \$10.05 D. \$10.13
MGSE9-12.S.ID.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). Students will examine graphical representations to determine if data are symmetric, skewed left, or skewed right and how the shape of the data affects descriptive statistics.	25	IV	A science teacher recorded the pulse of each of the students in her classes after the students had climbed a set of stairs. She displayed the results, by class, using the box plots shown.  Which class generally had the highest pulse after climbing the stairs? A. Class 1 B. Class 2 C. **Class 3** D. Class 4
MGSE9-12.S.ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).	26	III	This table shows dogs' weights at a competition. Choose the box plot of the weights. **Dogs' Weights (pounds)** 35, 22, 31, 23, 35, 22, 30, 35, 40 A.  B. 

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>C.


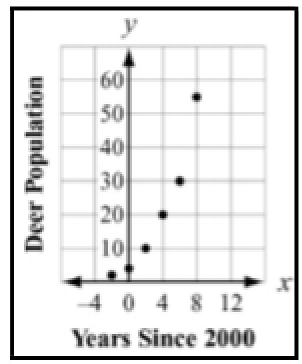
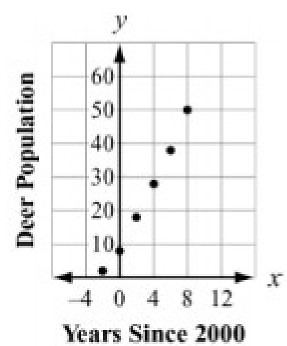
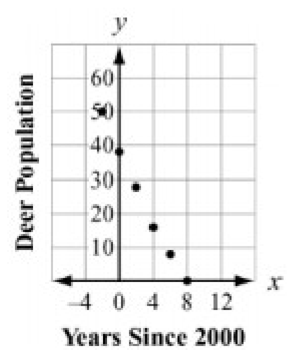
D.

</td>
</tr>
<tr>
<td>MGSE9-12.S.ID.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).</td>
<td>27</td>
<td>III</td>
<td>Ms. Cebrera counted the number of absences each student in her class had last year. She recorded the results on the dot plot below.


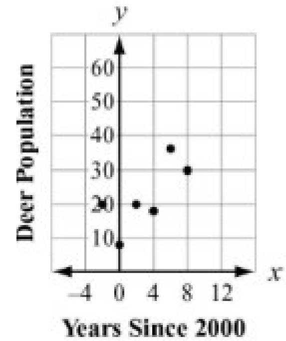
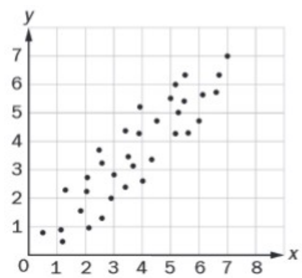
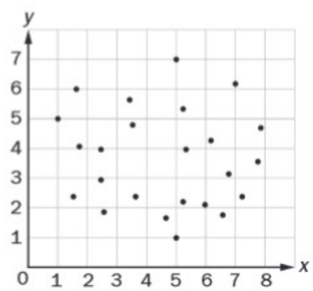
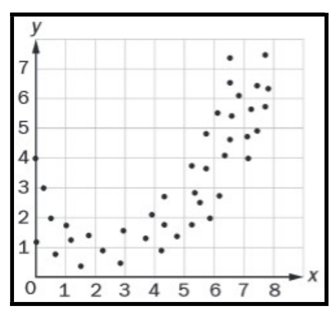
Which statement best describes the shape of the data?

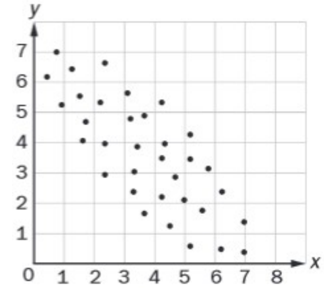
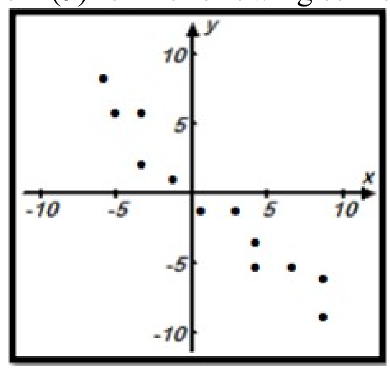
A. Pulled to the left
B. Pulled to the right
C. Symmetric
D. No noticeable shape</td>
</tr>
<tr>
<td>MGSE9-12.S.ID.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.</td>
<td>28</td>
<td>IV</td>
<td>Use the two-way frequency table below to determine which statement below is TRUE.
Foreign Language Enrollment Numbers at Phoenix High School
<table>
<tr><th></th><th>Spanish</th><th>French</th><th>German</th><th>Total</th></tr>
<tr><td>Males</td><td>42</td><td>17</td><td>29</td><td>88</td></tr>
<tr><td>Females</td><td>46</td><td>31</td><td>12</td><td>89</td></tr>
<tr><td>Total</td><td>88</td><td>48</td><td>41</td><td>177</td></tr>
</table>
A. There are more students enrolled in Spanish than French and German combined.
B. There are more females taking Spanish than total number of students taking German.
C. There are more males taking foreign language than females.
D. Spanish is the only course in which there are more females than males taking the course.</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>MGSE9-12.S.ID.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.</td><td>29</td><td>III</td><td>Using the frequency table below, out of all women in the sample, determine the percent of women that live off campus.
<table>
<tr><th></th><th>Live on Campus</th><th>Live off Campus</th><th>Total</th></tr>
<tr><td>Men</td><td>3216</td><td>4010</td><td>7226</td></tr>
<tr><td>Women</td><td>3824</td><td>3758</td><td>7582</td></tr>
<tr><td>Total</td><td>7040</td><td>7768</td><td>14,808</td></tr>
</table>
A. 25.4%
B. 49.6%
C. 98.3%
D. 52.5%</td></tr>
<tr><td>MGSE9-12.S.ID.6c Fit a linear function for a scatter plot that suggests a linear association</td><td>30</td><td>II</td><td>The data below are the final exam scores of 10 randomly selected students and the number of hours they studied for the exam.
<table>
<tr><td>Hours, x</td><td>3</td><td>5</td><td>2</td><td>8</td><td>2</td><td>4</td><td>4</td><td>5</td><td>6</td><td>3</td></tr>
<tr><td>Scores, y</td><td>65</td><td>80</td><td>60</td><td>88</td><td>66</td><td>78</td><td>85</td><td>90</td><td>90</td><td>71</td></tr>
</table>
Determine the linear regression equation that best fits the data.
A. $y = 5.09x + 55.23$
B. $y = 5.03x + 56.19$
C. $\mathbf{y = 5.04x + 56.11}$
D. $y = 3.65x + 63.96$</td></tr>
<tr><td>MGSE9-12.S.ID.6c Fit a linear function for a scatter plot that suggests a linear association</td><td>31</td><td>II</td><td>This graph plots the number of wins last year and this year for a sample of professional football teams.


Which equation BEST represents a line that matches the trend of the data?</td></tr>
</table>

			A. $y = x + 2$ B. $y = x + 7$ C. $y = 0.6x - 0.2$ D. $\mathbf{y = 0.6x + 2.4}$
MGSE9-12.S.ID.6a Decide which type of function is most appropriate by observing graphed data, charted data, or by analysis of context to generate a viable (rough) function to best fit. Use this function to solve problems in context. Emphasize linear, quadratic, and exponential models.	32	II	Which scatterplot best represents a model of exponential growth? A.  B.  C.  D.

			
MGSE9-12.S.ID.6a Decide which type of function is most appropriate by observing graphed data, charted data, or by analysis of context to generate a viable (rough) function to best fit. Use this function to solve problems in context. Emphasize linear, quadratic, and exponential models.	33	II	Which set of data could BEST be modeled by a quadratic function? A.  B.  C.  D.

			
MGSE9-12.S.ID.8 Compute (using technology) and interpret the correlation coefficient "r" of a linear fit. (For instance, by looking at a scatterplot, students should be able to tell if the correlation coefficient is positive or negative and give a reasonable estimate of the "r" value.) After calculating the line of best fit using technology, students should be able to describe how strong the goodness of fit of the regression is, using "r."	34	II	What would be the most likely correlation coefficient (r) for the following scatterplot?  A. $r \approx 0.922$ B. $r \approx 0.356$ C. $r \approx -0.351$ D. $\boldsymbol{r \approx -0.913}$
MGSE9-12.S.ID.9 Distinguish between correlation and causation.	35	II	Which statement describes an example of causation? A. When the weather becomes warmer, more meat is purchased at the supermarket. B. More people go to the mall when students go back to school. C. The greater the number of new television shows, the lesser the number of moviegoers. D. **After operating costs are paid at a toy shop, as more toys are sold, more money is made.**

MGSE9-12.F.LE.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function	36	IV	Which statement is true about graphs of exponential functions? A. The graphs of exponential functions never exceed graphs of linear and quadratic functions. B. The graphs of exponential functions always exceed the graphs of linear and quadratic functions. C. **The graphs of exponential functions eventually exceed the graphs of linear and quadratic functions.** D. The graphs of exponential functions eventually exceed the graphs of linear functions but not quadratic functions.
MGSE9-12.N.Q.1b Convert units and rates using dimensional analysis (English-to-English and Metric-to-Metric without conversion factor provided and between English and Metric with conversion factor)	37	III	If Mrs. Banks made 44 quarts of jelly, how many gallons did she make? A. **11 gallons** B. 22 gallons C. 88 gallons D. 176 gallons

Appendix F

Pretest and Posttest Question Order

Pretest and Posttest Question Order

Pretest Question Order	Posttest Question Order
13	1
20	2
19	3
17	4
37	5
25	6
29	7
15	8
36	9
9	10
11	11
22	12
34	13
21	14
12	15
1	16
16	17
35	18
30	19
5	20
3	21
26	22
31	23
27	24
10	25
33	26
8	27
14	28
18	29
4	30
28	31
24	32
32	33
2	34
23	35
6	36
7	37

Appendix G

Teacher Log Questions

Teacher Log Questions

Log 1: https://valdosta.co1.qualtrics.com/jfe/form/SV_2gwFdBjbsbZfxxc

- Please answer the following questions about FALs as you prepare to implement your first lesson.
  - How do you think the implementation of your chosen FALs will affect your students?
  - Do you think the FALs will be useful? Why or why not?
  - Teacher preparation:
    - What led you to select the FALs that you chose to implement?
    - What challenges do you anticipate for FAL implementation?
    - How are you preparing to implement FALs in your classroom? What challenges do you anticipate?

Logs 2 – 4: https://valdosta.co1.qualtrics.com/jfe/form/SV_5pA4jTEAVTvCfUq

- What type(s) of instructional strategies did you implement in your classroom this month? Indicate which instructional strategies, if any, were implemented as part of a FAL.
- How do you think the instructional strategies implemented this month affected your students?
  - Student Achievement:
    - In what areas are students excelling? What do you think has contributed to this success?
    - In what areas are students still struggling? What do you think could help students be more successful?
  - Student motivation:
    - When did students seem motivated to learn in class? What do you think contributed to students' motivation?
    - When did students seem unmotivated to learn in class? Why do you think students were unmotivated and what do you think could be done in class to increase motivation?
  - Student self-efficacy:
    - When did students seem to exhibit higher levels of self-efficacy in the classroom? What do you think contributed to students' self-efficacy?
    - When did students seem to exhibit lower levels of self-efficacy in the classroom? Why do you think students had low self-efficacy and what do you think could be done to increase students' self-efficacy?
- How do student achievement, motivation, and self-efficacy compare with what you have observed in previous months?
- Please answer the following questions if you implemented a FAL this month:

- What challenges did you face with FAL implementation?
- What went well with FAL implementation for you as a teacher? For your students?
- What think went poorly with FAL implementation for you as a teacher? For your students?
- What changes, if any, would you make the next time you implement a FAL in your classroom?

Log 5: https://valdosta.co1.qualtrics.com/jfe/form/SV_bsbX5YzY0vZnEtE

- How did the implementation of FALs in your classroom compare with what you expected at the beginning of the semester?
    - What impacts did FAL implementation have on you as a teacher?
    - What impacts did FAL implementation have on your students in terms of achievement, motivation, and self-efficacy?
- What do you think about implementing FALs in your classes in the future?
    - What improvements, if any, would you make for FAL implementation?
    - What suggestions would you give other teachers who are planning to implement FALs in their classrooms?

Appendix H

Teacher Interview Questions

Teacher Interview Questions

- FAL preparation:
    - How was preparing for FALs similar to what you typically do to prepare for class? How was it different?
    - How did the Teacher Guide impact your ability to prepare to implement the FALs?
    - Were you able to implement all parts of the FAL for each implementation? Why or why not?
- FAL Implementation:
    - What about FAL implementation was easy for you, as the teacher?
    - What about FAL implementation do you believe was challenging for you, as the teacher?
    - What did you like about using FALs in your classroom? What did you dislike about FAL implementation?
    - What would you keep the same if you were to implement FALs again in the future? What would you change?
    - Do you think FAL implementation helped improve your understanding of your students? How so?
- How did your students respond to the FALs?
    - What parts of the FALs were easy for your students? What parts were difficult?
    - How do you believe FALs affected your students' abilities to do well on math tests?
        - What students seemed to have the greatest improvement in achievement? What do you think contributed to this?
        - What students seemed to have the least improvement in achievement? What do you think contributed to this?
    - How do you believe FALs affected your students' motivation to learn math?
        - What students seemed to have the greatest improvement in motivation? The least improvement?
        - Did any students' motivation levels seem to decrease? Why do you think this happened?
    - How do you believe FALS affected your students' self-efficacy when completing math problems?
        - What students seemed to have the greatest increase in self-efficacy? The least increase?
        - Did any students seem to have less self-efficacy? Why do you think this happened?
- If used consistently, how do you think FALs would impact you as the teacher? How would frequent use impact your students?

Appendix I

FAL Guidelines for Teachers

FAL Guidelines for Teachers

The teacher guidelines for FAL implementation were constructed by the MARS (2015b) to help teachers effectively implement FALs in their classrooms. The image below is an excerpt from the guidelines which shows what information is presented in the brief guide for teachers.

Contents

WHAT IS THE PURPOSE OF THIS BOOKLET?

This booklet is designed to help classroom teachers and district administrators understand what the *Classroom Challenges* are and how they can help put the Common Core State Standards for Mathematics into action, including the Standards for Mathematical Practice. It describes the structure and organization of *Classroom Challenges* (CCs), how they address the CCSS, how they work[1], and how they function to stimulate and deepen students' mathematical thinking.

The booklet, along with the individual *Classroom Challenges* lesson and teacher's guides, describe a pedagogical stance and a role for the teacher that aligns with the research on formative assessment. Some teachers will likely find it different from their current practice. The booklet also includes the reactions of teachers who have used these lessons and their perspective based on interviews by an independent evaluation team with 12 middle and high school teachers. Each of the teachers interviewed piloted several *Classroom Challenges* in their classrooms. They come for three different states: California, Michigan and Rhode Island.

[1] The lessons have been developed, from research-based draft designs to the final products, through an iterative process of piloting and refinement. Reports on each pilot lesson are gathered from a trained observer, the teacher and the students – including samples of student work. This feedback covers how well (or not) the lessons are working as envisaged. These reports guide the revisions by the design team.

Classroom Challenges Page 1 A Brief Guide

Appendix J

FAL Pre-Assessment Task

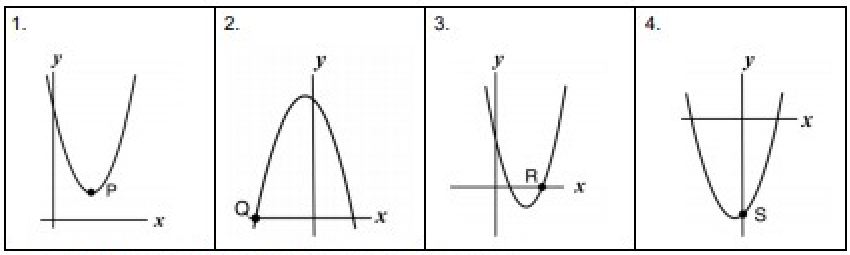
FAL Pre-Assessment Task

FAL Pre-Assessment Task: Representing Quadratic Functions Graphically. This is a sample pre-assessment task taken from one FAL related to Algebra 1 content (MARS, 2015c). This task would be completed by students before the collaborative activity and then again at the end of the collaborative activity as a post-assessment.

Quadratic Functions

1. Here are 4 equations of quadratic functions and 4 sketches of the graphs of quadratic functions.

A. $y = x^2 - 6x + 8$	B. $y = (x-6)(x+8)$	C. $y = (x-6)^2 + 8$	D. $y = -(x+8)(x-6)$



a. Match the equation to its graph and explain your decision.

Equation A ***matches*** Graph ......, because

....

Equation B ***matches*** Graph ......, because

....

Equation C ***matches*** Graph ......, because

....

Equation D ***matches*** Graph ......, because

....

b. Write the co ordinates of the points: P (.....,.....) Q(.....,.....) R (.....,.....) S (.....,.....)

2. The graph of a quadratic function has a y intercept at (0,5) and a minimum at (3, −4).

a. Write the equation of its curve.

....

b. Write the coordinates of the root(s) of this quadratic function.

....

Student materials Representing Quadratic Functions Graphically S-1

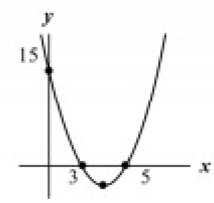
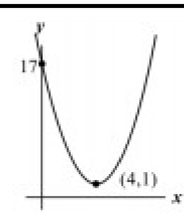
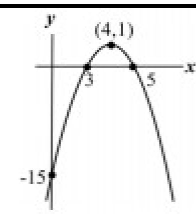
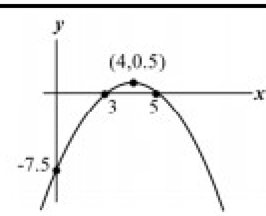
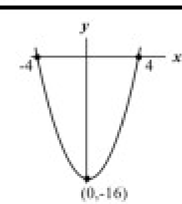
Appendix K

FAL Collaborative Activity

FAL Collaborative Activity

FAL Collaborative Activity: Representing Quadratic Functions Graphically Dominos. This is a sample of a portion of the dominos students would receive and match in the collaborative portion of the Representing Quadratic Functions Graphically FAL (MARS, 2015c).

Domino Cards: 1

<table>
<tr><td>A
$y = x^2 + 2x - 35$
$y =$ ....
$y =$ ....</td><td></td></tr>
<tr><td>B
$y = x^2 + 8x$..........
$y =$ ....
$y = (x+4)^2 - 1$</td><td></td></tr>
<tr><td>C
$y = x^2 - 8x$..........
$y = (x-4)(x-4)$
$y =$ ....</td><td></td></tr>
<tr><td>D
$y = -x^2 + 8x$..........
$y =$ ....
$y = -(x-4)^2 + 1$</td><td></td></tr>
<tr><td>E
$y = -x^2 - 6x + 16$
$y = -(x+8)(x-2)$
$y = -(x+3)^2 + 25$</td><td></td></tr>
</table>

Appendix L

Student Assent Form

Student Assent Form

Hi. My name is Leah Owens. I'm a doctoral student at Valdosta State University. Right now, I'm doing a research study titled "**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation**." This study is about how specific activities in math classes affect students' beliefs in their abilities to solve math problems, students' motivation to learn math, and students' performances on math tests. I would like to ask you to help me by being in a study, but before I do, I want to explain what will happen if you decide to help me.

I will ask you to complete a survey and pretest at the beginning of the Spring semester and a survey and posttest at the end of the Spring semester. The pretest will help me understand what types of Algebra 1 questions you already know how to solve and what types of Algebra 1 questions you still need to learn how to do at the beginning of the semester. The posttest will help me understand what types of Algebra 1 questions you have learned how to solve by the end of the semester. There are right and wrong answers on the pretest and posttest, but these tests will not affect your grade in any way. The survey will help me understand how motivated you are to learn math and your beliefs in your ability to solve math problems. There are no right or wrong answers on the survey and survey results will not affect your grade in any way. Having you complete the survey a second time at the end of the semester will help me see if your motivation and belief in your ability to solve math problems has changed from the beginning of the semester to the end of the semester. By being in the study, you will help me understand how activities in math class motivate you to learn, affect your belief in your abilities to solve math problems, and affect your performance on math tests. Sharing these results with other teachers could help teachers understand how to help you be more successful, more confident, and more motivated to learn in math classes.

Your teacher, parent/guardian, and classmates will not know what you have said in your survey. I will share results of the pretest with your teacher so that they can use the information to help teach you during the semester. When I tell other people about my study, I will not use your name, and no one will be able to tell who I'm talking about.

Your parents or guardians have said that it is okay for you to be in my study. However, if you don't want to be in the study, you don't have to be. What you decide won't make any difference with your grade in this class or with what your teachers and classmates think about you. I won't be upset, and no one else will be upset, if you don't want to be in the study. If you want to be in the study now but change your mind later, that's okay. You can stop at any time. If there is anything you don't understand you should tell me so I can explain it to you

You can ask me questions about the study. If you have a question later that you don't think of now, you can call me or ask your teacher, parent, or guardian to call me or send me an email.

Do you have any questions for me now?

Would you like to be in my study?

NOTES TO RESEARCHER: The child (under age 18) must answer "**Yes**" or "**No**." Only a definite "**Yes**" may be taken as assent to participate.

Name of Student:_
Parental Permission on File: ☐ Yes ☐ No
(If "No," do not proceed with assent or research procedures.)

Student's Voluntary Response to Participation: ☐ Yes ☐ No

Signature of Researcher: _______________**Date:** __________________

Appendix M

Parental Consent Forms

Parental Consent Forms – Treatment Group

Parental Consent Form – Treatment Group

VALDOSTA STATE UNIVERSITY
Parent/Guardian Permission for Child's/Ward's Participation in Research

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You are being asked to allow your child (or ward) to participate in a research study entitled "**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation**." This research study is being conducted by Leah Owens, a doctoral student in Curriculum and Instruction at Valdosta State University. The purpose of this research is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. Your child's participation in this study is entirely voluntary. From this point on in this form, the term "child" is used for either a child or a ward.

As described in more detail below, we will ask your child to complete a survey, pre-test, and post-test. Your student will also be asked to participate in two in-class activities, known as Formative Assessment Lessons, during the semester. Your child's participation will last for a total of approximately 375 minutes (equivalent to 5-8 class periods) throughout the semester. Someone in your position might be interested in allowing your child to participate because it may help students become more confident in their abilities to solve math problems, become more motivated to learn math, and experience higher levels of achievement on math tests. Additionally, understanding how these activities affect students may help teachers learn more about how to help increase student confidence, motivation, and achievement in math classes in the future. It is important for you to know that you or your child may discontinue participation at any time during this study.

This form includes detailed information to help you decide whether to participate in this study. Please read it carefully and ask any questions that you have before you agree to participate. Please be sure to retain a copy of this form for your records.

Procedures:
Your child's participation will involve the completion of a survey, a pre-test, post-test, and two in-class activities called Formative Assessment Lessons. Questions on the survey will be used to measure students' motivation to learn math and students' belief in their abilities to solve math problems. The survey will be administered by your child's teacher once at the beginning of the semester and once at the end of the semester. Each administration of the survey should take approximately 15 minutes for students to complete. The pre-test will be used to determine what types of Algebra 1 questions students already know how to solve and what types of Algebra 1 questions students still need to learn how to do. The pre-test will be administered by your child's teacher at the beginning of the semester and should take approximately 45 minutes to complete. The post-test will be used to determine what types of Algebra 1 questions students have learned

how to solve by the end of the semester. The post-test will be administered near the end of the semester and should take approximately 60 minutes to complete.

The two in-class activities, called Formative Assessment Lessons, are problem-solving tasks that help students apply what they have learned in class by working with other students to solve problems. During the Formative Assessment Lesson, students will attempt to solve a problem independently and will turn their work into the teacher. The teacher will then give feedback on their attempt at the beginning of the next class period in the form of comments and questions to help students think about the mistakes they made. After discussing common misconceptions presented in the initial attempts as a whole class, students will be asked to work together in a group setting to solve problems by completing a task. For example, students may be asked to work with their classmates to match equations of functions with their appropriate graphs using what they have learned in class about the functions and what their graphs should look like. At the end of the task, students will be asked to participate in a whole-class discussion about how they approached the task and share what strategies they used to solve the problems. Then, students will revisit the problem they attempted to solve independently and will re-solve the problem using new knowledge and strategies obtained from working with their classmates. The independent problems should each take approximately 15 minutes to complete. The class discussion and group activity should take approximately 90 minutes to complete.

Your child's total participation in this project throughout the semester is expected to be approximately 375 minutes. You or your child may discontinue participation at any time during this study regardless of the reason.

All direct interaction with your child will occur at your child's school during your child's regularly scheduled math class.

This study involves research. There are no alternatives to the experimental procedures in this study. The only alternative is for you to choose not to allow your child to participate.

Possible Risks or Discomfort:
This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. Although there are no known risks to your child associated with the research procedures, it is not always possible to identify all potential risks of participating in a research study. However, the University has taken reasonable safeguards to minimize potential but unknown risks. By agreeing to participate in this research project, you are not waiving any rights that you or your child may have against Valdosta State University for injury resulting from negligence of the University or its researchers.

Potential Benefits:
Participation in this study may help your child experience increased motivation to learn mathematics, increased belief in their ability to be successful in math class, or increase achievement on math tests. However, these benefits are not guaranteed. If your child does not benefit directly from this research, your participation will help the researcher gain additional understanding of how these instructional activities affect high school students in math classes. Knowledge gained may contribute to helping teachers understand how to motivate students to

learn math, how to help students become more confident in math class, and how to improve student achievement on math tests.

Costs and Compensation:
There are no costs to you and there is no compensation (no money, gifts, or services) for your participation in this research project.

Assurance of Confidentiality:
Valdosta State University and the researcher will keep your child's information confidential to the extent allowed by law. Members of the Institutional Review Board (IRB), a university committee charged with reviewing research to ensure the rights and welfare of research participants, may be given access to your child's confidential information.

Your child will be asked to report their student number on survey and assessment administrations in lieu of their name so that your child remains unidentifiable by persons outside of faculty members at your child's school. Student numbers will be used to keep track of data collected from each participant in the study for the purposes of interpreting scores and results of this study. At the end of the semester, when all data collection has been completed, student numbers will be replaced a different number, assigned by the researcher. This is to ensure that students will remain unidentifiable. Data from this study will be reported in combination with data obtained from other participants. None of the participants will be identified in this study by name or by student number. All information obtained from surveys and testing will be kept in the researcher's office secured by lock and key until the conclusion of the study. The only persons who will have access to the information is the researcher and the researcher's committee members from Valdosta State University who are overseeing the completion of this study.

Voluntary Participation:
Your decision to allow your child to participate in this research project is entirely voluntary. If you agree now to allow your child to participate and you change your mind later, you are free to withdraw your child from the study at that time. By not allowing your child to participate in this study or by withdrawing him/her from the study before the research is complete, you are not giving up any rights that you or your child have or any services to which you or your child are otherwise entitled to from Valdosta State University. If you decide to withdraw your child from the study after data collection is complete, your child's information will be deleted from the database and will not be included in research results.

Information Contacts:
Questions regarding the purpose or procedures of the research should be directed to Leah Owens at lowens@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Agreement to Participate:
The research project and my child's (or ward's) role in it have been explained to me, and my questions have been answered to my satisfaction. I grant permission for my child to participate in this study. By signing this form, I am indicating that I am either the custodial parent or legal guardian of the child. I have received a copy of this permission form.

I would like to receive a copy of the results of this study: _____ Yes _____ No

Mailing Address: ____

E-mail Address: _______________________

This research project has been approved by the Valdosta State University Institutional Review Board for the Protection of Human Research Participants through the date noted below:

VALDOSTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD
APPROVAL DATE 11.06.2020
IRB # 04096-2020
EXPIRATION DATE 11.06.2023

____
Printed Name of Child/Ward

____
Printed Name of Parent/Guardian

____
Signature of Parent/Guardian Date

____
Signature of Person Obtaining Consent Date

Parental Consent Forms – Treatment Group (Spanish Version)

Formulario de consentimiento de los padres - Grupo de tratamiento

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UNIVERSIDAD ESTATAL DE VALDOSTA
Permiso del padre / guardián para la participación del niño / pupilo en la investigación

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Se le pide que permita que su hijo (o pupilo) participe en un estudio de investigación titulado **"Un examen cuasi-experimental de la autoeficacia, la motivación y el logro de los estudiantes de secundaria en respuesta a la implementación de la lección de evaluación formativa"**. Este estudio de investigación está siendo realizado por Leah Owens, estudiante de doctorado en Currículo e Instrucción en la Universidad Estatal de Valdosta. El propósito de esta investigación es ver cómo las actividades de instrucción específicas, llamadas lecciones de evaluación formativa, afectan la motivación de los estudiantes para aprender matemáticas, la creencia de los estudiantes en sus habilidades para resolver problemas matemáticos y el desempeño de los estudiantes en las pruebas de matemáticas. La participación de su hijo en este estudio es completamente voluntaria. A partir de este momento en este formulario, el término "niño" se usa para un niño o un pupilo.

Como se describe con más detalle a continuación, le pediremos a su hijo que complete una encuesta, una prueba previa y una prueba posterior. También se le pedirá a su estudiante que participe en dos actividades en clase, conocidas como lecciones de evaluación formativa, durante el semestre. La participación de su hijo tendrá una duración total de aproximadamente 375 minutos (equivalente a 5-8 períodos de clase) durante el semestre. *S*i alguien en su posición podría estar interesado en permitir que su hijo participe, ya que puede ayudar a los estudiantes a tener más confianza en sus habilidades para resolver problemas de matemáticas, se vuelven más motivados para aprender matemáticas, y la experiencia de niveles más altos de rendimiento en las pruebas de matemáticas. Además, comprenden cómo estas actividades afectan a los estudiantes puede ayudar a los maestros a aprender más sobre cómo ayudar a aumentar la confianza, la motivación y el rendimiento de los estudiantes en las clases de matemáticas en el futuro. Es importante que sepa que usted o su hijo pueden dejar de participar en cualquier momento durante este estudio.

Este formulario incluye información detallada para ayudarlo a decidir si participa en este estudio. Léalo detenidamente y haga todas las preguntas que tenga antes de aceptar a participar. Asegúrese de conservar una copia de este formulario para sus registros.

Procedimientos:
La participación de su hijo involucrará la realización de una encuesta, una prueba previa, una prueba posterior y dos actividades en clase llamadas Lecciones de evaluación formativa. Las preguntas de la encuesta se utilizarán para medir la motivación de los estudiantes para aprender matemáticas y la creencia de los estudiantes en sus habilidades para resolver problemas matemáticos. La encuesta será administrada por el maestro de su hijo una vez al comienzo del semestre y una vez al final del semestre. Cada administración de la encuesta debe tomar aproximadamente 15 minutos para que los estudiantes la completen. La prueba previa se utilizará

para determinar qué tipos de preguntas de Álgebra 1 los estudiantes ya saben cómo resolver y qué tipos de preguntas de Álgebra 1 los estudiantes aún necesitan aprender a hacer. La prueba previa será administrada por el maestro de su hijo al comienzo del semestre y debería tomar aproximadamente 45 minutos para completar. La prueba posterior se utilizará para determinar qué tipos de preguntas de Álgebra 1 los estudiantes han aprendido a resolver al final del semestre. La prueba posterior se administrará cerca del final del semestre y debería tardar aproximadamente 60 minutos en completarse.

Las dos actividades en clase, llamadas lecciones de evaluación formativa, son tareas de resolución de problemas que ayudan a los estudiantes a aplicar lo que han aprendido en clase trabajando con otros estudiantes para resolver problemas. Durante la lección de evaluación formativa, los estudiantes intentarán resolver un problema de forma independiente y entregarán su trabajo al maestro. Luego, el maestro dará su opinión sobre su intento al comienzo del próximo período de clase en forma de comentarios y preguntas para ayudar a los estudiantes a piensen en los errores que cometieron. Después de discutir los conceptos erróneos comunes presentados en los intentos iniciales con toda la clase, se les pedirá a los estudiantes a que trabajen juntos en grupo para resolver problemas al completando una tarea. Por ejemplo, se les puede pedir a los estudiantes que trabajen con sus compañeros de clase para relacionar ecuaciones de funciones con sus gráficas apropiadas usando lo que han aprendido en clase sobre las funciones y cómo deberían verse sus gráficas. Al final de la tarea, se les pedirá a los estudiantes que participen en una discusión con toda la clase sobre cómo abordaron la tarea y compartan qué estrategias usaron para resolver los problemas. Luego, los estudiantes volverán a analizar el problema que intentaron resolver de forma independiente y volverán a resolver el problema utilizando nuevos conocimientos y estrategias obtenidas al trabajar con sus compañeros de clase. Cada uno de los problemas independientes debería tardar aproximadamente 15 minutos en completarse. La discusión en clase y la actividad en grupo deberían tomar aproximadamente 90 minutos para completarse.

Se espera que la participación total de su hijo en este proyecto durante el semestre sea de aproximadamente 375 minutos. Usted o su hijo pueden dejar de participar en cualquier momento durante este estudio, independientemente del motivo.

Toda la interacción directa con su hijo ocurrirá en la escuela de su hijo durante la clase de matemáticas programada regularmente.

Este estudio involucra investigación. No hay alternativas a los procedimientos experimentales en este estudio. La única alternativa es que usted elija no permitir que su hijo participe.

Posibles riesgos o molestias:
Este es un estudio de investigación de riesgo mínimo. Eso significa que los riesgos de participar no son más probables o graves que los que se encuentran en las actividades diarias. Aunque no existen riesgos conocidos para su hijo asociados con los procedimientos de investigación, no siempre es posible identificar todos los riesgos potenciales de participar en un estudio de investigación. Sin embargo, la Universidad ha tomado precauciones razonables para minimizar los riesgos potenciales pero desconocidos. Al aceptar participar en este proyecto de investigación,

no renuncia a ningún derecho que usted o su hijo puedan tener contra la Universidad Estatal de Valdosta por lesiones resultantes de la negligencia de la Universidad o sus investigadores.

Beneficios potenciales:
La participación en este estudio puede ayudar a su hijo a experimentar una mayor motivación para aprender matemáticas, una mayor creencia en su capacidad para tener éxito en la clase de matemáticas o aumentar el rendimiento en las pruebas de matemáticas. Sin embargo, estos beneficios no están garantizados. Si su hijo no se beneficia directamente de esta investigación, su participación ayudará al investigador a obtener una comprensión adicional de cómo estas actividades educativas afectan a los estudiantes de secundaria en las clases de matemáticas. El conocimiento adquirido puede contribuir a ayudar a los maestros a comprender cómo motivar a los estudiantes a aprender matemáticas, cómo ayudar a los estudiantes a tener más confianza en la clase de matemáticas y cómo mejorar el rendimiento de los estudiantes en las pruebas de matemáticas.

Costos y compensación:
No hay costos para usted y no hay compensación (dinero, obsequios o servicios) por su participación en este proyecto de investigación.

Garantía de confidencialidad:
La Universidad Estatal de Valdosta y el investigador mantendrán la confidencialidad de la información de su hijo en la medida permitida por la ley. Los miembros de la Junta de Revisión Institucional (IRB), un comité universitario encargado de revisar la investigación para garantizar los derechos y el bienestar de los participantes de la investigación, pueden tener acceso a la información confidencial de su hijo.

Se le pedirá a su hijo que informe su número de estudiante en la administración de encuestas y evaluaciones en lugar de su nombre para que su hijo no pueda ser identificado por personas ajenas a los miembros de la facultad en la escuela de su hijo. Los números de estudiantes se utilizarán para realizar un seguimiento de los datos recopilados de cada participante en el estudio con el fin de interpretar las puntuaciones y los resultados de este estudio. Al final del semestre, cuando se haya completado toda la recolección de datos, los números de los estudiantes serán reemplazados por un número diferente, asignado por el investigador. Esto es para asegurar que los estudiantes no se puedan identificar. Los datos de este estudio se informarán en combinación con los datos obtenidos de otros participantes. Ninguno de los participantes será identificado en este estudio por su nombre o número de estudiante. Toda la información obtenida de las encuestas y las pruebas se mantendrá en la oficina del investigador protegida con llave hasta la conclusión del estudio. Las únicas personas que tendrán acceso a la información son el investigador y los miembros del comité de investigadores de la Universidad Estatal de Valdosta que supervisan la realización de este estudio.

Participación voluntaria:
Su decisión de permitir que su hijo participe en este proyecto de investigación es completamente voluntaria. Si usted acepta ahora que permita que su hijo participe y luego cambia de opinión, está en la libertad de retirar a su hijo del estudio en ese momento. Al no permitir que su hijo participe en este estudio o al retirarlo del estudio antes de que se complete la investigación, no

está renunciando a ningún derecho que usted o su hijo tengan ni a ningún servicio al que usted o su hijo tengan derecho. de la Universidad Estatal de Valdosta. Si decide retirar a su hijo del estudio después de que se complete la recopilación de datos, la información de su hijo se eliminará de la base de datos y no se incluirá en los resultados de la investigación.

Contactos de información:
Las preguntas sobre el propósito o los procedimientos de la investigación deben dirigirse a Leah Owens. en lowens@valdosta.edu. Este estudio ha sido aprobado por la Junta de Revisión Institucional (IRB) de la Universidad Estatal de Valdosta para la protección de los participantes de la investigación humana. El IRB, un comité universitario establecido por la ley federal, es responsable de proteger los derechos y el bienestar de los participantes de la investigación. Si tiene inquietudes o preguntas sobre sus derechos como participante de una investigación, puede comunicarse con el Administrador del IRB al 229-253-2947 o irb@valdosta.edu.

Acuerdo para participar:
Se me ha explicado el proyecto de investigación y el papel de mi hijo (o pupilo) en él, y mis preguntas han sido respondidas satisfactoriamente. Doy permiso para que mi hijo participe en este estudio. Al firmar este formulario, estoy indicando que soy el padre con custodia o el guardián legal del niño. He recibido una copia de este formulario de permiso.

Me gustaría recibir una copia de los resultados de este estudio: _____ Sí _____ No

Dirección postal: ______________________________

Dirección de correo electrónico: ________________

____
Nombre en imprenta del niño / pupilo

____
Nombre en imprenta del padre / guardián

____
Firma del padre / guardián Fecha

____
Firma de la persona que obtiene el consentimiento - Fecha

Este proyecto de investigación ha sido aprobado por la Junta de Revisión Institucional de la Universidad Estatal de Valdosta para la Protección de los Participantes de la Investigación Humana hasta la fecha que se indica a

VALDOSTA STATE UNIVERSITY
APPROVAL DATE
11.06.2020
IRB #
04096-2020
EXPIRATION DATE
11.06.2023
INSTITUTIONAL REVIEW BOARD

Parental Consent Forms – Control Group

Appendix C (Four Forms Included)
Parental Consent Form – Control Group

VALDOSTA STATE UNIVERSITY
Parent/Guardian Permission for Child's/Ward's Participation in Research

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You are being asked to allow your child (or ward) to participate in a research study entitled "**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation**." This research study is being conducted by Leah Owens, a doctoral student in Curriculum and Instruction at Valdosta State University. The purpose of this research is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. Your child's participation in this study is entirely voluntary. From this point on in this form, the term "child" is used for either a child or a ward.

As described in more detail below, we will ask your child to complete a survey, pre-test, and post-test. Your child's participation will last for a total of approximately 135 minutes (equivalent to 1-3 class periods) throughout the semester. *S*omeone in your position might be interested in allowing your child to participate understanding how instructional activities affect students may help teachers learn more about how to help increase student confidence, motivation, and achievement in math classes in the future. It is important for you to know that you or your child may discontinue participation at any time during this study.

This form includes detailed information to help you decide whether to participate in this study. Please read it carefully and ask any questions that you have before you agree to participate. Please be sure to retain a copy of this form for your records.

Procedures:
Your child's participation will involve the completion of a survey, a pre-test, and a post-test. Questions on the survey will be used to measure students' motivation to learn math and students' belief in their abilities to solve math problems. The survey will be administered by your child's teacher once at the beginning of the semester and once at the end of the semester. Each administration of the survey should take approximately 15 minutes for students to complete. The pre-test will be used to determine what types of Algebra 1 questions students already know how to solve and what types of Algebra 1 questions students still need to learn how to do. The pre-test will be administered by your child's teacher at the beginning of the semester and should take approximately 45 minutes to complete. The post-test will be used to determine what types of Algebra 1 questions students have learned how to solve by the end of the semester. The post-test will be administered near the end of the semester and should take approximately 60 minutes to complete.

Your child's total participation in this project throughout the semester is expected to be approximately 135 minutes. You or your child may discontinue participation at any time during this study regardless of the reason.

All direct interaction with your child will occur at your child's school during your child's regularly scheduled math class.

This study involves research. There are no alternatives to the experimental procedures in this study. The only alternative is for you to choose not to allow your child to participate.

Possible Risks or Discomfort:
This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. Although there are no known risks to your child associated with the research procedures, it is not always possible to identify all potential risks of participating in a research study. However, the University has taken reasonable safeguards to minimize potential but unknown risks. By agreeing to participate in this research project, you are not waiving any rights that you or your child may have against Valdosta State University for injury resulting from negligence of the University or its researchers.

Potential Benefits:
Participation in this study will help the researcher gain additional understanding of how instructional activities affect high school students in math classes. Knowledge gained may contribute to helping teachers understand how to motivate students to learn math, how to help students become more confident in math class, and how to improve student achievement on math tests.

Costs and Compensation:
There are no costs to you and there is no compensation (no money, gifts, or services) for your participation in this research project.

Assurance of Confidentiality:
Valdosta State University and the researcher will keep your child's information confidential to the extent allowed by law. Members of the Institutional Review Board (IRB), a university committee charged with reviewing research to ensure the rights and welfare of research participants, may be given access to your child's confidential information. Your child will be asked to report their student number on survey and assessment administrations in lieu of their name so that your child remains unidentifiable by persons outside of faculty members at your child's school. Student numbers will be used to keep track of data collected from each participant in the study for the purposes of interpreting scores and results of this study. At the end of the semester, when all data collection has been completed, student numbers will be replaced a different number, assigned by the researcher. This is to ensure that students will remain unidentifiable. Data from this study will be reported in combination with data obtained from other participants. None of the participants will be identified in this study by name or by student number. All information obtained from surveys and testing will be kept in the researcher's office secured by lock and key until the conclusion of the study. The only persons who will have access to the information is the researcher and the researcher's committee members from Valdosta State

University who are overseeing the completion of this study.

Voluntary Participation:
Your decision to allow your child to participate in this research project is entirely voluntary. If you agree now to allow your child to participate and you change your mind later, you are free to withdraw your child from the study at that time. By not allowing your child to participate in this study or by withdrawing him/her from the study before the research is complete, you are not giving up any rights that you or your child have or any services to which you or your child are otherwise entitled to from Valdosta State University. If you decide to withdraw your child from the study after data collection is complete, your child's information will be deleted from the database and will not be included in research results.

Information Contacts:
Questions regarding the purpose or procedures of the research should be directed to Leah Owens at lowens@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Agreement to Participate:
The research project and my child's (or ward's) role in it have been explained to me, and my questions have been answered to my satisfaction. I grant permission for my child to participate in this study. By signing this form, I am indicating that I am either the custodial parent or legal guardian of the child. I have received a copy of this permission form.

I would like to receive a copy of the results of this study: _____ Yes _____ No

Mailing Address: ____

E-mail Address: __________________________

____
Printed Name of Child/Ward

____
Printed Name of Parent/Guardian

____
Signature of Parent/Guardian Date

____
Signature of Person Obtaining Consent Date

This research project has been approved by the Valdosta State University Institutional Review Board for the Protection of Human Research Participants through the date noted below:

VALDOSTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD
APPROVAL DATE 11.06.2020
IRB # 04096-2020
EXPIRATION DATE 11.06.2023

Formulario de consentimiento de los padres - Grupo de control

UNIVERSIDAD ESTATAL DE VALDOSTA

Permiso del padre / guardián para la participación del niño / pupilo en la investigaciónjm

Se le pide que permita que su hijo (o pupilo) participe en un estudio de investigación titulado **"Un examen cuasi-experimental de la autoeficacia, la motivación y los logros de los estudiantes de secundaria en respuesta a la implementación de la lección de evaluación formativa"**. Este estudio de investigación está siendo realizado por Leah Owens, estudiante de doctorado en Currículo e Instrucción en la Universidad Estatal de Valdosta. El propósito de esta investigación es ver cómo las actividades de instrucción específicas, llamadas lecciones de evaluación formativa, afectan la motivación de los estudiantes para aprender matemáticas, la creencia de los estudiantes en sus habilidades para resolver problemas matemáticos y el desempeño de los estudiantes en las pruebas de matemáticas. La participación de su hijo en este estudio es completamente voluntaria. A partir de este momento en este formulario, el término "niño" se usa para un niño o un pupilo.

Como se describe con más detalle a continuación, le pediremos a su hijo que complete una encuesta, una prueba previa y una prueba posterior. La participación de su hijo tendrá una duración total de aproximadamente 135 minutos (equivalente a 1-3 períodos de clase) durante el semestre. *S*i alguien en su posición podría estar interesado en permitir que su hijo participe en la comprensión de cómo afectan las actividades de instrucción a los estudiantes y pueden ayudar a los maestros para que aprendan a ayudarle a subir la autoestima del estudiante, la motivación y el rendimiento en las clases de matemáticas en el futuro. Es importante que sepa que usted o su hijo pueden dejar de participar en cualquier momento durante este estudio.

Este formulario incluye información detallada para ayudarlo a decidir si participa en este estudio. Léalo detenidamente y haga todas las preguntas que tenga antes de aceptar a participar. Asegúrese de conservar una copia de este formulario para sus registros.

Procedimientos:

La participación de su hijo implicará la realización de una encuesta, una prueba previa y una prueba posterior. Las preguntas de la encuesta se utilizarán para medir la motivación de los estudiantes para aprender matemáticas y la creencia de los estudiantes en sus habilidades para resolver problemas matemáticos. La encuesta será administrada por el maestro de su hijo una vez al comienzo del semestre y una vez al final del semestre. Cada administración de la encuesta debe tomar aproximadamente 15 minutos para que los estudiantes la completen. La prueba previa se utilizará para determinar qué tipos de preguntas de Álgebra 1 los estudiantes ya saben cómo resolver y qué tipos de preguntas de Álgebra 1 los estudiantes aún necesitan aprender a hacer. La prueba previa será administrada por el maestro de su hijo al comienzo del semestre y debería tomar aproximadamente 45 minutos para completarla. La prueba posterior se utilizará para determinar qué tipos de preguntas de Álgebra 1 los estudiantes han aprendido a resolver al final del semestre. La prueba posterior se administrará cerca del final del semestre y debería tomar aproximadamente 60 minutos para completarse.

Se espera que la participación total de su hijo en este proyecto durante el semestre sea de aproximadamente 135 minutos. Usted o su hijo pueden dejar de participar en cualquier momento durante este estudio, independientemente del motivo.

Toda la interacción directa con su hijo ocurrirá en la escuela de su hijo durante la clase de matemáticas programada regularmente.

Este estudio involucra investigación. No hay alternativas a los procedimientos experimentales en este estudio. La única alternativa es que usted elija no permitir que su hijo participe.

Posibles riesgos o molestias:
Este es un estudio de investigación de riesgo mínimo. Eso significa que los riesgos de participar no son más probables o graves que los que se encuentran en las actividades diarias. Aunque no existen riesgos conocidos para su hijo asociados con los procedimientos de investigación, no siempre es posible identificar todos los riesgos potenciales de participar en un estudio de investigación. Sin embargo, la Universidad ha tomado precauciones razonables para minimizar los riesgos potenciales pero desconocidos. Al aceptar participar en este proyecto de investigación, no renuncia a ningún derecho que usted o su hijo puedan tener contra la Universidad Estatal de Valdosta por lesiones resultantes de la negligencia de la Universidad o sus investigadores.

Beneficios potenciales:
La participación en este estudio ayudará al investigador a obtener una comprensión adicional de cómo las actividades de instrucción afectan a los estudiantes de secundaria en las clases de matemáticas. El conocimiento adquirido puede contribuir a ayudar a los maestros a comprender cómo motivar a los estudiantes a aprender matemáticas, cómo ayudar a los estudiantes a tener más confianza en la clase de matemáticas y cómo mejorar el rendimiento de los estudiantes en las pruebas de matemáticas.

Costos y compensación:
No hay costos para usted y no hay compensación (dinero, obsequios o servicios) por su participación en este proyecto de investigación.

Garantía de confidencialidad:
La Universidad Estatal de Valdosta y el investigador mantendrán la confidencialidad de la información de su hijo en la medida permitida por la ley. Los miembros de la Junta de Revisión Institucional (IRB), un comité universitario encargado de revisar la investigación para garantizar los derechos y el bienestar de los participantes de la investigación, pueden tener acceso a la información confidencial de su hijo. Se le pedirá a su hijo que informe su número de estudiante en la administración de encuestas y evaluaciones en lugar de su nombre para que su hijo no pueda ser identificado por personas ajenas a los miembros de la facultad en la escuela de su hijo. Los números de estudiantes se utilizarán para realizar un seguimiento de los datos recopilados de cada participante en el estudio con el fin de interpretar las puntuaciones y los resultados de este estudio. Al final del semestre, cuando se haya completado toda la recolección de datos, los

números de los estudiantes serán reemplazados por un número diferente, asignado por el investigador. Esto es para asegurar que los estudiantes no se puedan identificar. Los datos de este estudio se informarán en combinación con los datos obtenidos de otros participantes. Ninguno de los participantes será identificado en este estudio por su nombre o número de estudiante. Toda la información obtenida de las encuestas y las pruebas se mantendrá en la oficina del investigador protegida con llave hasta la conclusión del estudio. Las únicas personas que tendrán acceso a la información son el investigador y los miembros del comité de investigadores de la Universidad Estatal de Valdosta que supervisan la realización de este estudio.

Participación voluntaria:
Su decisión de permitir que su hijo participe en este proyecto de investigación es completamente voluntaria. Si usted acepta ahora que permita que su hijo participe y luego cambia de opinión, usted estará en la libertad de retirar a su hijo del estudio en ese momento. Al no permitir que su hijo participe en este estudio o al retirarlo del estudio antes de que se complete la investigación, usted no estará renunciando a ningún derecho que usted o su hijo tengan ni a ningún servicio al que usted o su hijo tengan derecho de la Universidad Estatal de Valdosta. Si decide retirar a su hijo del estudio después de que se complete la recopilación de datos, la información de su hijo se eliminará de la base de datos y no se incluirá en los resultados de la investigación.

Contactos de información:
Las preguntas sobre el propósito o los procedimientos de la investigación deben dirigirse a Leah Owens. en lowens@valdosta.edu. Este estudio ha sido aprobado por la Junta de Revisión Institucional (IRB) de la Universidad Estatal de Valdosta para la protección de los participantes de la investigación humana. El IRB, un comité universitario establecido por la ley federal es responsable de proteger los derechos y el bienestar de los participantes de la investigación. Si tiene inquietudes o preguntas sobre sus derechos como participante de una investigación, puede comunicarse con el Administrador del IRB al 229-253-2947 o irb@valdosta.edu.

Acuerdo para participar:
Se me ha explicado el proyecto de investigación y el papel de mi hijo (o pupilo) en él, y mis preguntas han sido respondidas satisfactoriamente. Doy permiso para que mi hijo participe en este estudio. Al firmar este formulario, estoy indicando que soy el padre con custodia o el guardián legal del niño. He recibido una copia de este formulario de permiso.

Me gustaría recibir una copia de los resultados de este estudio: _____ Sí _____ No

Dirección postal: ____

Dirección de correo electrónico: ____________________________

____
Nombre en imprenta del niño / pupilo

____
Nombre en imprenta del padre / guardián

Este proyecto de investigación ha sido aprobado por la Junta de Revisión Institucional de la Universidad Estatal de Valdosta para la Protección de los Participantes de la Investigación Humana hasta la fecha que se indica a

Firma del padre / guardián Fecha

Firma de la persona que obtiene el consentimiento – Fecha

VALDOSTA STATE UNIVERSITY
APPROVAL DATE
11.06.2020
IRB #
04096-2020
EXPIRATION DATE
11.06.2023
INSTITUTIONAL REVIEW BOARD

Appendix N

Teacher Consent Forms

Teacher Consent Forms – Treatment Group

Teacher Consent Form – Treatment Group

VALDOSTA STATE UNIVERSITY
Consent to Participate in Research

You are being asked to participate in a research project entitled "**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation.**" This research project is being conducted by Leah Owens, a doctoral student in Curriculum and Instruction at Valdosta State University. The purpose of this research is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. Your participation is entirely voluntary.

As described in more detail below, we will ask you to administer a survey, pre-test, and post-test. We will also ask you to implement two activities, called Formative Assessment Lessons, during the semester. *S*omeone in your position might be interested in participating because it will help us learn more about how to target student motivation, confidence, and achievement in the math classroom. Because there are some risks, such as altering your instructional calendar and increased in time required to prepare for implementing the Formative Assessment Lessons, you may not wish to participate. However, please know that careful consideration was taken to minimize the interruptions to your instructional calendar as much as possible. It is important for you to know that you can stop your participation at any time. More information about all aspects of this study is provided below.

This form includes detailed information to help you decide whether to participate in this study. Please read it carefully and ask any questions that you have before you agree to participate. Please be sure to retain a copy of this form for your records.

Procedures: Your participation will involve administering a survey, pre-test, post-test, and implementing two activities, called Formative Assessment Lessons, during the Spring semester. The survey will be administered once at the beginning of the semester, before any formal instruction has taken place for the semester, and once at the end of the semester, after instruction has concluded for the semester but prior to the final exam. The survey will be given in an online format and each administration of the survey should take students approximately 15 minutes to complete. The pre-test will be administered at the beginning of the semester, before any formal instruction has taken place for the semester. The pre-test will be a multiple-choice test given in an online format. Questions on the pre-test are equivalent but not identical to questions presented on the post-test. The pre-test should take students approximately 45 minutes to complete. The post-test will also be a multiple-choice test given in an online format. Questions on the post-test are equivalent but not identical to questions presented on the pre-test. The post-test should take approximately 60 minutes to complete.

The two activities, called Formative Assessment Lessons, will each be implemented separately during two instructional units of your choice. Your participation in each Formative Assessment Lesson will involve administering a pre-assessment question either in-class or assigned as homework for students to attempt independently and giving feedback on the pre-assessment by writing questions/comments on each student's work. A list of suggested questions and comments will be provided to you with the Formative Assessment Lesson Teacher Guidelines. Then, you will be asked to lead a whole-class discussion targeting misconceptions you identified in the students' pre-assessment work before facilitating a collaborative activity in which students work in groups to complete a task or solve a problem. For example, you may facilitate a collaborative activity in which students match equations of quadratic functions with graphs of quadratic functions based on what they have already learned about what quadratic functions should look like when represented graphically. Following the activity, you will be asked to lead another whole-class discussion in which students share how their group approached the activity and share strategies their group used to solve the problem. Finally, you will be asked to administer a post-assessment either in class or as homework in which students attempt to re-solve the problem presented in the pre-assessment using new knowledge gained from the whole-class discussions and participation in the collaborative activity. Neither the pre-assessment nor post-assessment are to be given numerical grades or affect student averages for the course. The pre- and post-assessment for each Formative Assessment Lesson should each take students approximately 15 minutes for students to complete. The whole-class discussions and collaborative activities for each Formative Assessment Lesson should take approximately 90 minutes to complete.

Your total participation in this project is expected to be approximately 375 minutes throughout the Spring Semester.

There are no alternatives to the experimental procedures in this study. The only alternative is to choose not to participate at all.

Possible Risks or Discomfort: This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. Although there are no known risks associated with these research procedures, it is not always possible to identify all potential risks of participating in a research study. However, the University has taken reasonable safeguards to minimize potential but unknown risks. By agreeing to participate in this research project, you are not waiving any rights that you may have against Valdosta State University for injury resulting from negligence of the University or its researchers.

Potential Benefits: Your participation will help the researcher gain additional understanding of how instructional strategies affect student motivation, confidence, and achievement in math classes. Knowledge gained from this study may help teachers understand how to help students become more motivated and confident in math classes which could ultimately help students reach higher levels of student achievement.

Costs and Compensation: There are no costs to you and there is no compensation (no money, gifts, or services) for your participation in this research project.

Assurance of Confidentiality: Valdosta State University and the researcher will keep your information confidential to the extent allowed by law. Members of the Institutional Review Board (IRB), a university committee charged with reviewing research to ensure the rights and welfare of research participants, may be given access to your confidential information. Data from this study will be reported in combination with data obtained from other participants. None of the participants will be identified in this study by name or employee number. All information obtained from surveys and testing will be kept in the researcher's office secured by lock and key until the conclusion of the study. The only persons who will have access to the information is the researcher and the researcher's committee members from Valdosta State University who are overseeing the completion of this study.

Voluntary Participation: Your decision to participate in this research project is entirely voluntary. If you agree now to participate and change your mind later, you are free to leave the study. Your decision not to participate at all or to stop participating at any time in the future will not have any effect on any rights you have or any services you are otherwise entitled to from Valdosta State University.

Information Contacts: Questions regarding the purpose or procedures of the research should be directed to Leah Owens at lowens@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Agreement to Participate: The research project and my role in it have been explained to me, and my questions have been answered to my satisfaction. I agree to participate in this study. By signing this form, I am indicating that I am 18 years of age or older. I have received a copy of this consent form.

I would like to receive a copy of the results of this study: _____ Yes _____ No

Mailing Address: ____

E-mail Address: ______________________

____
Printed Name of Participant

____
Signature of Participant Date

____
Signature of Person Obtaining Consent Date

This research project has been approved by the Valdosta State University Institutional Review Board for the Protection of Human Research Participants through the date noted below:

VALDOSTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD
APPROVAL DATE 11.06.2020
IRB # 04096-2020
EXPIRATION DATE 11.06.2023

Research Statement for Teacher Log

You are being asked to participate in a survey research project entitled *"**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation**,"* which is being conducted by Leah Owens, a student at Valdosta State University. The purpose of the study is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. You will receive no direct benefits from participating in this research study. However, your responses may help us learn more about how Formative Assessment Lessons affect student motivation, self-efficacy, and achievement in the math classroom. There are no foreseeable risks involved in participating in this study other than those encountered in day-to-day life. Participation should take up to approximately 1 hour to complete. Your participation is voluntary. You may choose not to complete the teacher log, to stop responding at any time, or to skip any questions that you do not want to answer. Participants must be at least 18 years of age to participate in this study. Your completion of the teacher log serves as your voluntary agreement to participate in this research project and your certification that you are 18 or older. You may print a copy of this statement for your records.

Questions regarding the purpose or procedures of the research should be directed to Leah Owens at lowens@valdosta.edu. This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Research Statement for Teacher Interview

You are being asked to participate in an interview as part of a research study entitled ***"A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation,"*** which is being conducted by myself, Leah Owens, a student at Valdosta State University. The purpose of the study is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. You will receive no direct benefits from participating in this research study. However, your responses may help us learn more about how Formative Assessment Lessons affect student motivation, self-efficacy, and achievement in the math classroom. There are no foreseeable risks involved in participating in this study other than those encountered in day-to-day life. Participation should take up to approximately 1.5 hours. In response to COVID-19, the interview can be conducted in-person or virtually via a Microsoft teams meeting, depending on your level of comfort. If conducted in person, the researcher and participants will wear masks and remain 6 feet apart throughout the duration of the interview. Your participation is voluntary. You may choose not to participate, to stop responding at any time, or to choose not to answer any questions that you do not want to answer. You must be at least 18 years of age to participate in this study. Your participation in the interview will serve as your voluntary agreement to participate in this research project and your certification that you are 18 years of age or older.

This study has been exempted from Institutional Review Board (IRB) review in accordance with Federal regulations. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Do you have any questions regarding the purpose or procedures of the research at this time? Do you have any additional questions before we begin the interview?

If you think of questions after the interview, you may contact me directly at lowens@valdosta.edu.

Teacher Consent Forms – Control Group

Appendix B (Two Forms Included)
Teacher Consent Form – Control Group

VALDOSTA STATE UNIVERSITY
Consent to Participate in Research

You are being asked to participate in a research project entitled "**A Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation.**" This research project is being conducted by Leah Owens, a doctoral student in Curriculum and Instruction at Valdosta State University. The purpose of this research is to see how specific instructional activities, called Formative Assessment Lessons, affect students' motivation to learn math, students' belief in their abilities to solve math problem, and students' performances on math tests. Your participation is entirely voluntary.

As described in more detail below, we will ask you to administer a survey, pre-test, and post-test. Someone in your position might be interested in participating because it will help us learn more about how to target student motivation, confidence, and achievement in the math classroom. Because there are some risks, such as altering your instructional calendar, you may not wish to participate. However, please know that careful consideration was taken to minimize the interruptions to your instructional calendar as much as possible. It is important for you to know that you can stop your participation at any time. More information about all aspects of this study is provided below.

This form includes detailed information to help you decide whether to participate in this study. Please read it carefully and ask any questions that you have before you agree to participate. Please be sure to retain a copy of this form for your records.

Procedures: Your participation will involve administering a survey, pre-test, and post-test during the Spring semester. The survey will be administered once at the beginning of the semester, before any formal instruction has taken place for the semester, and once at the end of the semester, after instruction has concluded for the semester but prior to the final exam. The survey will be given in an online format and each administration of the survey should take students approximately 15 minutes to complete. The pre-test will be administered at the beginning of the semester, before any formal instruction has taken place for the semester. The pre-test will be a multiple-choice test given in an online format. Questions on the pre-test are equivalent but not identical to questions presented on the post-test. The pre-test should take students approximately 45 minutes to complete. The post-test will also be a multiple-choice test given in an online format. Questions on the post-test are equivalent but not identical to questions presented on the pre-test. The post-test should take approximately 60 minutes to complete.

Your total participation in this project is expected to be approximately 135 minutes throughout the Spring Semester.

There are no alternatives to the experimental procedures in this study. The only alternative is to choose not to participate at all.

Possible Risks or Discomfort: This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. Although there are no known risks associated with these research procedures, it is not always possible to identify all potential risks of participating in a research study. However, the University has taken reasonable safeguards to minimize potential but unknown risks. By agreeing to participate in this research project, you are not waiving any rights that you may have against Valdosta State University for injury resulting from negligence of the University or its researchers.

Potential Benefits: Your participation will help the researcher gain additional understanding of how instructional strategies affect student motivation, confidence, and achievement in math classes. Knowledge gained from this study may help teachers understand how to help students become more motivated and confident in math classes which could ultimately help students reach higher levels of student achievement.

Costs and Compensation: There are no costs to you and there is no compensation (no money, gifts, or services) for your participation in this research project.

Assurance of Confidentiality: Valdosta State University and the researcher will keep your information confidential to the extent allowed by law. Members of the Institutional Review Board (IRB), a university committee charged with reviewing research to ensure the rights and welfare of research participants, may be given access to your confidential information. Data from this study will be reported in combination with data obtained from other participants. None of the participants will be identified in this study by name or employee number. All information obtained from surveys and testing will be kept in the researcher's office secured by lock and key until the conclusion of the study. The only persons who will have access to the information is the researcher and the researcher's committee members from Valdosta State University who are overseeing the completion of this study.

Voluntary Participation: Your decision to participate in this research project is entirely voluntary. If you agree now to participate and change your mind later, you are free to leave the study. Your decision not to participate at all or to stop participating at any time in the future will not have any effect on any rights you have or any services you are otherwise entitled to from Valdosta State University.

Information Contacts: Questions regarding the purpose or procedures of the research should be directed to Leah Owens at lowens@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Agreement to Participate: The research project and my role in it have been explained to me, and my questions have been answered to my satisfaction. I agree to participate in this study. By signing this form, I am indicating that I am 18 years of age or older. I have received a copy of this consent form.

I would like to receive a copy of the results of this study: _____ **Yes** _____ **No**

Mailing Address: ____

E-mail Address: ______________________________

____
Printed Name of Participant

____
Signature of Participant Date

____
Signature of Person Obtaining Consent Date

This research project has been approved by the Valdosta State University Institutional Review Board for the Protection of Human Research Participants through the date noted below:

VALDOSTA STATE UNIVERSITY
APPROVAL DATE 11.06.2020
IRB # 04096-2020
EXPIRATION DATE 11.06.2023
INSTITUTIONAL REVIEW BOARD

Appendix O

University IRB Approvals

University IRB Approval

Institutional Review Board (IRB)
for the Protection of Human Research Participants

EXPEDITED PROTOCOL APPROVAL

Protocol Number: IRB-04096-2020

Responsible Researcher: Leah Owens

Supervising Faculty: Dr. E-ling Hsiao

Project Title*: Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation.*

Level of Risk: ☒ Minimal ☐ More than Minimal
Type of Review: ☒ Expedited ☐ Convened (Full Board)
Approval Category: 7
Approval Date: 11.06.2020
Expiration Date: 11.06.2023

Consent Requirements:

- ☒ Adult Participants – Written informed consent with documentation (signature)
- ☐ Adult Participants – Written informed consent with waiver of documentation (signature)
- ☐ Adult Participants – Verbal informed consent (Research Statement)
- ☐ Adult Participants – Waiver of informed consent
- ☒ Minor Participants – Written parent/guardian permission with documentation (signature)
- ☐ Minor Participants – Written parent/guardian permission with waiver of documentation (signature)
- ☐ Minor Participants – Verbal parent/guardian permission
- ☐ Minor Participants – Waiver of parent/guardian permission
- ☐ Minor Participants – Written assent with documentation (signature)
- ☒ Minor Participants – Written assent with waiver of documentation (signature)
- ☐ Minor Participants – Verbal assent
- ☐ Minor Participants – Waiver of assent
- ☐ Waiver of some elements of consent/permission/assent

Approval: This research protocol is **approved.** Your approved consent form(s), with IRB approval stamp are attached. If you prefer the original stamped consent, please email tmwright@valdosta.edu and the form will be sent via inter-office mail, or you may come by the OSPRA office to obtain the original. Please see page 2 for additional important information for researchers.

Comments:

Elizabeth Ann Olphie *11.06.2020*
Elizabeth Ann Olphie, IRB Administrator Date

Thank you for submitting an IRB application.
Please direct questions to irb@valdosta.edu or 229-253-2947.

Form Revised: 06.02.16

University IRB Modification Approval

Institutional Review Board (IRB)
for the Protection of Human Research Participants

PROTOCOL MODIFICATION AND/OR CONTINUATION APPROVAL

PROTOCOL NUMBER: 04096-2020 **INVESTIGATOR(s): Leah Owens**

PROJECT TITLE: ***Quasi-Experimental Examination of High School Students' Self-Efficacy, Motivation, and Achievement in Response to Formative Assessment Lesson Implementation.***

MODIFICATION APPROVAL DATE: 02.19.2021 **NEW EXPIRATION DATE: 02.19.2024**

TYPE OF REVIEW:

- ☒ Modification request of previously expedited protocol.
- ☐ Expedited Review Category 8 - Review of a protocol previously approved through convened review where:
  - ☐ The research is permanently closed to enrollment of new participants, all participants have completed all research-related interventions, and the research remains active only for long-term follow-up of participants; or
  - ☐ No participants have been enrolled and no additional risks have been identified; or
  - ☐ The remaining research activities are limited to data analysis
- ☐ Expedited Review Category 9 – Continuing review of research, not conducted under an investigational new drug application or investigational device exemption, where Expedited Categories 2 through 8 do not apply but the IRB has determined and documented at a convened meeting that the research involves no greater than minimal risk and no additional risks have been identified
- ☐ Convened review

DETERMINATION:

Your continuation request has been **approved** beginning 02.19.2021, **through the new expiration date noted above**. Please use updated consent document(s) bearing the new expiration date. Consent documents will be sent through email unless other arrangements have been made.

Please also remember the following:

1. You must receive IRB approval for any protocol modifications prior to implementing them;
2. You must report to the IRB Administrator any unanticipated problems or adverse events which become apparent during the course or as a result of the research and the actions you have taken; and
3. You may not conduct research activities involving participants or data about them (including interaction, intervention, data collection, and data analysis) beyond the expiration date noted above.

Elizabeth W. Olphie *02.19.2021*
Elizabeth Olphie, IRB Administrator Date

Thank you for submitting a continuation request.
Please direct questions to irb@valdosta.edu or 229-259-5045.

Revised: 06.08.2016

Appendix P

School District IRB Approval

School District IRB Approval

FORSYTH COUNTY SCHOOLS

Quality Learning and Superior Performance for All

Dr. Jeffrey Bearden, Superintendent • 1120 Dahlonega Highway • Cumming, Georgia 30040 •
Telephone 770.887.2461

10/23/20

To Whom It May Concern,

Forsyth County School District grants Leah Owens permission to conduct her research project, pending receipt of VSU approval.

Thank You,

Joey Pirkle

Deputy Superintendent
Forsyth County Schools

www.forsyth.k12.ga.us

Appendix Q

Descriptive Data for Self-Efficacy by Question

Descriptive Data for Self-Efficacy by Question

#	Comp.	Treatment					Control				
		Pre		Post			Pre		Post		
		M	*SD*	*M*	*SD*	Gain	*M*	*SD*	*M*	*SD*	Gain
ME ---		4.22	0.77	4.24	1.06	0.02	4.42	0.97	4.29	1.02	-0.13
Q2	ME	4.44	0.73	4.38	1.36	-0.06	5.00	0.82	4.50	0.58	-0.50
Q14	ME	4.75	0.86	4.50	1.03	-0.25	4.75	1.26	4.50	1.29	-0.25
Q15	ME	3.75	1.53	3.88	1.59	0.13	2.75	0.50	3.50	1.29	0.75
Q16	ME	4.88	1.03	4.50	1.55	-0.38	5.25	1.50	4.75	1.50	-0.50
Q19	ME^	4.31	1.25	4.50	1.67	0.19	4.75	1.26	4.75	1.50	0.00
Q23	ME	3.19	1.11	3.69	1.25	0.50	4.00	0.82	3.75	0.96	-0.25
VE ---		4.20	0.74	3.84	0.87	-0.36	3.83	0.53	3.67	0.81	-0.16
VA ---		4.34	0.70	4.22	0.84	-0.13	3.89	0.49	3.75	0.65	-0.13
Q1	VA	4.19	0.98	3.94	1.29	-0.25	3.00	1.16	3.25	0.50	0.25
Q8	VA	4.50	0.89	4.50	1.27	0.00	4.75	0.50	4.25	1.26	-0.50
VP ---		3.89	1.23	3.47	1.07	-0.41	3.38	1.11	3.25	0.87	-0.13
Q12	VP	4.06	1.65	3.75	1.61	-0.31	2.75	1.50	3.00	0.82	0.25
Q24	VP	3.69	1.14	3.19	1.28	-0.50	4.00	0.82	3.50	1.00	-0.50
VS ---		4.38	0.87	3.84	1.15	-0.53	4.25	0.65	4.00	1.08	-0.25
Q4	VS	4.50	0.89	3.81	1.22	-0.69	4.50	0.58	4.00	0.82	-0.50
Q17	VS	4.25	1.29	3.88	1.54	-0.37	4.00	0.82	4.00	1.41	0.00
P ---		3.47	1.14	3.71	1.21	0.24	2.42	1.21	3.38	0.88	0.96
Q6	P	3.19	1.64	3.50	1.41	0.31	2.50	1.73	3.25	1.71	0.75
Q10	P	3.00	1.46	3.13	1.54	0.13	2.25	0.96	2.75	1.50	0.50
Q11	P	4.06	1.12	4.12	1.26	0.06	2.75	1.26	3.50	1.29	0.75
Q18	P	3.37	1.50	3.56	1.41	0.19	2.50	1.29	4.00	1.41	1.50
Q20	P	3.50	1.59	3.63	1.67	0.13	1.50	1.00	3.75	0.50	2.25
Q21	P	3.69	1.40	4.31	1.30	0.63	3.00	1.83	3.00	1.16	0.00
PH ---		4.36	0.86	3.78	0.80	-0.58	5.17	0.43	4.17	0.76	-1.00
Q3	PH^	4.19	1.17	4.00	1.32	-0.19	5.00	0.82	4.25	0.96	-0.75
Q5	PH^	4.25	1.48	4.38	1.41	0.13	5.75	0.50	5.50	0.58	-0.25
Q7	PH^	4.19	1.11	4.00	1.03	-0.19	5.50	0.58	4.75	1.50	-0.75

Q9	PH^	3.94	1.29	4.44	1.26	0.50	5.50	1.00	5.25	0.50	-0.25
Q13	PH^	4.38	0.96	4.12	1.67	-0.25	4.00	1.16	3.25	2.06	-0.75
Q22	PH^	5.25	0.93	5.25	1.00	0.00	5.25	.50	5.00	0.82	-0.25

Note. ME = Mastery Experiences; VE = Vicarious Experience; VA = Vicarious Experience from Adults; VP = Vicarious Experience from Peers; VS = Vicarious Experience from Self; P = Social Persuasions; PH = Physiological State; ^ Reverse-scored item;

Appendix R

t-test Results for Self-Efficacy by Question *t*-test Results for Self-Efficacy by Question

	Treatment		Control					
Comp.	Gain *M*	Gain *SD*	Gain *M*	Gain *SD*	*t*	*df*	*p*	*Cohen's d*
ME --	0.02	0.61	-0.13	1.03	0.38	18	0.712	0.21
Q2	-0.06	1.00	-0.50	1.00	0.78	18	0.443	0.44
Q14	-0.25	0.68	-0.25	1.26	0.00	18	1.000	0.00
Q15	0.13	0.62	0.75	0.96	-1.63	18	0.121	-0.91
Q16	-0.38	0.72	-0.50	1.73	0.14	3	0.896	0.13
Q19^	0.19	1.22	0.00	2.00	0.24	18	0.811	0.14
Q23	0.50	1.03	-0.25	0.50	1.39	18	0.181	0.78
VE --	-0.36	0.60	-0.16	0.58	-0.57	18	0.579	-0.32
VA --	-0.13	0.72	-0.13	1.03	0.00	18	1.000	0.00
Q1	-0.25	0.86	0.25	1.50	-0.90	18	0.380	-0.50
Q8	0.00	1.41	-0.50	1.00	0.66	18	0.517	0.37
VP --	-0.41	1.05	-0.13	0.48	-0.51	18	0.614	-0.29
Q12	-0.31	1.25	0.25	0.96	-0.83	18	0.415	-0.47
Q24	-0.50	1.41	-0.50	0.58	0.00	18	1.000	0.00
VS --	-0.53	0.74	-0.25	0.87	-0.66	18	0.518	-0.37
Q4	-0.69	0.87	-0.50	0.58	-0.40	18	0.691	-0.23
Q17	-0.37	1.26	0.00	1.15	-0.54	18	0.596	-0.30
P --	0.24	0.91	0.96	0.84	-1.43	18	0.169	-0.80
Q6	0.31	1.30	0.75	1.71	-0.57	18	0.577	-0.32
Q10	0.13	1.78	0.50	1.29	-0.39	18	0.700	-0.22
Q11	0.06	1.34	0.75	1.71	-0.87	18	0.394	-0.49
Q18	0.19	1.64	1.50	0.58	-1.55	18	0.139	-0.87
Q20	0.13	1.54	2.25	0.96	-2.60*	18	0.018	-1.45
Q21	0.63	1.02	0.00	2.16	0.87	18	0.396	0.49
PH --	-0.58	0.81	-1.00	0.56	0.97	18	0.347	0.54
Q3^	-0.19	1.52	-0.75	0.50	0.72	18	0.481	0.40
Q5^	0.13	1.36	-0.25	0.50	0.53	18	0.600	0.30
Q7^	-0.19	1.22	-0.75	0.96	0.85	18	0.406	0.48

Q9^	0.50	1.37	-0.25	0.96	1.03	18	0.318	0.57
Q13^	-0.25	1.61	-0.75	2.50	0.50	18	0.624	0.28
Q22^	0.00	1.15	-0.25	0.50	0.42	18	0.682	0.23

Note. ME = Mastery Experiences; VE = Vicarious Experience; VA = Vicarious Experience from Adults; VP = Vicarious Experience from Peers; VS = Vicarious Experience from Self; P = Social Persuasions; PH = Physiological State; ^ Reverse-scored item; *. The mean difference is significant at the .05 level

Appendix S

Descriptive Data for Motivation by Question

Descriptive Data for Motivation by Question

#	Treatment					Control				
	Pre		Post			Pre		Post		
	M	*SD*	*M*	*SD*	G	*M*	*SD*	*M*	*SD*	G
Autonomy	3.98	.95	3.73	1.28	-.25	3.92	1.17	3.92	0.88	.00
Q4	3.50	.89	3.50	1.41	.00	4.25	1.26	3.75	1.89	-.50
Q8	4.00	1.46	3.50	1.63	-.50	3.50	1.00	3.25	.50	-.25
Q12	4.44	1.15	4.19	1.68	-.25	4.00	1.41	4.75	.50	.75
Competence	4.96	.80	5.02	.74	.06	5.00	.82	4.75	.50	-.25
Q1	5.06	.93	5.12	1.15	.06	5.00	1.16	4.25	.96	-.75
Q7	4.25	1.39	4.13	1.15	-.13	5.00	1.16	4.50	1.00	-.50
Q11	5.56	1.03	5.81	.83	.25	5.00	.82	5.50	.58	.50
Relatedness	3.73	1.10	3.75	1.12	.02	3.25	1.85	3.58	1.32	.33
Q2	4.37	1.20	4.56	1.46	.19	3.50	1.73	3.75	.96	.25
Q5	3.94	1.48	3.87	1.67	-.06	3.50	2.38	3.50	1.73	.00
Q10	2.88	1.20	2.81	1.33	-.06	2.75	1.71	3.50	1.73	.75

Note. Q3: "Stressed", Q6: "Pressured", and Q9: "Uptight" are filler items that are not scored; G = Gain

Appendix T

t-test Results for Motivation by Question *t*-test Results for Motivation by Question

Comp.	Treatment Gain *M*	Treatment Gain *SD*	Control Gain *M*	Control Gain *SD*	*t*	*df*	*p*	*Cohen's d*
Autonomy	-0.25	1.08	0.00	1.22	-0.41	18	.690	-0.23
Q4	0.00	1.37	-0.50	1.29	0.66	18	.517	0.37
Q8	-0.50	0.97	-0.25	1.26	-0.44	18	.666	-0.24
Q12	-0.25	1.98	0.75	1.50	-0.94	18	.362	-0.52
Competence	0.06	0.78	-0.25	0.69	0.73	18	.475	0.41
Q1	0.06	0.77	-0.75	1.26	1.67	18	.113	0.93
Q7	-0.13	1.20	-0.50	1.00	0.57	18	.574	0.32
Q11	0.25	1.29	0.50	0.58	-0.37	18	.714	-0.21
Relatedness	0.02	1.09	0.33	0.61	-0.55	18	.591	-0.31
Q2	0.19	1.28	0.25	0.96	-0.09	18	.929	-0.05
Q5	-0.06	1.91	0.00	0.82	-0.06	18	.951	-0.04
Q10	-0.06	1.39	0.75	1.50	-1.03	18	.316	-0.58

Note. Q3: "Stressed", Q6: "Pressured", and Q9: "Uptight" are filler items that are not scored

Appendix U

Pass Rates for Pretest and Posttest by Question

Pass Rates for Pretest and Posttest by Question

	Treatment					Control					
	Pre		Post			Pre		Post			
Q	n	%	n	%	Change	n	%	n	%	Change	T-C
1	0	0.00%	18	56.25%	56.25%	3	25.00%	5	41.67%	16.67%	39.58%
2	4	12.50%	19	59.38%	46.88%	3	25.00%	8	66.67%	41.67%	5.21%
3	1	3.13%	9	28.13%	25.00%	2	16.67%	5	41.67%	25.00%	0.00%
4	7	21.88%	10	31.25%	9.38%	4	33.33%	4	33.33%	0.00%	9.38%
5	6	18.75%	19	59.38%	40.63%	3	25.00%	6	50.00%	25.00%	15.63%
6	3	9.38%	12	37.50%	28.13%	2	16.67%	4	33.33%	16.67%	11.46%
7	1	3.13%	23	71.88%	68.75%	2	16.67%	5	41.67%	25.00%	43.75%
8	5	15.63%	22	68.75%	53.13%	0	0.00%	5	41.67%	41.67%	11.46%
9	2	6.25%	16	50.00%	43.75%	1	8.33%	5	41.67%	33.33%	10.42%
10	5	15.63%	10	31.25%	15.63%	3	25.00%	4	33.33%	8.33%	7.29%
11	9	28.13%	25	78.13%	50.00%	2	16.67%	8	66.67%	50.00%	0.00%
12	5	15.63%	15	46.88%	31.25%	4	33.33%	2	16.67%	-16.67%	47.92%
13	2	6.25%	20	62.50%	56.25%	1	8.33%	9	75.00%	66.67%	-10.42%
14	2	6.25%	20	62.50%	56.25%	0	0.00%	8	66.67%	66.67%	-10.42%
15	12	37.50%	21	65.63%	28.13%	4	33.33%	7	58.33%	25.00%	3.12%
16	5	15.63%	20	62.50%	46.88%	2	16.67%	7	58.33%	41.67%	5.21%
17	9	28.13%	7	21.88%	-6.25%	4	33.33%	1	8.33%	-25.00%	18.75%
18	7	21.88%	7	21.88%	0.00%	3	25.00%	4	33.33%	8.33%	-8.33%
19	2	6.25%	11	34.38%	28.13%	1	8.33%	6	50.00%	41.67%	-13.54%
20	23	71.88%	14	43.75%	-28.13%	9	75.00%	5	41.67%	-33.33%	5.21%
21	0	0.00%	14	43.75%	43.75%	1	8.33%	5	41.67%	33.33%	10.42%
22	13	40.63%	20	62.50%	21.88%	6	50.00%	7	58.33%	8.33%	13.54%
23	12	37.50%	11	34.38%	-3.13%	3	25.00%	5	41.67%	16.67%	-19.79%
24	1	3.13%	13	40.63%	37.50%	2	16.67%	6	50.00%	33.33%	4.17%
25	5	15.63%	15	46.88%	31.25%	0	0.00%	7	58.33%	58.33%	-27.08%
26	16	50.00%	15	46.88%	-3.13%	5	41.67%	4	33.33%	-8.33%	5.21%
27	12	37.50%	17	53.13%	15.63%	4	33.33%	5	41.67%	8.33%	7.29%
28	1	3.13%	11	34.38%	31.25%	2	16.67%	7	58.33%	41.67%	-10.42%
29	5	15.63%	17	53.13%	37.50%	1	8.33%	3	25.00%	16.67%	20.83%
30	5	15.63%	13	40.63%	25.00%	1	8.33%	3	25.00%	16.67%	8.33%
31	6	18.75%	17	53.13%	34.38%	1	8.33%	3	25.00%	16.67%	17.71%
32	3	9.38%	16	50.00%	40.63%	0	0.00%	8	66.67%	66.67%	-26.04%
33	3	9.38%	19	59.38%	50.00%	1	8.33%	6	50.00%	41.67%	8.33%
34	13	40.63%	14	43.75%	3.13%	6	50.00%	5	41.67%	-8.33%	11.46%
35	5	15.63%	18	56.25%	40.63%	1	8.33%	6	50.00%	41.67%	-1.04%
36	18	56.25%	12	37.50%	-18.75%	7	58.33%	3	25.00%	-33.33%	14.58%
37	14	43.75%	19	59.38%	15.63%	4	33.33%	8	66.67%	33.33%	-17.71%