THE RELATIONSHIP OF GRIT, MATHEMATICS SELF-EFFICACY, STEM CAREER INTEREST, AND ACADEMIC ACHIEVEMENT FOR MIDDLE SCHOOL STUDENTS IN ALGEBRA I

by

Amanda Smith, M.Ed.

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Amanda Smith

APPROVED BY

_____
Suzanne Brown, Ph.D., Chair

_____
Michelle Peters, Ed.D., Committee Member

_____
Amy Orange, Ed.D., Committee Member

_____
Kent Divoll, Ed.D., Committee Member

RECEIVED/APPROVED BY THE COLLEGE OF EDUCATION

_____
Felix Simieou III, Ph.D., Interim Associate Dean

_____
Joan Y. Pedro, Ph.D., Dean

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ABSTRACT

THE RELATIONSHIP OF GRIT, MATHEMATICS SELF-EFFICACY,
STEM CAREER INTEREST, AND ACADEMIC ACHIEVEMENT
FOR MIDDLE SCHOOL STUDENTS IN ALGEBRA I

Amanda Smith
University of Houston – Clear Lake

Dissertation Chair: Suzanne Brown, Ph.D.

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement in Algebra I. The study was intentional in examining the concepts of self-efficacy, achievement, and career interest as part of STEM education research. The research was completed during the fall in 2019 with 118 seventh and eighth grade Algebra I students within a large suburban district located in southeast Texas. Students participated in quantitative data collection with the Short Grit Scale, the S-STEM, and individual interviews. All 118 students completed the survey and 11 students participated with individual interviews. Pearson's Product-Moment correlation (r), structural equation modeling (SEM), and thematic coding were used to analyze the data collected.

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CHAPTER I:

INTRODUCTION

Having grit and tenacity are characteristics used to describe an individual capable of turning a goal into a reality (Phillips-Martinez, 2017). Beliefs that students have about their personal intellectual abilities in the realm of rigorous instructional areas, such as mathematics, are possibly influential on academic achievement and performance within instructional areas (Dweck, 2014). Mathematics is a key component of science, technology, engineering, and mathematics (STEM) education and in order to be successful in STEM education, it is critical that students utilize critical thinking and problem-solving skills, as STEM courses are found to be mathematically intensive and challenging (Reinking & Martin, 2018).

In order to be internationally competitive within STEM backgrounds, both educational and career related fields have been in demand since the 2010 President's Council of Advisors on Science and Technology conveyed the importance of STEM demands (Reinking & Martin, 2018). Students' career interest in STEM fields is correlated to exposure and achievement in mathematics courses (Huang, Zhang, & Hudson, 2018). One predictor of academic achievement that has been found to predict academic achievement is academic self-efficacy; additionally, academic self-efficacy has been shown to influence career trajectory (Dixson, Worrell, Olszewski-Kubilius, & Subotnik, 2016).

Therefore, as society continues to face the demands for a global workforce within the realm of STEM, examining the influence of academic self-efficacy, such as mathematics self-efficacy could provide insight to understanding the critical importance for students to feel successful and perform successfully in a STEM course, such as mathematics. An individual who is determined to be successful in STEM field

coursework is one who understands the challenges and problems to be solved through the process but is driven with persistence to solve problems presented in those STEM educational opportunities (Sublett & Plasman, 2017). This research study examined factors that contribute to success for students, known as psychosocial factors, specifically for middle school students who are enrolled in a STEM field course at an early age.

Research Problem

The past two decades have shown a heightened demand for driven youth to enter STEM fields of study in efforts to increase the STEM pipeline with successful students. However, student STEM career interest and readiness is stagnant (Yoon & Strobel, 2017). The time that students spend in middle and high school compose the years of educational and career trajectory for students; furthermore, these years of learning opportunity are when students take college prerequisite coursework (Kim, Sinatra, & Seyranian, 2018).

In Texas, students can take accelerated mathematics courses, including Algebra 1 and Geometry while enrolled in middle school. Students taking accelerated mathematics courses while in middle school are typically following a pathway that fosters the participation in Advanced Placement (AP) mathematics courses in high school which is intended to support a STEM career trajectory (Yoon & Strobel, 2017). Accelerated mathematics courses, such as AP classes are designed to engage students in higher order thinking and instruction is differentiated for students capable of this type of critical thinking (Judson, 2017). Moreover, AP coursework offers whole class discussions where students are disaggregating data in order to provide evidence for a response claim. Even in mathematics courses, students engage in formulating responses using mathematical discourse in order to fulfill constructed responses; furthermore, critical thinking at higher

order levels is required in order for students to be successful on the end of course exams where college credit can be earned (Judson, 2017).

The gateway course of Algebra I is a prerequisite for college level classes such as AP Calculus and AP Statistics. Taking Algebra I as a middle grade student offers students the opportunity to engage in higher order thinking at an early age to begin the rigorous course sequence that is a used to prepare for college level classes while in high school. Furthermore, a strong foundation and deep understanding of algebraic concepts, such as mathematical algorithms and complex computation tasks, are foundational in order for students to be successful in advanced mathematics coursework that continues on past Algebra I (Dougherty, Goodman, Hill, Litke, & Page, 2015). Ketterlin-Geller, Gifford, and Perry (2015) report that students enrolled in advanced levels of mathematics coursework and perform successfully in Algebra II are four times as likely to matriculate through college as students that take lower-level mathematics coursework in high school. Within STEM education reform and in regard to national economic success and global competitiveness, the importance of mathematics achievement for Americans is deemed as being imperative (Chazan, 2008; The College Board, 2000).

Over the past two decades, research in the field of STEM related education and careers has been prevalent; furthermore, inquiry, exploration, and discussion in efforts to explain the phenomenon of avoidance for mathematical coursework and careers is ongoing (Huang et al., 2018). Investigations into mathematics anxiety and self-efficacy are variables that are studied and examined in relation to STEM or mathematics career interest (Huang et al., 2018). Pertinent studies related to the topic of STEM career interest indicate that the beginning of high school is the predictive period of time for students to develop STEM career interest, if they are expected to choose a STEM field job after college and between the ages of 10 and 14 positive attitudes towards STEM declines

(Blotnicky, Franz-Odendaal, French, & Joy, 2018). Adolescence is a time period of complexity for students as this is when students are comparing themselves to others and show a tendency for self-examining with a fixed mindset (Dweck, 2008).

Mathematics self-concept, which is considered to be a psychological component of self is foundational to how one perceives self in the mathematics field and is associated with self-confidence and self-efficacy; furthermore, mathematics self-concept is often used as a predictor for career expectancy in the STEM fields (Kanny, Sax, & Riggers-Piehl, 2014). A recent study by Brown, Concannon, Marx, Donaldson, and Black (2016) collected data by surveying 200 middle school students. The findings from the study indicated that academic self-efficacy was a significant indicator in the students' intentions in STEM career fields.

As society continues to face the demands for a global workforce within the realm of STEM, the need for students to perform successfully in STEM related coursework is critical (Reinking & Martin, 2018). An individual who is determined to be successful in STEM field coursework is one who understands the challenges and problems to be solved through the process but is driven with persistence to solve problems presented in those specific educational opportunities (Sublett & Plasman, 2017). Bandura (1977) defines self-efficacy as how an individual perceives one's ability to adeptly engage in specific activities. Academic self-efficacy beliefs are indicated as a factor that steers students' career expectancy and serve as predictors of students' career trajectory expectations (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996, 2001). The examination of grit and academic efficacy as factors that influence academic success for adolescents in accelerated mathematics courses and STEM career trajectory may be beneficial in helping to understand the barriers to STEM engagement. This study examined middle school students' achievement in an accelerated mathematics courses and investigated the

relationship of grit, mathematics self-efficacy, STEM career interest, and student achievement.

Significance of the Study

This study was significant in gaining an understanding of factors that could possibly influence middle school students in STEM field courses, such as Algebra I. This understanding could possibly help educators incorporate best practices within instructional methods to help facilitate middle school students to be able to persevere when the learning becomes highly challenging in a rigorous mathematics course taken above grade level. Learning environments that are intentionally designed to engage students and to support perseverance through the use of choice, problem solving skills, and authentic learning opportunities can result in higher levels of self-efficacy for students (Laursen, 2015). There is a need for students to feel successful as related to academic achievement in order to persist through the intensive studies that STEM fields encompass in order to continue on a STEM career path (Zhang & Barnett, 2015).

Research Purpose and Questions

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement for middle school students enrolled in Algebra I. The study addressed the following research questions:

1. Is there a statistically significant relationship between grit and achievement for middle school students enrolled in Algebra I?
2. Is there a statistically significant relationship between mathematics self-efficacy and achievement for middle school students enrolled in Algebra I?
3. Is there a statistically significant relationship between student career interest in STEM and achievement for middle school students enrolled in Algebra I?

4. Is there a statistically significant relationship between grit, mathematics self-efficacy, STEM career interest, and academics achievement for middle school students enrolled in Algebra I?

5. How do middle school students perceive grit to influence their achievement in Algebra I?

6. How do middle school students perceive mathematics self-efficacy to influence their achievement in Algebra I?

7. How does the perception of STEM career interest influence achievement for middle school students in Algebra I?

Definitions of Key Terms

Academic Achievement: The term academic achievement refers to a measurable aspect of academic performance based on a standardized test used to measure proficiency and usually given at the end of the accomplishment of a long-term educational objective, such as at the end of a course (Simpson & Weiner, 2000).

Grit: The term is defined as perseverance in the face or failure and an intense commitment towards long-term goals (Duckworth & Gross, 2014).

Mathematics Self-efficacy: The term refers to the belief that a person has in their own ability to successfully perform in mathematics based on their perception of their capability and the likelihood of their achieving success in mathematics (Blotnicky, Franz-Odendaal, French, & Joy, 2018).

Short Grit Scale (GRIT-S): The term refers to an 8-item survey modified from the original Grit Scale composed of 27 items. The GRIT-S is designed to measure perceptions of perseverance and passion towards long-term goals (Duckworth et. al, 2007).

STEM: The acronym stands for Science Technology Engineering and Mathematics; career fields or education (Yoon & Strobel, 2017).

STEM Career interest: The term career interest refers to the likelihood or preparedness and goal orientation that a student possesses to enter the STEM field as a career (Dasgupta & Stout, 2014).

S-STEM: The term refers to the Student Attitudes Toward STEM (S-STEM) Survey. The survey was developed for middle and high school students in sixth to twelfth grades and is intended to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers (Friday Institute for Educational Innovation, 2012).

Conclusion

This chapter provides an examination of the purpose for the study, background information related to the research problem, the significance of the study, and key definitions to help understand concepts presented throughout the research. The study was significant for gaining understanding of influencing factors of academic achievement for middle school students in a STEM field course, Algebra I. The following chapter contains a literature review of the major concepts that are investigated in this study.

CHAPTER II:

REVIEW OF LITERATURE

Gaining an understanding of factors that have an effect on academic achievement for middle school students in STEM field courses is critical for educators. If educators are to foster more students to be successful in accelerated mathematics classes, then educators need to understand the importance of cultivating students to have grit and academic self-efficacy in accelerated mathematics coursework. This understanding could help educators incorporate best practices within pedagogical methods to help facilitate middle school students to perseverance when the learning becomes highly challenging within a mathematics course taken above grade level.

Learning environments that are intentionally designed to engage students and to support perseverance can result in higher levels of self-efficacy for students; furthermore, students need to feel successful as related to academic achievement in order to persist through the intensive studies that STEM fields encompass in order to continue on a STEM career path (Laursen, 2015). This literature review will highlight research on grit, mathematics self-efficacy, STEM career interest, and academic achievement in order to help educators develop an understanding of the constructs. Therefore, educators can use this knowledge to model and foster factors of success for students when learning becomes challenging.

Grit

In recent years, the term grit has gained attention in educational psychology research as a predicting factor of personal success in education and in life (Park, Tsukayama, Yu, & Duckworth, 2019). Grit is defined as perseverance or passionate dedication towards long term goals (Duckworth, Peterson, Matthews, & Kelly, 2007). Furthermore, Duckworth et al. (2007) believe grit to be a predictor of academic

achievement, lifetime educational attainment, and job performance and retention. Grit as a predicting factor of personal success specifically involves effort and interest when an individual works towards long-term goals with goal directedness (Duckworth et al., 2007).

Grit and Achievement

The examination of how grit influences academic achievement illuminates the contribution of a non-cognitive factor on an academic outcome. Previous research in academic settings supports grit as a significant contributor to individual academic success because of the role self-interest plays (Lam & Zhou, 2019). Duckworth and Gross (2014) proposed people with grit focus their individual interest toward clear goals and work hard continuously with commitment in wanting to achieve the goals. Additionally, grit overlaps with self-regulation and intrinsic motivation and in an academic setting (Lam & Zhou, 2019).

Christensen and Knezek (2014) conducted a study to determine the relationship between motivational constructs, including grit, perseverance, persistence, and motivation on achievement. The researchers utilized the Grit survey (Duckworth & Quinn, 2009) and the Computer Attitude Questionnaire (CAQ) for motivation/persistence and study habits subscales with 151 (79 male and 72 female) secondary school students who were completing their last year at a mathematics and science residential academy in Texas. The students were admitted to the academy as freshman and earn two years of university credit while enrolled in their final two years of secondary school.

The researchers' data analysis included internal consistency reliability analysis, factor analysis, hierarchical cluster analysis, and multidimensional scaling. Findings indicated traditional measures of motivation and persistence are related to grit and that the constructs are similar. Additionally, the researchers did not find any significant

differences by gender for the grit survey, which is different from previous Duckworth studies that report that the results as related to gender are typically skewed. Furthermore, Christensen and Knezek (2014) indicated that when students are challenged with a level of difficulty, persisting through the challenge is a result of persevering and consistently focusing interest over time, which is grit.

In another study, Sheehan (2014) conducted a cross-sectional research study to examine differences in grit, hope, life satisfaction, happiness, and academic achievement in efforts to determine which of the constructs was the strongest predictor in academic achievement. Sheenhan's (2014) sample was composed of 179 students at a high school located in the United States. For the research study, Sheehan (2014) utilized the Grit survey (Duckworth & Quinn, 2009), the Children's Hope Scale (Synder, 2002), Satisfaction with Life Scale (SWLS) (Deiner et al., 1985), The Subjective Happiness Scale (SHS) (Lyumbomirsky & Lepper, 1997), and the high school students unweighted cumulative high school grade point average (GPA).

Sheehan (2014) conducted a factor analysis for the grit and hope items, a correlation matrix for the constructs, a multiple analysis of variance (MANOVA), and a regression analysis for the research study. Findings indicated grit to be distinct from hope, but that grit and hope are overlapping factors as direct predictors of academic success. Furthermore, findings indicated hope and grit were the most powerful predictors of academic success among all four non-cognitive factors within the study.

In order to contribute to the limited research on grit and academic achievement and to further an understanding of why some students are grittier than others, Park et al. (2018) conducted their study to examine the relationship between grit, goal structures (mastery vs. performance), and academic achievement. Park et al. (2018) were interested in whether goal structure, performance vs. mastery goals, had a positive or negative

influence on the two components of grit, which are consistency of interest and perseverance of long-term goals. Additionally, the researchers examined the relationship between grit and academic achievement. The researchers conducted a year-long longitudinal study with 1277 middle school students from California, Pennsylvania, and Texas. For the longitudinal study, data were collected during the fall and the spring of the school year from the middle school students.

For the study, Park et al. (2018) collected data on students' self-reported perceptions of their school's goal structures, grit, and report card grades. The researchers used an adapted survey created by Roeser et al. (1996) to collect quantitative data on performance goal structure in the students' schools and used an adapted form of the Grit survey (Park et al., 2019). Grade Point Averages (GPA) were collected from semester report card grades after the fall and spring semesters of the school years; moreover, the GPAs for the students were standardized within each school and then across all schools. The researchers tested the significance of indirect effects in the mediation analyses and examined the indirect effect of perceived goal structures on GPA through grit. Furthermore, Park et al. (2019) conducted path analyses while controlling for demographics including gender, ethnicity, free or reduced lunch indicator, and school affiliation.

Findings from the study indicated when students were pursuing mastery goals, they pursued the mastery goals with consistent interest and perseverance, also known as grit, which aided in higher academic achievement for the adolescent students. When the students were pursing performance goals, the students were less gritty than when pursing mastery goals and academic achievement declined. The researchers' findings were consistent with previous studies noting student motivation is increased when working with mastery goals versus performance goals (Park et al., 2019).

In another study, Khan (2018) conducted a research study examining the factors of grit and mindset on academic achievement using a cross-sectional survey. Furthermore, the researcher collected data to determine how the factors of grit and mindset influenced academic success in mathematics and science. For the study, Kahn (2018) used a sample of 117 students enrolled in fifth through twelfth from a private school located in New York.

Khan (2018) collected data using an 8-item, 6-point Likert scale on mindset (Dweck, 2006) and collected data on student beliefs on mathematics and science abilities as related to fixed and growth mindset. In order to measure grit, the researcher used the *Short Grit Scale (Grit-S)* (Duckworth & Quinn, 2009). The data from the surveys were collected using Qualtrics in the fall of 2017 during the students' classes. The data were correlated to determine if the psychosocial factors in the study had a relationship with academic performance. A correlation analysis was completed to test the relationship among grit and mindset. A linear regression was conducted to determine if mindset was a predictor of grit and to examine the correlation among grit and mindset. The researcher aimed to observe the data of isolated factors and the combined effect of the factors. An ANOVA was completed to examine any differences that appeared in the age groups.

Findings indicated that mindset and grit are two separate constructs; however, there was a significant relationship between the two factors found. There was a positive relationship found between passion and science scores, fixed mindset with mathematics scores, and fixed mindset with science scores. Findings indicated as growth mindset increased grit increased and mindset was a predictor of grit. Low growth mindset and high fixed mindset were found to be a predictor of mathematics grades; however, students with high mathematics grades were not affected by growth mindset. Furthermore, students with high levels of perseverance were found not to be high

achieving in mathematics or science. The researcher reported age group differences in grit; moreover, students in fifth through eighth grades had a low fixed mindset compared to students in ninth through twelfth grades. Students in sixth through eighth grades indicated the highest levels in perseverance compared to students in the higher grades with low levels of perseverance. Findings indicated students in the older grade levels demonstrated high levels of fixed mindset and students in the younger grades demonstrated high levels of passion and high levels of growth mindset.

Grit and Self-Efficacy

The topic of grit has become very popular in educational settings; however, research has proven to be limited when examining overlapping motivational concepts and grit (Muenks, Yang, & Wigfield, 2017). The examination of grit and other non-cognitive motivational concepts, such as task value and self-efficacy, as a predictor for academic achievement could be of value to educators in developing an understanding of how to move students towards their future educational outcomes. Bandura (1986) argued an individual's self-efficacy beliefs informed outcome expectations. Furthermore, Bandura's argument was posited as he believed when an individual is confident in his or her own performance capabilities, the outcome expectations were more favorable (Sheu et al., 2018). Research on grit and other non-cognitive motivational constructs, such as self-efficacy, is increasing in efforts to close the gap in research-based literature and provides a unique contribution to the research area for educational settings.

Usher, Li, Butz, and Rojas (2018) conducted a longitudinal study to examine if grit and self-efficacy are essential for academic achievement in reading and mathematics for elementary and middle school students. The researchers conducted the investigation in an urban school district located in the Southeastern United States with 2,430 students in third through eighth grade from three elementary schools and four middle schools. The

students were surveyed in their mathematics and reading classes during the 2011-2012 school year.

The researchers collected data using survey method and utilized school district data from the Northwest Education Association (NWEA) Measure of Academic Progress (MAP) assessment from the spring of 2016 administration (NWEA, 2015). Additionally, the researchers used NWEA MAP fall 2015 administration scores as control variables. Grit was examined using the *Values in Action (VIA) strength survey for children* (Peterson & Seligman, 2001, 2004); moreover, grit was assessed to evaluate students' tenacity, effort, and perseverance perceptions. In order to examine self-efficacy, the researchers developed a 4-item, 6-point Likert-type scale based on Bandura (2006) record of constructed self-efficacy scales which evaluated academic and self-regulatory self-efficacy of the student participants. In addition to the NWEA MAP assessment data, the researchers collected data from state standard achievement scores from the spring of 2016 assessment which evaluates proficiency in mathematics and reading.

Statistical analysis of the data was conducted by the researchers using a structural equation model (SEM) and through means, standard deviation, and latent bivariate correlations were calculated to evaluate the relationships among self-efficacy or grit and achievement. Furthermore, the researchers utilized structural models to examine how the roles self-efficacy or grit intervened with achievement and used the models to draw conclusions based on data. Findings suggested that grit positively correlated with each of the mathematics and reading self-efficacy measures and weakly correlated with achievement. Additionally, student self-efficacy positively correlated with achievement in mathematics and in reading. Further findings suggested middle school students had lower levels of grit and self-efficacy than that of elementary students within the study and female students had higher levels of grit than male students.

In another study, Dixson et al. (2016) conducted an investigation to examine how perceived ability, grit, hope, and academic self-efficacy contributed to academic achievement. The sample was composed of 609 students ages 10-18 that were enrolled in a summer program for academically talented youth that was held at an urban located major research university in a western state of America. The research participants submitted responses to four surveys based on the four psychosocial variables and academic achievement was measured using data based on the student participants' self-reported grade point average.

The measurement of perceived ability was conducted using a 1-item, 4-point Likert scale survey that asked the student participants to compare their personal academic ability to others within the summer program. In order to collect data on student grit, the researchers used the *Short Grit scale* (Grit-S) (Duckworth & Quinn, 2009), which is an 8-item, 5-point Likert scale that examines participants' passion and commitment or perseverance towards long term goals. The researchers used the *Children's Hope Scale (CHS)* (Valle, Huebner, & Suldo, 2004) which is a 6-item, 6-point Likert scale survey that measures perception of future and alternate pathways of future goals and measures a person's beliefs and ability to accomplish future goals. Data collected to evaluate academic self-efficacy resulted from student participants' input on *the Self-efficacy for Academic Achievement Scale (SEAA)* (Bandura, 1989) which is a 9-item, 6-point Likert scale. Furthermore, Dixson et al. (2016) collected data through an online version of a comprehensive questionnaire that was administered to the student participants at the conclusion of the summer program.

The researchers conducted statistical analysis of the data by reporting means, standard deviations, and inter-correlations of the psychosocial constructs for the research study. Furthermore, exploratory factor analysis and regression analyses were completed

by the researchers to examine relationships among the roles of the variables and interactions among the factors. Findings suggested hope and academic self-efficacy significantly predicted students' perceived ability; however, grit was not a factor that contributed to perceived ability. The findings indicated academic self-efficacy was determined to be a significant predictor of academic achievement. Additionally, the researchers concluded that academic self-efficacy has an influence on academic achievement more than hope and grit do and hope is more than an influencing psychosocial factor on academic achievement than grit. In conclusion, Dixson et al. (2018) indicated that the psychosocial factors within the study are differentiated variables that contribute to educational outcomes.

In another study conducted in 2017, researchers surveyed 190 high school students in the Mid-Atlantic region of the U.S. to examine the relationship between grit, achievement goal orientations, self-efficacy, and task value as predicting motivational constructs for student academic achievement (Muenks et al., 2017). Grit was measured using both subscales, consistency of interests and persistence of efforts, from the Grit-S (Duckworth & Quinn, 2009). The researchers measured achievement goal orientations with the Achievement Goal Orientation scale (Elliot & Murayama, 2008), which is students respond to items about mastery approach and goal orientations for their current mathematics and science classes. The researchers used the self-efficacy subscale from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) which is a 7-item survey, and the students were asked to think about the items in terms of their current mathematics or science classes they were enrolled in. To collect data on task value, the researchers used the task value subscale from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) which is

a 6-item subscale survey, and the students were asked to think about the items in terms of their current mathematics or science classes they were enrolled in.

This study was the first study to examine the relationship between grit and future oriented motivation constructs using factor analytic method. Furthermore, the research was the first study to examine the relationship between grit and self-efficacy, task value, goal orientations while specifically examining how strongly grit is a predicting factor for achievement when controlling for the motivational constructs with a sample of high school students (Muenks et al., 2017). The researchers' conducted and exploratory analysis in MPlus version 6.12 due to the exploratory nature of the research. Additionally, the researchers statistically analyzed data with correlations and regression analysis to look at the independent effects of each predictive outcome for the motivational constructs.

Findings from the study indicated grit was positively correlated with mastery approach goal orientation, task value, and self-efficacy. However, grit was most strongly positively correlated with self-efficacy over any of the other motivational constructs for the sample of high school students. When examining grit more closely and looking specifically at consistency of interests and perseverance of efforts, both parts of grit were significantly correlated with student self-efficacy, conveying that grit is notably associated with students feeling efficacious (Muenks et al., 2017). Overall, perseverance of effort was positively correlated to the motivational constructs over consistency of interests. Through hierarchical regression analysis, the researchers found that the consistency of interest, a function of grit, was not a predictor for academic achievement compared to perseverance of effort, which significantly predicted achievement when all motivational variables were controlled. Muenks et al. (2017) noted that perseverance of effort might have been a stronger predictor of academic achievement because shifting of

interests is a common behavior of high school aged students. Moreover, the researchers supported that even when students were uninterested in mathematics or science, being persistent in the face of challenges (grit) was likely to be a stronger indicator of students' academic achievement than the students' ability to hold consistent interests.

Academic Self-Efficacy

Bandura (1977) defined self-efficacy as an individual's beliefs of his or her own capabilities when performing as task. Bandura (1986) argued, as an important part of his social cognitive theory, when individuals are confident, they can produce desired outcomes, then the individuals are self-incentivized to act to make the outcomes a reality. Furthermore, Bandura et al. (1996) argued students form their self-efficacy beliefs by interpreting information from performance mastery, observing the actions of others (modeling), and social persuasions that students receive from others, including teachers, parents, and peers.

Mathematics Self-Efficacy and Achievement

Building on self-efficacy research in an academic setting, Peters (2013) noted self-efficacy as a mediating factor for academic outcomes, academic performance, and cognitive engagement. Specifically, Peters (2013) noted mathematics self-efficacy was positively correlated with mathematics performance and when self-efficacy is lacking in mathematics, the lack of mathematics self-efficacy contributes to the lack of mathematics achievement. Additionally, research in the area of mediating effects of mathematics self-efficacy on mathematics performance has been appealing to researchers in efforts to understand motivating factors of achieving goals in academic venues (Peters, 2013). Mathematics self-efficacy is defined as self-efficacy in the academic context of mathematics (Gates, 2015).

Taylor (2018) aimed to research if there was a significant correlation between student self-efficacy and subsequent mathematics achievement in the middle grades by conducting a study of 556 students (258 male students and 298 female students) in rural Kentucky. Data were collected in order to examine the strength of correlation between self-perception of mathematics ability and mathematics achievement over a time period of four years. Taylor (2018) utilized district data from Northwest Education Association (NWEA) Measure of Academic Progress (MAP) assessment in the fall testing session and the *Academic Self-efficacy scale* from *Patterns of Adaptive Learning Scale (PALS)* (Midgley et al., 2000) which is a 5-item, 5-point Likert scale that evaluates student motivations and behavior towards mathematics. The data collected from the MAP assessment percentile scores and the PALS responses were analyzed to indicate if there was a correlation of self-efficacy and future performance on the MAP assessment; furthermore, the researcher utilized a composite variable score from the surveys to correlate with percentile scores of the MAP assessment. Self-efficacy was the input and academic outcome was the response in a regression model.

Taylor (2018) investigated the relationship between self-efficacy and mathematics achievement and determined that there was a positive correlation using MAP data from fall 2017 percentile scores and the PALS scores. However, there was a low correlation with the PALS scores and low future performance. The researcher determined that a variance existed among three of the four years of data. Furthermore, the percentile scores from fall 2016 were indicated as a strong predictor of performance using the correlation of PALS scores and MAP assessment data.

In another study, McMillian (2017) explored fifth grade student perceptions and beliefs about self-efficacy as related to mathematics performance. Furthermore, the study investigated the relationship between mathematics performance on a high-stakes

assessment and factors, which included mathematics anxiety and self-efficacy. The sample was composed of less than fifteen students in a fifth-grade class in a Title I school. The sample was purposefully selected and identified from the initial population of students located in the southeastern U.S., specifically an urban area of North Carolina during the 2016-2017 school year.

Initially, the sample participated in the survey, *Mathematics Anxiety Rating Scale for Elementary Students (MARS-E)*, created by Suinn, Taylor, and Edwards (1988) in order for the researcher to be able to utilize a sample of fifth-grade students with mathematics anxiety and self-efficacy present at different levels. The MARS-E is a 26-item Likert-type survey. The students participated in the research by completing the *Self Efficacy Questionnaire for Children (SEQC)* (Muris, 2001), which is a 24-item survey that assesses self-efficacy. The surveys were administered by the teacher-of-record over three class periods. Furthermore, McMillian (2017) accessed student data from the school district using the North Carolina Standard Course of Study End of Grade Mathematics assessment (NC Standard Course of Study, 2003) for quantitative data purposes. The state test is composed of 54 multiple choice and open response questions that are taken over a 180-minute period of time and the assessment is aligned with state standards for mathematics instruction.

All of the quantitative data were statistically analyzed by the researcher. Findings from the study indicated that students with high self-efficacy and low mathematics anxiety were more likely to engage in challenging mathematics tasks. However, there was not a strong correlation between these students and their performance data.

In a mixed methods case study, Gates (2015) examined the relationship between student achievement in a mathematics program and students' mathematics self-efficacy with 112 middle school students in sixth through eighth grade. The case study was

conducted in 2013-2014 school year in southeastern Massachusetts and gathered data quantitatively using a survey with students and student focus groups. Gates (2015) desired to use a case study in order to perform in-depth research while utilizing multiple sources of information.

For the quantitative portion of the case study, the research used the Sources of Middle School Mathematics Self-Efficacy Scale (SMSMSS) (Usher, 2007), which is a 24-item survey using a 6-point Likert scale for responses based on Bandura's (1977) four hypothesized components of self-efficacy and was developed to be used with middle school students (Gates, 2015). The researcher used student focus groups with a purposeful selection of 37 students. Gates (2015) used group interviews with students in order to for the participants to elicit comments specific to mathematics performance and mathematics self-efficacy. The researcher analyzed the survey data using descriptive statistics and Pearson's moment correlations to determine the strength of the relationship between variables. For the qualitative component of the study, Gates (2015) used focus group transcriptions loaded into MAXQDA to look for themes that emerged from the focus group participants' responses to interview questions.

Findings from the quantitative portion of the research indicated a statistically significant relationship between mathematics self-efficacy and mathematics performance; moreover, as mathematics self-efficacy increased, mathematics performance increased and as mathematics self-efficacy decreased, mathematics performance decreased (Gates, 2015). For the qualitative portion of the case study, two themes emerged from the student and teacher focus groups. Student participants reported feeling more positive about mathematics as a result of being in the mathematics intensive program at their middle school and felt their mathematics skills improved over time which increased their confidence (Gates, 2015).

STEM Career Interest

For decades, STEM education has been a major focus of federal, state, and local education policies due to labor statistics projections of an exponentially large growth in the STEM labor market and due to the overwhelming concern that the U.S. is not educating a sufficient number of STEM-prepared students to meet the demand (Sublett & Plasman, 2017). In efforts to address the concern, federal, state, and local education agencies have developed STEM curriculum and pathways (Sublett, 2016). STEM career interest is foundational on STEM career knowledge, which is a student's awareness of careers that exist based on STEM in the workforce and the level of knowledge that a student possesses in regard to available STEM careers directly effects the pursuit of a career in the STEM field (Blotnicky et al., 2018). Beyond knowledge of STEM careers, the understanding how motivational factors relate to STEM based coursework and achievement is needed to improve STEM career interest (Sublett & Plasman, 2017).

Mathematics Self-Efficacy and STEM Career Interest

Within STEM education research, self-efficacy, achievement, and STEM career interest are heightened areas of discussion; moreover, researchers believe the connections between student self-efficacy, achievement, and career interest are important to understand in order to increase the number of students pursuing STEM career paths (Kwon, Vela, Williams, & Barroso, 2019). Self-efficacy has been correlated with academic achievement, engagement, effort, and motivation in previous studies (Bandura, 1997; Webb-Williams, 2018; Wigfield & Ecccles, 2000; Zimmermann, 2000); furthermore, self-efficacy in mathematics has been correlated with mathematics achievement (Kwon et al., 2019). Research has shown positive educational outcomes that are a result of mathematics self-efficacy are likely to influence a student to want to take

more advanced mathematics courses in the future and interest in particular STEM fields (Kwon et al., 2019).

Grigg, Perera, McIlveen, and Svetleff (2018) conducted a study to investigate a model of the relationships among mathematics self-efficacy, mathematics interests and intentions, and achievement in early and middle adolescent students. Furthermore, the researchers aimed to determine if the relationships among the constructs were reciprocal or unidirectional. The research sample was composed of 400 students from two independent (non-government) schools in Eastern Australia. Included in the sample were 275 females with the mean age of 13.4. The students were enrolled in sixth through tenth grade with 34 students in sixth grade, 113 students in seventh grade, 93 students in eighth grade, 65 students in ninth grade, and 95 students in tenth grade. All students were enrolled in on-level mathematics classes.

The students participated in computer administered surveys under the supervision of their teachers twice during the school year with six months in between each of the data collection. During the first survey administration, the participants completed socio-demographic items in addition to the survey items regarding measures of mathematics self-efficacy and mathematics interests and intentions. During the second survey administration, the students completed items for the constructs of the research. The researchers collected additional qualitative data from the students' first semester mathematics course grades, prior semester mathematics course grades, and end of the school year mathematics achievement test scores. There were three instruments utilized in the research. The researchers measured perceived mathematics abilities using the *Mathematics Self-efficacy scale* from Education Longitudinal Study (2002) which is a 5-item, 4-point Likert scale. Mathematics interest was measured using the *PISA 2003 Index of Mathematics Interest* (Organization for Economic Cooperation and Development,

2005) which is a 4-item, 4-point Likert scale that measures cognitive-affective components of mathematics interest. Mathematics intentions were measured using the *Mathematics and Science Goal Intentions Scale* (Smith & Fouad, 1999) which measures a student's interest or intent to pursue mathematics and science coursework and careers.

The researchers used statistical analysis to determine descriptive statistics and correlations from the study. The data analysis incorporated a variable modeling framework and used longitudinal measurement invariance models (Grigg et al., 2018). Findings suggested that mathematics self-efficacy beliefs indicated positive prediction of mathematics achievement in both coursework grades and assessment scores. Student interest in mathematics predicted mathematics self-efficacy beliefs and there was a reciprocal relationship between students' mathematics interests and intentions which provided a reinforcement for motivation of academic coursework and career choice associated with mathematics and science. Findings indicated that mathematics self-efficacy was significantly positive as a predictor of mathematics achievement across all grade levels in the study. Additionally, the researchers determined prior mathematics interests were a positive predictor of mathematics self-efficacy beliefs over time.

Huang et al. (2018) conducted research on a proposed model that predicted mathematics and science career interest in middle school students based on three factors, including mathematics anxiety, mathematics self-efficacy, and implicit theories of intelligence. Furthermore, the researchers aimed to investigate gender differences in perspectives of male and female students on mathematics self-efficacy, mathematics anxiety, implicit theories of intelligence, and career interest. Huang et al. (2018) assessed the model to determine if mathematics self-efficacy mediated the affect between mathematics anxiety and career interest and if mathematics self-efficacy mediated the affect between implicit theories of intelligence and career interest. The sample used in the

study was composed of 152 seventh-grade students enrolled in six sections of seventh-grade mathematics (two sections of Pre-Algebra and four sections of on-level mathematics). Half the sample was male, and half of the sample was female. The students attended a rural middle school in the U.S. and the ethnicity of the sample was representative of the school's student population.

The sample completed four surveys. The researchers used the *Mathematics Anxiety Scale for Children (MASC)* created by Chiu and Henry (1990), which is a 22 item, 4-point Likert scale that measures mathematics anxiety. For the mathematics self-efficacy investigation, the researchers used a 5-item and 5-point Likert scale (Griggs, Patton, Rimm-Kaufman, & Merritt, 2013) which was adapted from *Academic Efficacy subscale of Patterns of Adapted Learning Scales (PALS)* (Midgley et al., 2000). For implicit theories of intelligence, the researchers used an 8-item, 6-point survey that evaluates fixed and growth mindset (Dweck, 1999) and for student career interest, the researchers utilized a 2-item, 6-point Likert scale that indicated student career interest in the mathematics or science fields (Riegle-Crumb, Moore, & Ramos-Wada, 2011). The students completed each of the four surveys in their mathematics class under the supervision of their teacher during the spring semester of 2015. The surveys were then returned to the researchers.

Huang et al. (2018) used an analysis of covariance (ANCOVA) test to investigate if there were gender differences among the factors, including mathematics self-efficacy, mathematics anxiety, growth mindset, and career interest. Furthermore, the data were analyzed to examine the relationships among the factors. The researchers used a multi-group path analysis to evaluate the effects of the factors for male and female students simultaneously and to compare the effects of the factors between groups. Finally, the researchers identified a best fit model and used the model to compare gender differences

and the effects of the factors directly and indirectly. Findings from the research show females have higher mathematics anxiety than males, males have more of a growth mindset than females, and there was no significant difference for mathematics self-efficacy and career interest; however, means showed males indicated mathematics self-efficacy and career interest slightly higher than females. Additionally, findings from the study indicated females' mathematics anxiety had a direct effect on mathematics and science career interest and growth mindset did not have a direct or indirect effect on career interest. For males, growth mindset had a direct effect on mathematics self-efficacy; however, mathematics anxiety had no direct or indirect effect on career interest.

In another study, Blotnicky et al. (2018) examined the relationships of knowledge of mathematics and science that are involved in Science, Technology, Engineering, and Mathematics (STEM) careers, mathematics self-efficacy, career interest and activities, and STEM career expectancy. The researchers' sample was composed of 1448 students from public schools located in provinces of Atlantic Canada (even numbers of female and male students) who were in the seventh or ninth grades with the mean age of 13.5 years. The students participated in an online survey format in their classes and the sample was purposefully chosen by the researchers.

The students participated in five different measures in order for the researchers to collect data for the study. Student participants responded to statements about their perceptions of mathematics and science knowledge being required for career fields through the *STEM Career Knowledge scale (SCK)*. Data on mathematics self-efficacy were collected using a 5-item, 5-point Likert scale developed based on Bandura (1977) recommendations for self-efficacy surveys. The researchers used *Holland's Theory of Career Choice and Development* (Holland, 1973), a 6-item, 6-point ordinal response survey with two parts including preference for career activities and preference for career

interests. Additionally, a measure for career expectancy or likelihood of choosing a career was assessed with a 4-item, 4-point Likert scale to gather information from the student participants.

The data from the five measures were analyzed using different descriptive statistical analysis methods. The researchers used Chi-square analysis to determine associations between ordinal and nominal variables. An analysis of variance (ANOVA) was utilized to determine differences in variables with greater than two response variables. Logistical regression was used to investigate the variables and research questions and other analysis regressions were conducted to explore relationships among variables.

Findings indicated that most students perceived mechanical engineering required mathematics and science knowledge and that other careers were less likely to required mathematics and science even though the careers are globally recognized as STEM careers. The researchers determined that STEM career knowledge among students was limited; however, students in ninth grade knew more than students in seventh grade that mathematics and science are required in STEM careers other than mechanical engineering. Overall, findings indicated that students were more favorable towards artistic and creative career activities and demonstrated low ratings for the career activity for helping others and indicated that students had the lowest ratings for career interests in working with people. Students in the seventh grade indicated that they preferred career interest in manual and mechanical skills which are indicated as practical or concrete skills and students in the grade nine preferred working with others over other career interests. Further findings indicated that there was no preferred career correlated with mathematics self-efficacy; however, students with high mathematics self-efficacy were positively correlated with career interest in technical and science skills. Findings suggested students

that had knowledge of mathematics and science used in STEM careers were likely to indicate STEM career interest.

Summary of Findings

In reviewing the literature related to grit, mathematics self-efficacy, STEM career interest, and academic achievement, current research supports positive relationships among the research constructs. Research on the psychosocial factor of grit indicated that when students are challenged with a level of difficulty, persisting through the challenge is a result of persevering and consistently focusing interest over time (Christensen & Knezek, 2014). This research is aligned with grit research by Duckworth et al. (2007) who defines grit as perseverance and passion towards long-term goals.

Dixson et al. (2016) determined academic self-efficacy to be a significant predictor of academic achievement; furthermore, the researchers concluded academic self-efficacy has an influence on academic achievement more than grit does.

In another research study, Brennan (2015) determined academic self-efficacy had a positive correlation with achievement. When examining mathematics self-efficacy as a type of academic self-efficacy, mathematics self-efficacy and mathematics achievement were determined to be positive correlated (Taylor, 2018). Additionally, research findings suggested mathematics self-efficacy beliefs indicated positive prediction of mathematics achievement in both coursework grades and assessment scores in mathematics courses.

Grigg et al. (2018) researched mathematics self-efficacy, academic achievement, and STEM career interest. The researchers found student interest in mathematics predicted mathematics self-efficacy beliefs and there was a reciprocal relationship between students' mathematics interests and intentions which provided a reinforcement for motivation of academic coursework and career choice associated with mathematics and science. Furthermore, research findings indicated that mathematics self-efficacy was

significantly positive as a predictor of mathematics achievement. Additionally, current research suggested students who had knowledge of mathematics and science used in STEM careers were likely to indicate STEM career interest (Blotnicky et al., 2018).

Theoretical Framework

The data collected in this study were analyzed through the lens of Locke and Latham's (1990) goal-setting theory. The goal-setting theory is a motivational theory that integrates aspects of self-efficacy theory (Bandura, 1986). Locke and Latham (1990) suggested an individual's goal is (1) an efficient cause of behavior and an individual's performance is maximized when the set goal is specific and difficult and (2) the individual understands the behaviors that are required to reach the goal and feels competent in those behaviors (Gagne & Deci, 2005). The aspects of the goals, such as difficulty level, are used to predict work outcomes (Gagne & Deci, 2005).

Additionally, the data collected in this study were analyzed through the lens of self-determination theory (Deci & Ryan, 1985). Deci and Ryan (1985) developed the theory which suggests individuals are motivated to grow and become self-determined when their needs for competence, connection, and autonomy are satisfied. Self-determination theory (Deci & Ryan, 1985) supports autonomous motivation and intrinsic goals as predictors of performance in tasks that individuals are interested in or curious about.

When examining academic achievement as related to grit, mathematics self-efficacy, and STEM career interest for middle school students in Algebra I, Locke and Latham's (1990) goal-setting theory and Deci and Ryan's (1985) self-determination theory could help educators understand how the psychosocial factors of success play an important role in student success in academic achievement. Setting goals while understanding and feeling competent in the behaviors needed to reach the set goals is

aligned with perseverance and passion towards long-term goals, which is known as grit (Duckworth, 2016). Furthermore, Locke and Latham (1990) supported goal setting as a predictor of work outcome, so when examining STEM career interest, students who are goal-oriented in STEM content areas may be likely to pursue a STEM career. Middle school students in Algebra I with mathematics self-efficacy may be motivated by their interest in mathematics content and the rigor of the content acceleration. Deci and Ryan (1985) argued activities that are interesting to individuals are intrinsically motivating.

Literature Gap

There are two major gaps in literature related to this research study. The first gap is research in the area of grit and STEM career interest. Research on the effects of grit and STEM career interest specifically related to middle school students is lacking within educational research. The other gap in literature is in the area of motivational constructs including grit and mathematics self-efficacy and how these two constructs relate to academic achievement specifically for middle school aged (adolescents) children.

Conclusion

This chapter presented a review of relevant literature relating to the purpose of this study, which will be to examine the relationship between grit, mathematics self-efficacy, STEM career interest, and academic achievement for middle school students enrolled in Algebra I. In Chapter III, methodological aspects of this dissertation are detailed to include the operationalization of theoretical constructs, research purpose and questions, research design, population and sampling selection, data collection procedures, data analysis techniques, privacy and ethical considerations, and the research design limitations for this study.

CHAPTER III:

METHODOLOGY

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement in Algebra I. The mixed methods study collected survey and interview data from a purposeful sample of seventh and eighth grade students within a large suburban district located in southeast Texas. Quantitative data, collected from the *Short Grit Scale* (Grit-S) and *Student Attitudes Toward STEM Survey* (S-STEM), were analyzed using Pearson's product moment correlations (*r*) and were analyzed using frequencies and percentages, while a thematic coding process was used to look for themes that may have emerged from the participant interviews. This chapter presents an overview of the research problem, operationalization of theoretical constructs, research purpose and questions, research design, population and sampling selection, instrumentation used, data collection procedures, data analysis, privacy and ethical considerations, and the research design limitations of this study.

Overview of the Research Problem

As society continues to face the demands for a global workforce within the realm of STEM, the need for students to perform successfully in STEM related coursework is critical (Reinking & Martin, 2018). An individual who is determined to be successful in STEM field coursework is one who understands the challenges and problems to be solved through the process and is driven with the persistence to solve problems presented in those specific educational opportunities. Bandura (1986) supports self-efficacy as how an individual perceives one's ability to adeptly engage in specific activities. Academic self-efficacy beliefs are believed to be a factor that steers students' career interest and serve as predictors of students' career trajectory expectations (Bandura et al., 1996, 2001). The

examination of grit and mathematics self-efficacy as factors that influence academic success for middle school students in an accelerated mathematic course and STEM career interest may be beneficial in helping to understand the barriers to STEM engagement.

Operationalization of Theoretical Constructs

The study consists of the following constructs: (a) grit, (b) mathematics self-efficacy, (c) STEM career interest, and (c) student achievement. Grit is defined as perseverance in the face of failure and an intense commitment towards long-term goals (Duckworth & Gross, 2014). This construct was measured using the *Short Grit Scale* (Grit-S). Academic self-efficacy builds on Bandura's (1977) definition of self-efficacy and refers to one's beliefs that he or she can execute actions required for academic tasks while prosperously completing those academic tasks at designated levels (Schunk, 1991). STEM expectancy is defined as students' interest in STEM careers as related to students' confidence and efficacy in STEM subjects (Friday Institute for Educational Innovation, 2012). Mathematics self-efficacy and career interest were measured using the *Student Attitudes Toward STEM Survey* (S-STEM). Student achievement is defined by how students beneficially perform on the *State of Texas Assessment of Readiness* (STAAR) (Texas Education Agency, 2012). Student achievement was measured using each participating seventh-grade student's Fall 2019 Semester Exam consisting of STAAR Algebra I End of Course (EOC) exam questions from 2018.

Research Purpose and Questions

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement in Algebra I. The study addresses the following research questions:

1. Is there a statistically significant relationship between grit and achievement for middle school students enrolled in Algebra I?

2. Is there a statistically significant relationship between mathematics self-efficacy and achievement for middle school students enrolled in Algebra I?

3. Is there a statistically significant relationship between student career interest in STEM and achievement for middle school students enrolled in Algebra I?

4. Is there a statistically significant relationship between grit, mathematics self-efficacy, STEM career interest, and achievement for middle school students enrolled in Algebra I?

5. How do middle school students perceive grit to influence their achievement in Algebra I?

6. How do middle school students perceive mathematics self-efficacy to influence their achievement in Algebra I?

7. How does the perception of STEM career interest influence achievement for middle school students in Algebra I?

Research Design

For this study, the researcher used a mixed-methods design (QUAN→qual). This design consisted of two phases: first, a quantitative phase and second, a qualitative phase. The advantage of implementing this design is it allowed for a more thorough and in-depth exploration of the quantitative results by following up with a qualitative phase. Furthermore, the interview sessions with participants were conducted to provide a deeper analysis of how students feel about the accelerated mathematics learning experience as adolescents in Algebra I. A purposeful sample of seventh and eighth grade students from a large suburban school district in the Southeast region of Texas were solicited to complete the *Short Grit Scale* (Grit-S) and the *Student Attitudes Toward STEM Survey* (S-STEM). In addition, individual interviews were conducted to provide a deeper analysis of how students perceive the research constructs and the influence on their

achievement in the accelerated mathematics course. Quantitative data were analyzed using Pearson's *r* and a structural equation model (SEM) while qualitative data were analyzed using an inductive coding process.

Population and Sample

The population of this study consisted of students from two middle schools within a large suburban school district in southeast Texas. The schools are located within a large school district that contains seven middle school campuses. One of the middle schools (A) has a student population of 769 students, 264 sixth grade students, 258 seventh-grade students, and 247 eighth grade students. The other middle school (B) has a student population of 781 students, 261 sixth grade students, 266 seventh-grade students, and 254 eighth grade students. Table 3.1 provides the middle schools' campus data obtained from the 2018-2019 Texas Academic Performance Report.

Table 3.1

Middle School Campuses Student Demographic Data

	Frequency (n)	Percentage (%)
Middle School (A)		
1. Gender		
Female	365	47.5
Male	392	52.5
2. Ethnic Distribution		
African American	25	3.3
Hispanic	498	64.8
White	226	29.4
American Indian	1	0.1
Asian	8	1.0
Pacific Islander	0	0.0
Two or More Races	11	1.4
3. Economically Disadvantaged	556	72.3
4. English Language Learners	145	18.9
5. At-Risk	471	61.2
6. Special Education	135	17.6
7. Algebra I Students	47	6.1
Middle School (B)		
1. Gender		
Female	389	49.8
Male	392	50.2
2. Ethnic Distribution		
African American	317	40.6
Hispanic	110	14.1
White	136	17.4
American Indian	5	0.6
Asian	193	24.7
Pacific Islander	0	0.0
Two or More Races	20	2.6
3. Economically Disadvantaged	231	29.6
4. English Language Learners	34	4.4
5. At-Risk	266	34.1
6. Special Education	65	8.3
7. Algebra I Students	217	27.8

Overall, middle school (A) has 769 students enrolled. There are 47 students enrolled in Algebra I, which is composed of 14 seventh graders and 33 eighth graders. There is one teacher for Algebra I and two sections of the course. Middle school (B) has 781 students enrolled. There are 217 students enrolled in Algebra I, which is composed of 73 seventh graders and 144 eighth graders. There are two teachers for Algebra I and six sections of the course. At both middle schools, seventh-grade students in Algebra I are required to take Algebra I as part of a specialized accelerated STEM-based academics program that the students are enrolled in. The seventh-grade students received eighth grade mathematics standards-based instruction as sixth graders and receive Geometry standards-based instruction as eighth graders. A purposeful sample of seventh and eighth grade students from the participating middle schools was solicited to participate in this study. Table 3.2 presents the course enrollment data.

Table 3.2

Algebra I Student Enrollment for the Middle Schools

	Frequency (n)	Percentage (%)
Middle School (A)		
Grade 7 Females	1	2.1
Grade 7 Males	13	27.7
Grade 8 Females	17	36.2
Grade 8 Males	16	34.0
Student Total (n)	47	100.0
Middle School (B)		
Grade 7 Females	38	17.5
Grade 7 Males	35	16.6
Grade 8 Females	74	34.1
Grade 8 Males	70	32.3
Student Total (n)	217	100.0

Participant Selection

Seventh and eighth grade students enrolled in Algebra I were invited to participate in the individual interviews in addition to the surveys the students were asked to complete. The interview questions were used to collect information about the participants' perceptions of factors that can contribute to success in mathematics coursework, such as Algebra I. The participants for the qualitative portion of the study were selected from participants who completed the Short Grit Survey and the Student Attitudes Towards STEM Survey. These participants would have taken the Algebra I End of Course Assessment in the spring of 2020, but due to the worldwide pandemic, the exam was canceled. Therefore, the Semester Exam data from the fall of 2019 made from STAAR 2018 End of Course exam questions were used to provide student achievement data. The students volunteered to participate in the individual interviews.

Instrumentation

Short Grit Survey

The Short Grit Scale (Grit-S) was developed by Duckworth and Quinn (2009) from the original Grit Scale (Duckworth et al., 2007). Initially, the original *Grit Scale* developed in 2007 was a 27-item scale used with a sample of 1,545 adults (mean age = 45) and was reduced to a 12-question scale after thorough exploratory factor analysis led to the elimination of 15 items (McFarlane, 2018). The 12-item *Grit Scale* was used with West Point Military Academy cadets to examine the relationship between perseverance and passion towards long-term goals and achievement to determine if grit was a predictor of success for the cadets. Grit was shown to be a variable that predicted which of the cadets would exit the academy after the difficult first summer training (Christensen & Knezek, 2014). From the study at West Point Military Academy, Duckworth et al. (2007) determined that grit is a predictor of success over talent. The remaining 12-items on the

most recent *Grit Scale* are established as a true measure of grit, which is defined as perseverance and passion for long-term goals and a predicting factor of achievement in challenging domains beyond capacity of talent (Duckworth et al., 2007).

The *Grit-S* is an 8-item scale that uses a 5-point Likert-type scale ranging from one to five. An overall score of one indicates a very low level of grit and an overall score of five indicates a very high level of grit. Table 3.3 presents sample items from the scale and descriptions of scoring the items.

Table 3.3

Sample Items for Short Grit Scale and Scoring

Item Number on Scale	Example	Likert-type response choice scoring (points)
1, 3, 5, 6	I often set a goal but later choose to pursue a different one.	1 = very much like me 2 = mostly like me 3 = somewhat like me 4 = not much like me 5 = not like me at all
2, 4, 7, 8	I am a hard worker.	1 = not like me at all 2 = not like me 3 = somewhat like me 4 = mostly like me 5 = very much like me

If the score is indicated as a 5, which is the maximum score on the *Grit-S*, then the participant is determined to be extremely gritty. If the score is indicated as a 1, which is the minimum score on the *Grit-S*, then the participant is determined to be not at all gritty (Duckworth & Quinn, 2009). In order to calculate an overall score, all of the points must be added together in order for the sum to indicate the raw score which is then divided by eight to determine the participant's final grit score. Table 3.4 presents descriptions for the levels of grit.

Grit-S is found to be reliable and has demonstrated high internal consistency ($\alpha = 0.85$) for the overall scale (Baquerizo, 2018). The predictive validity, stability over time, and reliability of the *Grit-S* were determined from six studies by

Duckworth and Quinn (2009) and indicated that the improvement of students' academic success is potentially affected by grit (McFarlane, 2018). Furthermore, grit scales have been determined to possess the consistent reliability of .80, which indicates that grit is a predicting factor of career goal retention. Table 3.4 presents the reliabilities of *Grit-S.*

Table 3.4

Reliabilities of Short Grit Scale

	Items	Alpha Coefficients (Baquerizo, 2018)
1. Consistency of Interests	1, 3, 5, 6	0.84
2. Perseverance of Effort	2, 4, 7, 8	0.78

Student Attitudes Toward STEM Survey

The *Student Attitudes Toward STEM Survey* (S-STEM) for middle and high school students (grades 6 – 12) is a comprehensive survey that measures perceived efficacy in STEM subjects for students and interest in STEM field careers. The researchers desired to create a tool that would measure affective constructs of students' career development in STEM fields; furthermore, the researchers implemented a deductive scale development process to produce the survey (Unfried, Faber, Stanhope, & Wiebe, 2015). Previous to the final version of the *S-STEM*, the researchers piloted construct measurements based on attitudes towards science, mathematics, and engineering in subscales as originated in Erkut and Marz's (2005) survey; however, the constructs did not measure students' attitudes towards technology.

The survey for middle school and high school was given to 109 students in grades 6 – 12 in North Carolina for the pilot study. The students were participants in a STEM

elective and after-school or summer program. In order to assess validity, the researchers conducted an exploratory factor analysis and collected content validity evidence through subject matter experts. Through this process, several of the items were removed due to present biases. The survey is composed of subscales, including subscales for academic efficacy for mathematics, science, engineering and technology, and student STEM field career interest.

The mathematics subscale is composed of eight items. The 5-point Likert scale includes ratings of strongly disagree to strongly agree. The STEM career interest subscale is composed of twelve items with a 4-point Likert scale with the ratings of not at all interested to very interested. Table 3.5 presents descriptions and sample items of the STEM-S subscales.

Table 3.5

Sample Items for S-STEM and Scoring

Subscale	Items	Sample	Ratings
Mathematics	1 to 8	Math is hard for me.	Strongly Disagree Disagree Neither Agree or Disagree Agree Strongly Agree
Your Future	1 to 12	STEM Career List	Not at all interested Not so interested Interested Very interested

The *S-STEM* was developed by The Friday Institute (2010) and educators were given the instrument to examine the readability and clarity of items based on appropriate reading levels for students. Factor analysis indicated clear structure of the scale and Cronbach's alpha measured internal-consistency reliability for each of the constructs of .89 - .92 (Unfried et al., 2015). Table 3.6 presents the reliabilities for the *S-STEM*.

Table 3.6

Reliabilities of S-STEM Scale

	Items	Alpha Coefficients (Unfried et al., 2015)
1. Mathematics	1 to 8	0.85
2. Your Future	1 to 12	0.87

State of Texas Academic Readiness (STAAR) Test

Student achievement for students in the U.S. is measured based on performance on state assessment data. In Texas, students participate in the State of Texas Assessment of Academic Readiness (STAAR) (Texas Education Agency, 2010). The first administration of the STAAR tests included reading and mathematics assessment in grades 3-8, writing assessment in grade 4 and 7, science assessment in grades 5 and 8, social studies assessment in grade 8, and end of course (EOC) assessments for Algebra I, English I and II, Biology, and United States History at the high school level. The purpose of the STAAR test is to determine if standards have been approached, met, or mastered for specific knowledge at the grade level tested (Texas Assessment Management System, TEA, 2017).

The STAAR assessments are based on the Texas Essential Knowledge and Skills (TEKS) which is the state mandated curriculum for Texas public schools (TEA, 2010). The assessments are administered in the spring semester within the academic school year of which the students receive instruction based on specific knowledge and skills needed for students to learn each year. The students' performance is based on progress from one year to the next.

Algebra I EOC. The Algebra I End of Course (EOC) exam is given to students who take Algebra during an academic school year. Traditionally, the Algebra I EOC is

administered to students in the ninth grade in May of the spring semester. However, there are districts in Texas where students in the seventh and eighth grades take Algebra I. This is an accelerated mathematics pathway for students and is sometimes associated with students who are participating in a STEM-based academic program. There are five reporting categories that are measured: (a) number and algebraic methods, (b) describing and graphing linear functions, equations, and inequalities, (c) writing and solving linear functions, equations, and inequalities, (d) quadratic functions and equations, and (e) exponential functions and equations (TEA, 2019). The Algebra I EOC contains 49 multiple choice items and 5-grid items. During the 2011-2012 school year, reliability for the STAAR assessments were estimated using statistical measures in areas such as: internal consistency, classical standard error of measurement, conditional standard error of measurement, and classification accuracy.

Data Collection Procedures

Quantitative

Prior to data collection, the researcher gained approval from the University of Houston-Clear Lake's (UHCL's) Committee for Protection of Human Subjects (CPHS) and the school district in which the study will take place. Next, the middle school principals were contacted via email with information regarding the purpose of the study and the process for collecting surveys. The researcher disseminated an electronic link containing access to the surveys using Google Forms.

Letters of parental consent and student assent outlining the details of the study were given to parents and students. Students received the consent/assent letters via the campus research assistant and/or teacher prior to the administration of the surveys. Appendix A contains the minor assent form. The consent/assent states that participation is voluntary, the participant can quit at any time during the study, the approximate

timeline to complete the surveys (30 minutes), and that demographic information will remain confidential. Once the consent/ assent letters were signed by participants and their respective parent/guardian and returned to the campus research assistant or teachers the surveys were administered. Students were provided with an electronic link for the survey which contained the survey cover letter.

The survey responses were collected over a four-week period. The campus research assistant, teachers, and students were notified of the survey via email at the beginning of the data collection period. Follow-up emails were sent to teachers during both the first two weeks and again during weeks four and five of the data collection period. Upon receipt of the survey responses, the data were entered into quantitative research software Statistical Package for the Social Sciences (SPSS) for further analysis.

All data were secured in a password-protected folder on the researcher's computer and in the researcher's office within a locked file cabinet at all times. At the culmination of the study, the data will be maintained by the researcher for five years, which is the time required by CPHS and district guidelines. The researcher will destroy the contents of the file once the deadline has expired.

Qualitative

Qualitative data were collected through a series of individual interviews that were conducted in person. The researcher conducted one 20-minute semi-structured interview with each participating student. An interview script was used in order to gather the information necessary to identify perceptions of grit, mathematics self-efficacy, and STEM career interest as factors that influence student achievement (see Appendix E). Interviews data from one-one-one interview protocol were recorded with permission, transcribed by the researcher, coded, and analyzed to determine emergent themes within participant responses. The interviews were conducted in the front office of a school

campus at a time that was convenient for them. Pseudonyms were used to protect the participants involved in the study. After each interview, the recording was uploaded to the researcher's personal computer, password protected, and stored on the hard drive and an external hard drive for safe keeping.

Data Analysis

Quantitative

Following data collection, the data were downloaded from Qualtrics into SPSS and AMOS for statistical analysis. To answer Research Question 1-3, a Pearson's product moment correlation (*r*) was conducted to determine if there was a statistically significant relationship between students' grit and the students' achievement, mathematics self-efficacy and the students' achievement, and STEM career interest and the students' achievement. To answer Research Question 4, a structural equation model (SEM) was conducted to determine if there was a statistically significant relationship between students' grit, mathematics self-efficacy, STEM career interest, and the students' achievement. All variables were continuous in measurement.

Qualitative

Prior to the analysis of the quantitative data, the research constructs were utilized to develop the interview questions in an attempt to provide a more in-depth understanding of the relationship between grit, mathematics self-efficacy, STEM career interest, and student achievement. To answer research questions 5-7, qualitative data gathered from individual student interviews was examined, analyzed, and coded for themes. The data were then sorted and categorized by themes. Obtaining additional data from the qualitative portion of the research study allowed the researcher to further study the constructs in greater detail.

The open-ended questions were aimed at providing an in-depth understanding of the general patterns that could have possibly emerged from the quantitative study. In order to bring focus to the important aspects of the interviews, the researcher began with interview condensation which helped to reduce extraneous and unrelated information (Saldana & Omasta, 2018). After identifying the related information, the values coding process was utilized to include and emphasize themes and patterns that could have emerged from the data. Using values coding, the researcher noted the participants' responses to the interview questions as related to an individual's values system, including attitudes, values, and/or beliefs (Saldana & Omasta, 2018). The data were organized within the values system and the findings were recorded.

Validity

During the qualitative components of the study, the researcher employed several methods to help improve accuracy, credibility, and validity of the study: peer review of the interview protocols, member checking, and triangulation of data. The initial interview protocols were reviewed and revised based on peer review to ensure the interview questions were aligned with the research questions and then were used with two students as part of a pilot study. A few of the interview questions were revised for the final set of questions that were utilized within the study. Next, member checking was used to ensure accurate representation of each participant's interview transcript. As a final effort, triangulation of the data was accomplished by comparing the survey responses on the grit survey, Student Attitudes Toward STEM survey, and the Semester Exam/Algebra I EOC questions assessment data that was collected.

Privacy and Ethical Considerations

Prior to the collection of any data, the researcher gained approval from the UHCL's CPHS and the school district in which the study took place. Given that the intended survey instruments are pre-existing, the researcher asked for written approval for their use. All participants were provided with detailed information related to the purpose of the study and directions for completing the surveys. Parent consent and student assent forms were collected from participants prior to collecting any survey data. The data collected will remain securely locked in a cabinet and pin drive in the researcher's office. The researcher will maintain the data for 5 years as required by the CPHS and school district guidelines. After the deadline has passed, the researcher will destroy all data files associated with the study.

Research Design Limitations

The research design consists of several limitations. First, the student's class scheduling presented a limitation in that it was difficult to coordinate interview sessions while aiming to avoid having the participants miss classroom instruction as a result of participation in the study. This potentially could have impacted the validity of the responses within the interview sessions because the data is only as accurate as the honesty of the respondents who missed classroom instruction. Second, given that only two groups of seventh and eighth grade students enrolled in Algebra I were studied, the generalizations of the findings could be limited. Third, the level of honesty of the participants could vary based on them being adolescents. One must assume the participants were completely honest when they provided responses to the survey items and interview questions. The validity of the findings could have been jeopardized if the participants were dishonest.

Fourth, the middle schools have a specialized STEM-based academic program in which the seventh-grade participants are enrolled. The STEM-based academic program is offered at all the middle schools in the school district, but the number of students enrolled in the program at each of the middle school campuses varies based on location. For this study, only two groups of seventh-grade students participating in the STEM-based academic program were selected to participate. Therefore, the findings of this study are limited to the responses of the sample group selected for this study only.

Conclusion

The purpose of this study was to examine the relationships between grit, mathematics self-efficacy, STEM career interest, and student achievement for students in Algebra I offered above grade level. This chapter identifies the need to further examine the relationship amongst the constructs. In order to better understand the student perceptions of grit, mathematics self-efficacy, and STEM-based career interest and the relationships to academic achievement, both the quantitative and qualitative findings are essential to this study. In Chapter IV, survey and interview response data is analyzed and discussed in further detail.

CHAPTER IV:

RESULTS

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement in Algebra I. This chapter presents the results from the quantitative and qualitative analysis of the study. Survey, Algebra I EOC, and interview data were analyzed. This chapter begins with a presentation of the participant demographics, then data analysis for each of the seven research questions, and then concludes with a summary of the findings of each of the research questions that guided this study.

Participant Demographics

Participants for this study consisted of seventh and eighth grade Algebra I students enrolled in two middle schools within a large suburban school district in southeast Texas. The middle schools are located within a large school district that contains seven middle school campuses. One hundred and eighteen parents consented to having their student participate in the survey and individual interviews; 118 students completed the survey (100.0% response rate). Table 4.1 provides specific participating student demographics per campus. Of the 118 participants, 59 students indicated they were female (50.0%), while 59 students indicated they were male (50.0%). Of the 118 student participants, 16 students (13.6%) indicated they were African American, 35 students (29.7%) indicated they were Asian, one student (0.8%) indicated she was Hawaiian or Pacific Islander, 17 students (14.3%) indicated they were Hispanic, four students (3.4%) indicated they were Native Alaskan or American Indian, 25 students (21.2%) indicated they were two or more races, and 17 students (20.0%) indicated they were white.

Table 4.1

Student Participant Demographics of Participating Campuses

	All (%)	Campus A (%)	Campus B (%)
Total	100.0 (n = 118)	27.1 (n = 32)	72.9 (n = 86)
Female	50.0 (n = 59)	46.9 (n = 15)	51.2 (n = 44)
Male	50.0 (n = 59)	53.1 (n = 17)	48.8 (n = 42)
African American	13.6 (n = 16)	0.0 (n = 0)	18.6 (n = 16)
Asian	29.7 (n = 35)	3.1 (n = 1)	39.5 (n = 34)
Hawaiian or Pacific Islander	0.8 (n = 1)	0.0 (n = 0)	1.2 (n = 1)
Hispanic	14.3 (n = 17)	46.9 (n =15)	2.3 (n = 2)
Native Alaskan or American Indian	3.4 (n = 4)	3.1 (n = 1)	3.5 (n = 3)
Two or More	21.2 (n = 25)	31.3 (n = 10)	17.4 (n = 15)
White	17.0 (n = 20)	15.6 (n = 5)	17.4 (n = 15)

Of the 118 student participants, 11 students participated in the individual interviews. Table 4.2 provides specific participating student demographics per campus for each of students that participated in the individual interviews. Of the 11 interview participants, five students indicated they were female (45.5%), while six students indicated they were male (54.5%). Of the 11 students, one student (9.1%) indicated she was African American, one student (9.1%) indicated she was Asian, six students (54.5%) indicated they were Hispanic, and three students indicated (27.2%) they were white.

Table 4.2

Student Interview Participant Demographics

	Interviewees
Total	100.0 (n = 11)
Female	45.5 (n = 5)
Male	54.5 (n = 6)
African American	9.1 (n = 1)
Asian	9.1 (n = 1)
Hispanic	54.5 (n = 6)
White	27.2 (n = 3)

Instrument Reliability

Cronbach's alphas were calculated to assess the reliability of the *Grit-S* (Duckworth & Quinn, 2009). The reliability coefficients ranged from 0.73 to 0.84. Cronbach's alphas were calculated to assess the reliability of the *S-STEM* (The Friday Institute, 2010). The reliability coefficients ranged from 0.72 to 0.89. Reliability coefficients greater than .70 are considered acceptable (Fraenkel & Wallen, 2006). The instruments used in the study are presented in Table 4.3.

Table 4.3

Reliability Coefficients for Instrumentation

	Cronbach's α Smith (2021)	Cronbach's α* Clark and Malecki (2019) Unfried et al. (2015)
1. Grit – S: (Items 1 to 8)	0.73	0.84
2. S - STEM Mathematics Self-Efficacy Subscale (Items 1 to 8)	0.89	0.85
3. S – STEM STEM Career Interest (Items 1 to 12)	0.72	0.87

*Cronbach's α for the Grit – S was obtained from Clark and Malecki (2019). Cronbach's α for the S – STEM was obtained from Unfried et al. (2015).

Research Question One

Research question one, Is there a statistically significant relationship between grit and achievement for middle school students enrolled in Algebra I, was answered using Pearson's Product-Moment correlation (r). Results of the Pearson's r indicated there was not a statistically significant relationship between grit and Algebra I EOC scores, $r = .047$, $p = .616$. Additionally, research question one was measured using frequencies and percentages for the student responses from the Grit-S (Duckworth & Quinn, 2009).

The survey questionnaire for the Grit-S included 8-items using a 5-point Likert scale (Not Much Like Me At All, Not Much Like Me, Somewhat Like Me, Mostly Like Me, Very Much Like Me). The point values from the survey are on a scale ranging from one to five. An overall score of one indicates a very low level of grit and an overall score of five indicates a very high level of grit. If the score is indicated as a 5, which is the maximum score on the Grit-S, then the participant is determined to be extremely gritty. If

the score is indicated as a 1, which is the minimum score on the Grit-S, then the participant is determined to be not at all gritty. In order to calculate an overall score, all of the points must be added together in order for the sum to indicate the raw score which is then divided by eight to determine the participant's final grit score. A composite score for grit is a sum of all of the scored items, where the maximum score equals 40 points. A higher composite score is equated to a higher amount of grit for the participant. The specific responses to the grit survey are provided in Tables 4.4 and 4.5.

The Grit-S statements are based on an individual's self-perception of interest of consistency or self-perception of effort of perseverance. The Grit-S items one, three, five, and six are consistency of interests' sub-scale statements as related to grit and sustaining focus on long-term ideas or projects. Overall based on collapsed response data, students (65.2%) indicated they are sometimes distracted by new ideas and projects compared to previous projects and 60.2% of the students indicated they become obsessed with a certain idea or project only for a short time. Additionally, students (62.7%) indicated they set a goal and later pursue a different one and 56.8% of the students indicated they lose focus over time on projects that take more than a few months to complete. Student responses for the consistency of interests' sub-scale items did not strongly indicate self-perception of being committed to new ideas and projects over time.

The Grit-S items two, four, seven, and eight are perseverance of efforts sub-scale statements as related to grit. Overall and based on collapsed response data, students (72.0%) indicated they are not discouraged by setbacks and 97.4% of the students indicated they are hard workers. Additionally, students (91.5%) indicated they finish what they begin and 99.2% of the students indicated they are diligent. Overall, there was a strong student response for the perseverance of efforts' sub-scale statements, which means the students perceive themselves to have grit as related to their perseverance of

efforts. Moreover, even though the students lose interest over time, the students are committed to their efforts, work hard, and diligently finish projects they are involved in.

Table 4.4

Expanded Responses to Grit-S for All Participants

Survey Item		Not Like Me At All	Not Much Like Me	Somewhat Like Me	Mostly Like Me	Very Much Like Me
Grit 1: New ideas and projects sometimes distract me from previous ones.	All (n = 118)	11.9 (n = 14)	22.9 (n = 27)	42.4 (n = 50)	20.3 (n = 24)	2.5 (n = 3)
Grit 2: Setbacks don't discourage me.	All (n = 118)	7.6 (n = 9)	20.3 (n = 24)	39.0 (n = 46)	25.4 (n = 30)	7.6 (n = 9)
Grit 3: I have been obsessed with a certain idea or project for a short time but later lost interest.	All (n = 118)	16.1 (n = 19)	23.7 (n = 28)	22.9 (n = 27)	26.3 (n = 31)	11.0 (n = 13)
Grit 4: I am a hard worker.	All (n = 118)	0.0 (n = 0)	2.5 (n = 3)	14.4 (n = 17)	48.3 (n = 57)	34.7 (n = 41)
G5: I often set a goal but later choose to pursue a different one.	All (n = 118)	11.9 (n = 14)	25.4 (n = 30)	23.7 (n = 28)	27.1 (n = 32)	11.9 (n = 14)
Grit 6: I have difficulty maintaining my focus on projects that take more than a few months to complete.	All (n = 118)	24.6 (n = 29)	18.6 (n = 22)	22.0 (n = 26)	24.6 (n = 29)	10.2 (n = 12)
Grit 7: I finish whatever I begin.	All (n = 118)	0.8 (n = 1)	7.6 (n = 9)	31.4 (n = 37)	34.7 (n = 41)	25.4 (n = 30)
Grit 8: I am diligent.	All (n = 118)	0.0 (n = 0)	0.8 (n = 1)	26.3 (n = 31)	47.5 (n = 56)	25.4 (n = 30)

Table 4.5

Collapsed Responses to Grit-S for All Participants

Survey Item		Not Like Me	Somewhat Like Me	Like Me
Grit 1: New ideas and projects sometimes distract me from previous ones.	All (n = 118)	34.8 (n = 41)	42.4 (n = 50)	22.8 (n = 27)
Grit 2: Setbacks don't discourage me.	All (n = 118)	27.9 (n = 33)	39.0 (n = 46)	33.0 (n = 39)
Grit 3: I have been obsessed with a certain idea or project for a short time but later lost interest.	All (n = 118)	41.7 (n = 47)	22.9 (n = 27)	37.3 (n = 44)
Grit 4: I am a hard worker.	All (n = 118)	2.5 (n = 3)	14.4 (n = 17)	83.0 (n = 98)
G5: I often set a goal but later choose to pursue a different one.	All (n = 118)	37.3 (n = 44)	23.7 (n = 28)	39.0 (n = 46)
Grit 6: I have difficulty maintaining my focus on projects that take more than a few months to complete	All (n = 118)	43.2 (n = 51)	22.0 (n = 26)	34.8 (n = 41)
Grit 7: I finish whatever I begin.	All (n = 118)	8.4 (n = 10)	31.4 (n = 37)	60.1 (n = 71)
Grit 8: I am diligent.	All (n = 118)	0.8 (n = 1)	26.3 (n = 31)	72.9 (n = 86)

Research Question Two

Research question two, Is there a statistically significant relationship between mathematics self-efficacy and achievement for middle school students enrolled in Algebra I?, was answered using Pearson's Product-Moment correlation (r). Results of the Pearson's r indicated there was a statistically significant relationship between

mathematics self-efficacy and mathematics achievement, $r = .288$, $r^2 = .083$, $p = .002$. As a student's mathematics self-efficacy increases, his or her mathematics achievement score increases. Approximately 8.3% of the variance in a student's achievement can be attributed to the student's mathematics self-efficacy. Additionally, research question two was examined using frequencies and percentages of student responses from the Mathematics Self-efficacy from the Student Attitudes Toward STEM Survey (Mathematics Attitudes) (Friday Institute for Educational Innovation, 2012).

The Student Attitudes Towards STEM Survey mathematics subscale is composed of eight items. The 5-point Likert scale with the ratings of Strongly Disagree, Disagree, Neither Disagree Nor Agree, Agree, and Strongly Agree. An overall score of one indicates a very low level of mathematics self-efficacy and an overall score of five indicates a very high level of mathematics self-efficacy. If the score is indicated as a 5, which is the maximum score on the S-STEM mathematics subscale, then the participant is determined to have high mathematics self-efficacy. If the score is indicated as a 1, which is the minimum score on the S-STEM mathematics subscale, then the participant is determined to have low mathematics self-efficacy (Friday Institute for Educational Innovation, 2012). In order to calculate an overall score, all of the points must be added together in order for the sum to indicate the raw score which is then divided by eight to determine the participant's final mathematics self-efficacy score. A composite score for mathematics self-efficacy is a sum of all of the scored items, where the maximum score equals 40 points. A higher composite score is equated to a higher amount of mathematics self-efficacy for the participant.

The specific responses to the mathematics attitudes survey are provided in Tables 4.6 and 4.7. The statements from the Mathematics Self-efficacy from the Student Attitudes Toward STEM Survey (Mathematics Attitudes) are based on an individual's

attitude towards mathematics or mathematics efficacy. Overall and based on the collapsed data students (61.8%) indicated mathematics is their worst subject and 60.1% of the students indicated mathematics is hard for them. However, students (67.8%) indicated they do well in mathematics, 89.9% of the students indicated they can get good grades in mathematics, and 72.9% of the students perceive themselves to be good at mathematics. Furthermore, students (74.6%) indicated they can do advanced mathematics. Overall, the student responses indicated high mathematics self-efficacy based on the survey items because even though students perceive mathematics as being difficult, the students still believe they can do well in mathematics.

Table 4.6

Expanded Responses to Mathematics Self-Efficacy for All Participants

Survey Item		Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
Mathematics Self-Efficacy 1: Math has been my worst subject.	All (n = 118)	51.6 (n = 6)	11.0 (n = 13)	22.0 (n = 26)	23.7 (n = 28)	38.1 (n = 45)
Mathematics Self-Efficacy 2: I would consider choosing a career that uses math.	All (n = 118)	114.4 (n = 7)	14.4 (n = 17)	27.1 (n = 32)	31.4 (n = 37)	12.7 (n = 15)
Mathematics Self-Efficacy 3: Math is hard for me.	All (n = 118)	2.5 (n = 3)	11.0 (n = 13)	26.3 (n = 31)	34.7 (n = 41)	25.4 (n = 30)
Mathematics Self-Efficacy 4: I am the type of student to do well in math.	All (n = 118)	1.7 (n = 2)	5.9 (n = 7)	24.6 (n = 29)	41.5 (n = 49)	26.3 (n = 31)
Mathematics Self-Efficacy 5: I can handle most subjects well, but I cannot do a good job with math.	All (n = 118)	3.4 (n = 4)	5.9 (n = 7)	23.7 (n = 28)	35.6 (n = 42)	31.4 (n = 37)
Mathematics Self-Efficacy 6: I am sure I could do advanced work in math.	All (n = 118)	4.2 (n = 5)	4.2 (n = 5)	16.9 (n = 20)	42.4 (n = 50)	32.2 (n = 38)
Mathematics Self-Efficacy 7: I can get good grades in math.	All (n = 118)	0.8 (n = 1)	0.8 (n = 1)	8.5 (n = 10)	52.5 (n = 62)	37.3 (n = 44)
Mathematics Self-Efficacy 8: I am good at math.	All (n = 118)	1.7 (n = 2)	4.2 (n = 5)	21.2 (n = 25)	44.1 (n = 52)	28.8 (n = 34)

Table 4.7

Collapsed Responses to Mathematics Self-Efficacy for All Participants

Survey Item		Disagree	Neither Agree Nor Disagree	Agree
Mathematics Self-Efficacy 1: Math has been my worst subject.	All (n = 118)	16.1 (n = 19)	22.0 (n = 26)	61.8 (n = 73)
Mathematics Self-Efficacy 2: I would consider choosing a career that uses math.	All (n = 118)	28.8 (n = 34)	27.1 (n = 32)	44.1 (n = 52)
Mathematics Self-Efficacy 3: Math is hard for me.	All (n = 118)	13.5 (n = 16)	26.3 (n = 31)	60.1 (n = 71)
Mathematics Self-Efficacy 4: I am the type of student to do well in math.	All (n = 118)	7.6 (n = 9)	24.6 (n = 29)	67.8 (n = 80)
Mathematics Self-Efficacy 5: I can handle most subjects well, but I cannot do a good job with math.	All (n = 118)	9.3 (n = 11)	23.7 (n = 28)	67.0 (n = 79)
Mathematics Self-Efficacy 6: I am sure I could do advanced work in math.	All (n = 118)	8.4 (n = 10)	16.9 (n = 20)	74.6 (n = 88)
Mathematics Self-Efficacy 7: I can get good grades in math.	All (n = 118)	1.6 (n = 2)	8.5 (n = 10)	89.9 (n = 106)
Mathematics Self-Efficacy 8: I am good at math.	All (n = 118)	5.9 (n = 7)	21.2 (n = 25)	72.9 (n = 86)

Research Question Three

Research question three, Is there a statistically significant relationship between student career interest in STEM and achievement for middle school students enrolled in Algebra I, was answered using Pearson's Product-Moment correlation (r). Results indicated there was not a statistically significant relationship between STEM career interest and mathematics achievement, $r = .008$, $p = .927$. Additionally, research question three was measured using frequencies and percentages for the students' responses for each of the twelve STEM career fields within the Student Attitudes Toward STEM Survey (STEM Career Interest) (Friday Institute for Educational Innovation, 2012).

The Student Attitudes Towards STEM Survey STEM Career Interest subscale is composed of twelve items based on STEM career fields, including Physics, Environmental work, Biology and Zoology, Veterinarian work, Mathematics, Medicine, Earth Science, Computer Science, Medical Science, Chemistry, Energy, and Engineering. The 4-point Likert scale uses ratings of 1 - Not At All Interested, 2 - Not So Interested, 3 - Interested, and 4 - Very Interested. A composite score for STEM career interest is a sum of all of the scored items, where the maximum score equals 48 points. A higher composite score is equated to a higher amount of STEM career interest for the participant.

Specific responses to the STEM Career Interest survey are provided in Tables 4.8 and 4.9. Overall and based on the collapsed data for the 12 STEM fields provided on the Student Attitudes Toward STEM Survey (Friday Institute for Educational Innovation, 2012), the Medical and/or Medical Science careers had the highest student interest indicated (65.2% and 59.4% respectively). Furthermore, the lowest STEM career interest indicated by the students was within the fields of Earth Science (35.6%), Environmental Work (33.9%), and Energy fields (32.2%). Therefore, students are somewhat interested in

STEM career fields based on their responses, which corroborates with item 2 on the mathematics attitude survey about STEM career interest.

Table 4.8

Expanded Responses to STEM Career Interest for All Participants

Survey Item		Not At All Interested	Not So Interested	Interested	Very Interested
STEM Career Interest: Physics	All (n = 118)	14.4 (n =17)	40.7 (n = 48)	33.9 (n = 40)	11.0 (n = 13)
STEM Career Interest: Environmental Work	All (n = 118)	27.1 (n = 32)	39.0 (n = 46)	28.8 (n = 34)	5.1 (n = 6)
STEM Career Interest: Biology and Zoology	All (n = 118)	23.7 (n = 28)	32.2 (n = 38)	31.4 (n = 37)	12.7 (n = 15)
STEM Career Interest: Veterinary Work	All (n = 118)	25.4 (n = 30)	39.8 (n = 47)	23.7 (n = 28)	11.0 (n = 13)
STEM Career Interest: Mathematics	All (n = 118)	29.7 (n = 35)	32.2 (n = 38)	24.6 (n = 29)	13.6 (n = 16)
STEM Career Interest: Medicine	All (n = 118)	12.7 (n = 15)	22.0 (n = 26)	27.1 (n = 32)	38.1 (n = 45)
STEM Career Interest: Earth Science	All (n = 118)	28.0 (n = 33)	36.4 (n = 43)	30.5 (n = 36)	5.1 (n = 6)
STEM Career Interest: Computer Science	All (n = 118)	26.3 (n = 31)	38.1 (n = 45)	25.4 (n = 30)	10.2 (n = 12)
STEM Career Interest: Medical Science	All (n = 118)	12.7 (n = 15)	28.0 (n = 33)	26.3 (n = 31)	33.1 (n = 39)
STEM Career Interest: Chemistry	All (n = 118)	28.0 (n = 33)	22.9 (n = 27)	35.6 (n = 42)	13.6 (n = 16)
STEM Career Interest: Energy	All (n = 118)	24.6 (n = 29)	43.2 (n = 51)	26.3 (n = 31)	5.9 (n = 7)
STEM Career Interest: Engineering	All (n = 118)	15.3 (n = 18)	35.6 (n = 42)	39.8 (n = 47)	9.3 (n = 11)

Table 4.9

Collapsed Responses to STEM Career Interest for All Participants

Survey Item		Not Interested	Interested
STEM Career Interest: Physics	All (n = 118)	55.1 (n = 65)	44.9 (n = 53)
STEM Career Interest: Environmental Work	All (n = 118)	66.1 (n = 78)	33.9 (n = 40)
STEM Career Interest: Biology and Zoology	All (n = 118)	55.9 (n = 66)	44.1 (n = 52)
STEM Career Interest: Veterinary Work	All (n = 118)	65.2 (n = 77)	34.7 (n = 41)
STEM Career Interest: Mathematics	All (n = 118)	61.9 (n = 73)	38.2 (n = 45)
STEM Career Interest: Medicine	All (n = 118)	34.7 (n = 41)	65.2 (n = 77)
STEM Career Interest: Earth Science	All (n = 118)	64.4 (n = 76)	35.6 (n = 42)
STEM Career Interest: Computer Science	All (n = 118)	64.4 (n = 76)	35.6 (n = 42)
STEM Career Interest: Medical Science	All (n = 118)	40.7 (n = 48)	59.4 (n = 70)
STEM Career Interest: Chemistry	All (n = 118)	50.9 (n = 60)	49.2 (n = 50)
STEM Career Interest: Energy	All (n = 118)	67.9 (n = 80)	32.2 (n = 38)
STEM Career Interest: Engineering	All (n = 118)	50.9 (n = 60)	49.1 (n = 58)

Research Question Four

Research question four, Is there a statistically significant relationship between grit, mathematics self-efficacy, student career interest in STEM, and achievement for middle school students enrolled in Algebra I? was answered using structural equation modeling (SEM) to determine if there was a correlation between grit, mathematics self-efficacy, STEM career interest, and student achievement in Algebra I, as well as correlations between each of the factors. The Goodness of Fit index (GFI) was .89. According to Byrne (2001), a value over .80 is an acceptable fit and values approaching 1.0 are deemed excellent. Correlation coefficients were computed among the four factors with interactions in the specified model. A p-value less than .05 was required for statistical significance.

The SEM results indicated there was a statistically significant correlation between grit and STEM career interest, $p = .02$. The SEM results, on the other hand, did not indicate a statistically significant correlation between: (a) grit and mathematics self-efficacy, (b) grit and student achievement, (c) mathematics self-efficacy and STEM career interest, (d) mathematics self-efficacy and student achievement, or (e) STEM career interest and student achievement. Figure 4.1 depicts the SEM model of relationships between grit, mathematics self-efficacy, STEM career interest, and student achievement in Algebra I. The correlational analyses presented in Table 4.10 showed that one of the six correlations examined was statistically significant.

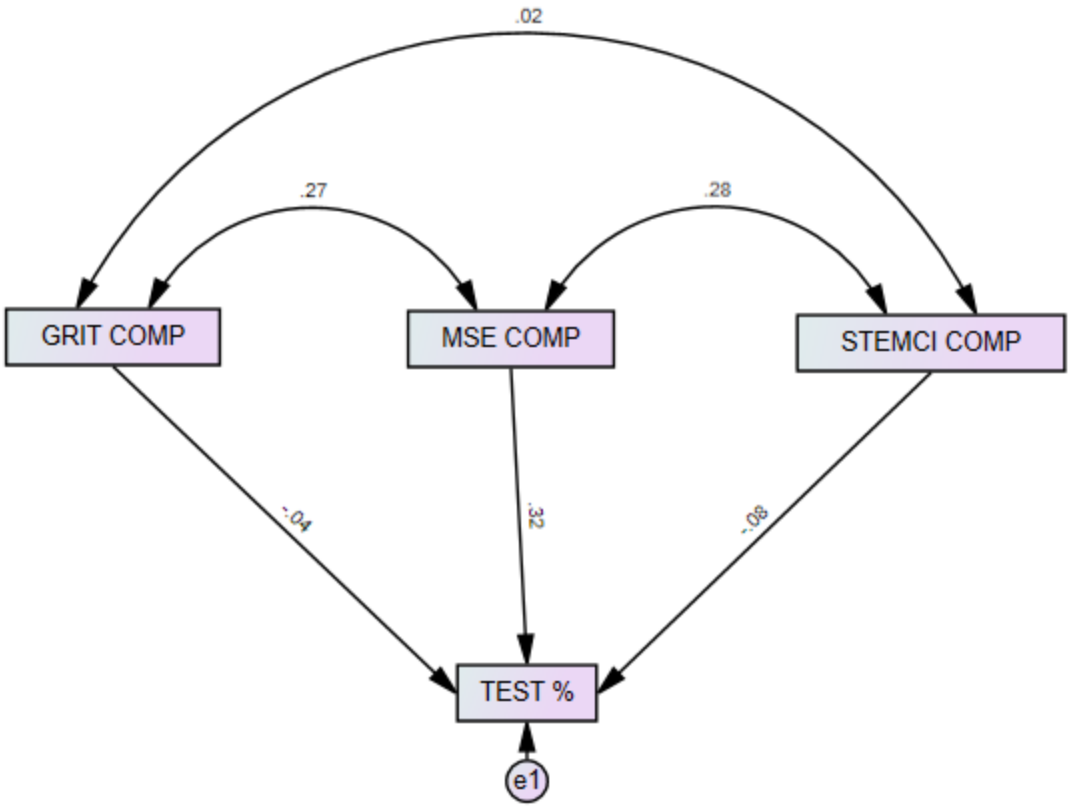

Figure 4.1 Structural Equation Model of Factors Affecting Student Achievement in Algebra I.

Path analysis of the direct and indirect relationships between factors affecting student achievement in Algebra I. Rectangles in the top row denote independent variables and the rectangle at the bottom row represents the dependent variable of student achievement, which is measured in a percentage correct score for the Algebra I EOC.

Table 4.10

Correlation Coefficients Among Grit, Mathematics Self-Efficacy, STEM Career Interest, and Student Achievement

	Mathematics Self-Efficacy	STEM Career Interest	Student Achievement
Grit	0.27	0.02*	-0.04
Mathematics Self-Efficacy		0.28	0.32
STEM Career Interest			-0.08

*Statistically Significant ($p < .05$)

Research Question Five

Research question five, *How do middle school students perceive grit to influence their achievement in Algebra I?*, was answered using qualitative inductive coding process using the interview response data from eleven students (6 seventh graders and 5 eighth graders) enrolled in Algebra I within one of the middle schools. This study's findings illuminate information that the students shared in order to help explain their perceptions of grit as related to achievement in Algebra I. The perceptions of the students are presented to provide in-depth information and a rich description about the students' personal experiences in Algebra I. From the eleven student interviews, three themes emerged as related to first of three qualitative research questions.

Interviews were conducted with a representative group from 7th and 8th grade students about their perceptions of grit and academic achievement in the Algebra I class they were enrolled in. The seventh-grade students were taking Algebra I above grade level (two to three years above grade level) as part of the requirements for a mathematics and science gifted education program. The eighth graders were taking Algebra I above grade level (one year above grade level) as part of the prerequisite for high school advanced mathematics' coursework. An inductive coding analysis derived three themes based on the responses concerning grit and academic achievement in Algebra I: passion

and positivity, pushing through goals, and personal success. The emergent themes obtained are provided below followed by a sample of the students' comments.

Passion and Positivity

Passion and positivity was an emergent theme that emerged from the qualitative interview questions that were intended to help students think about the concept of grit and how grit might be connected to achievement. Duckworth et al. (2007) defined grit as "perseverance and passion for long-term goals" (p. 1087). The part of passion for long-term goals within grit is the element of what Duckworth et al. (2007) believed to be known as having consistency of interests. When an individual has consistency of interests, the individual is passionate about what he or she is involved in or in completing a task with passion. Seven of the participants shared their perceptions of grit and their work in Algebra I as described below.

Two of the students described the characteristic of grit as a passion. One seventh-grade student described grit as "a passion for a long-term goal" and an eighth-grade student said grit was a "passion towards something." Another seventh-grade student believed grit had to do with him staying positive and an eighth-grade student stated, "Grit is when a task has to be done and the task is completed the right way."

A seventh-grade student believed grit to positively influence his achievement. Specifically, the student said, "I always look back on my goal if I feel like giving up." The student referenced how he used his goal to look back on in order to evaluate his progress. Moreover, the student's end goal was the motivator to keep going.

Pushing Through Goals

Grit, as defined by Duckworth et al. (2007), includes the factor of perseverance of effort. The goal orientation component of grit is foundational in individuals pushing towards a long-term goal. As the interviews continued, several of the interviewees'

responses led the researcher to conclude many of the students are goal-oriented in their Algebra I class. Many of the students' responses indicated that the students are persistent towards their long-term goals demonstrating the students possess grit through their perceptions.

Two seventh-grade students and one eighth grade student described the characteristic of grit as having a long-term goal for the future. One of the students stated, "I push through because I know that by doing so, I can achieve my goal of doing architectural engineering." One of the seventh-grade students described grit to be the "push to complete something." Another seventh-grade student stated, "Having little goals is good. They all add up to your final goal to achieve your dream." Another student noted, "Mini-goals are like ants. Just one won't do much but many mini-goals all together is power in numbers." The idea that the student is aware and focused on setting mini goals is aligned with the idea that the student is working with grit to achieve success within Algebra I.

Additionally, a seventh-grade student and an eighth-grade student believed grit to be an example of hard work. The eighth-grade student stated, "Someone gritty will probably succeed." Another seventh-grade student and an eighth-grade student noted grit to be like determination. One eighth grade student said, "I feel like it is a determination and passion towards something." When thinking about grit as an influencing factor of achievement in Algebra I, two seventh graders and two eighth graders noted grit to help them push to get past the challenges of the coursework. An eighth grader said, "It moves really fast, and you have to keep up with the pace."

Personal Success

When the students were presented with questions related specifically to grit and achievement in their Algebra I class, six of the students spoke specifically of their own

personal success. The idea of moving past mistakes in efforts of attaining success emerged. Additionally, many of the students spoke of their personal success rather than the overall success of the class.

One seventh-grade student noted she pushes Algebra I because it will help her achieve her future career goal that is a mathematics-based career; furthermore, she stated, "I need to be able to analyze and calculate structural problems in order to engineer a solution that will ensure a structure will remain stable." Another seventh-grade student stated, "I want to go to college, so I try my best to succeed in Algebra I. I don't want to just pass the class. I want to master the class." Furthermore, this student doesn't let mistakes hold him back and he wants to be prepared for future advanced mathematics coursework. The student went on to say, "Grit is like determination. If I fail, that's just one small experience among many." An eighth-grade student said she is determined to be successful, and another eighth-grade student noted she wanted to "excel in Algebra" and do to so she must keep up with the pace. Another eighth grader determined her success in Algebra I as earning at least a 90 in the class. Lastly, an eighth-grade student stated, "Someone gritty will probably succeed."

Summary

The themes of passion and positivity, pushing through goals, and personal success emerged through the interview process with the eleven students. These three themes are related to the first qualitative research question intended to understand students' perception of the relationship between grit and academic achievement in Algebra I. In Algebra I, students move through the school year with multiple assessments that lead up to the Algebra I End of Course Exam (Viera, 2012). While moving through the rigorous coursework of Algebra I, a student proceeds through the various assessments knowing the summative assessment at the end of the year is high stakes and a passing score is

needed for graduation status. For research question four, it is evident the students perceive grit to contribute to their academic achievement in their Algebra I class. Grit is foundational in two aspects, including the concept of consistency of interests and perseverance through long-term goals (Duckworth et al., 2007). Overall, the majority of the students were able to convey self-perceptions of ideas specifically related to the two aspects of grit.

Research Question Six

Research question six, *How do middle* school *students perceive mathematics self-efficacy to influence their achievement in Algebra I?* was answered using an inductive coding process using the interview response data from eleven students (6 seventh graders and 5 eighth graders) enrolled in Algebra I within one of the middle schools. The interview responses helped to explain the students' perceptions of mathematics self-efficacy as related to their experiences in Algebra I. From the eleven student interviews, two themes emerged as related to the second of three qualitative research questions. The emergent themes obtained related to mathematics self-efficacy are provided below followed by a sample of the students' comments.

Confidence

Mathematics self-efficacy relates to how individuals attribute their success to effort and diligence within the content area of mathematics (Gates, 2015). The concept of self-efficacy is similar to how confident individuals feel about how the individual can perform the task at hand. The majority of the students, both seventh and eighth graders, were very confident when talking about their experiences with achievement in Algebra I. Therefore, the students seemed to demonstrate self-efficacy in their efforts while persevering in advanced mathematics.

One seventh-grade student described success in Algebra I, “I get better as the weeks go by and I can say I have done a good job so far.” Another seventh-grade student described success in Algebra I, as doing “really well”; additionally, another seventh grader described his success as, “I am doing good and I definitely pass even with taking Algebra I early, so it’s even harder.” One seventh-grade student stated, “I want to do well in Algebra. I want to be able to succeed.” The seventh graders are taking Algebra I multiple grade levels above in an accelerated program. The seventh graders often expressed their level of comfortability despite the accelerated content they work with. Therefore, demonstrating an increased perception of mathematics self-efficacy.

All of the eighth graders conveyed confidence when asked about their success level in Algebra I. One eighth grade student said she was doing great and has had an “A” in Algebra so far. Another eighth grader noted he was doing very well, and another eighth grader said she was in “the high levels” which helps her stay more advanced in future mathematics courses. Another eighth-grade student noted, “I like math and I like to work hard at it.” Even though the students don’t specifically know the concept of mathematics self-efficacy, the eighth graders were often reflecting on “doing well” and they generally believe they have done a good job in Algebra so far, which conveys confidence in their experiences in the class.

Mathematics self-efficacy relates to how individuals attributes their success to effort and diligence within the content area of mathematics (Gates, 2015). The majority of the students, both seventh and eighth graders, were very confident when talking about their experience with achievement in Algebra I demonstrating self-efficacy in their efforts while persevering in advanced mathematics.

Mathematics-based Careers

Some of the interview questions prompted the students to think about perception of personal performance in Algebra I and how that was connected to their future. The majority of the students described the importance of their performance in the advanced mathematics class and the influence of their performance on their future college intentions or career paths. Ten of the eleven students supported achievement in mathematics as an influence on their future career choice.

One seventh-grade student believed mathematics achievement to influencing his career choice "greatly" and another seventh grader noted he needed to be "excellent at math to excel in my dream." The student responses indicated there was a connection between their current experiences in Algebra I and the importance of being successful as influencing their future paths. One seventh grader stated his future career choice "heavily relies on exact number placement and quick thinking." Another seventh-grade student says his mathematics achievement opens many "promising career paths." One eighth grader described achievement in Algebra I, "Algebra gives me useful brain power for the future" and another eighth grader said she wants to be a doctor. She said, "In the medical field, math is really important." The specific student responses regarding their experiences in Algebra I and their future career paths involving mathematics help to illuminate the students' connections between mathematics self-efficacy, achievement, and their future.

Summary

The student interviews provided an opportunity for the researcher to explore student perceptions related to their mathematics self-efficacy in Algebra I and how their achievement in Algebra I influences their future career choice. Peters (2009) noted mathematics self-efficacy was positively correlated with mathematics performance,

which corroborates with the perceptions of the students' interview responses related to mathematics self-efficacy and academic achievement. The Algebra I course content is above grade level for the students and is perceived to be challenging; however, the students believe they want to be successful because it matters to them and they believe achievement is possible if they work hard for what they want. Research has shown positive educational outcomes that are a result of mathematics self-efficacy are likely to influence a student to want to take more advanced mathematics courses in the future and interest in particular STEM fields (Kwon et al., 2019).

Research Question Seven

Research question seven, *How does the perception of STEM career interest influence achievement for middle school students in Algebra I?,* was answered using qualitative inductive coding process using the interview response data from eleven students (6 seventh graders and 5 eighth graders) enrolled in Algebra I within one of the middle schools. The participant's interview responses help explain STEM career interest as related to achievement in Algebra I. From the eleven student interviews, two themes emerged as related to the third qualitative research question. The emergent themes obtained, STEM career interest and future unknown are provided below followed by a sample of the students' comments.

STEM Career Interest

Diekman, Weisgram, and Belanger (2015) believed adolescence to be a period of time within an individual's life that is distinctly important when deciding to go into the STEM career fields. Many of the students discussed their STEM career interest and the importance of studying advanced mathematics as related to STEM career choice. Some students discussed careers, including aerospace engineering, architecture, chemistry, and

medical science. Ten of the eleven students noted they have STEM career interest for high school graduation pathways.

One seventh grader noted his achievement in Algebra I influences his engineering interest because "it will make class easier and simpler to understand." One seventh grader who was interested in engineering said he has known since he was in sixth grade that he wanted to study engineering. One seventh-grade student believed he has always wanted to pursue a career in mathematics or science, and he believed he wanted to study chemistry because chemistry is interesting. One seventh-grade student had a definite focus on the future and wants to be an aeronautical engineer or astronaut. The student stated, "I want to be an astronaut…an aerospace engineer and I need math and science to achieve this goal." The student went further to state, "I want to be able to solve problems on the spot when I am working as an astronaut." This is a very specific goal, and the student has a definite understanding that there is grave importance when it comes to the academic preparation for the field of study.

One eighth grade student interested in being a doctor stated, "Math is important. I want to do well in Algebra so I can continue to do well in my other high school math classes." One seventh grader and one eighth grader discussed STEM career interest in the computer science fields, specifically game design and computer programming respectively; moreover, both students recognized computer science as a STEM career field and both students were aware, they could take computer science classes in high school to prepare for future careers. One eighth grade student showed some interest in going into the veterinary medicine pathway in high school but was not exactly sure she was ready to decide what career she would choose. Over the past decade, federal, state, and local education agencies have been trying to address deficits in the STEM labor market by creating and offering STEM related coursework for high school students

(Sublett & Plasman, 2017). From the interview responses with the students, there is evidence the students have awareness that STEM coursework is available for them to participate with in high school. Most of the interview participants showed interest in STEM career fields when thinking about their future opportunities.

Future Unknown

Career interest relies on the formation of a vocational identity; moreover, as adolescents are forming personal identity, it is not uncommon for adolescents to be uncertain of their vocational identity (Rogers, Creed, & Praskova, 2016). Two of the eighth-grade students that participated in the interviews were unsure of their career pathways when thinking about high school coursework. One eighth grade student replied, "I don't really know what I want to do yet" when she was asked about high school and college studies. Another eighth grader noted she did not know what she wanted to do in the future during the interview. One of the eighth-grade students that was unsure of the future did perceive achievement in Algebra I do help her no matter what she chose to do in the future. The two eighth grade students' responses indicate the students have not yet formed a vocational identity.

Summary of Findings

This chapter provided an analysis of both the quantitative and qualitative data collected during the study to address the seven research questions. Surveys were sent to 118 students who were seventh and eighth grade Algebra I students and out of the 118 students who participated in the study, 11 students participated in individual interviews. The population varied by ethnicity/race demographic and there was an even distribution of male and female students for gender demographics.

Quantitative analysis resulted in a statistically significant relationship between mathematics self-efficacy and student achievement. Additionally, structural equation

modeling resulted in a statistically significant correlation between grit and STEM career interest. There was not a statistically significant relationship between grit and mathematics self-efficacy or grit and academic achievement, mathematics self-efficacy and academics achievement or STEM career interest, or between STEM career interest and student achievement; however, students' responses indicated the student participants were gritty, had mathematics self-efficacy, and were interested in a STEM career field in the future.

Qualitative analysis resulted in themes related to grit, mathematics self-efficacy, STEM career interest, and achievement emerged from the interview responses. Passion and positivity, pushing through goals, and personal success are themes that emerged related to grit. Confidence and mathematics-based careers are themes that emerged related to self-efficacy. STEM career interest and future unknown are themes that emerged from STEM career interest interview responses. Qualitative analysis illustrated significance in the students' perceptions of grit, mathematics self-efficacy, and student achievement as related to personal performance in Algebra I.

Conclusion

This chapter presented the results of the quantitative and qualitative data analysis of this study. Quantitative analysis resulted in a statistically significant relationship between mathematics self-efficacy and student achievement. Additionally, structural equation modeling demonstrated that grit was related to STEM career interest. Qualitative analysis illustrated a significance in the students' perceptions of grit, mathematics self-efficacy, and student achievement as related to personal performance in Algebra I.

In the next chapter, the findings of the present study will be compared and contrasted with prior studies in the research literature. Additionally, the implications of

the results of this study will be discussed with considerations toward instructional practices in efforts to help teachers guide students with developing grit, mathematics self-efficacy, and promoting STEM career interest. Further research study ideas will be identified, as well.

CHAPTER V:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study was to examine the relationship between grit, mathematics self-efficacy, students' career interest in STEM, and student achievement in Algebra I. Within STEM education research, the concepts of self-efficacy, achievement, and career interest are prevailing in discussion (Kwon et al., 2019). However, the relationship between the constructs is limited when it comes to middle school age students, which is an important time period for building mathematics self-efficacy and influencing STEM career interest (Blotnicky et al., 2018).

This study was completed during the fall in 2019 with 118 seventh and eighth grade Algebra I students within a large suburban district located in southeast Texas. Students participated in quantitative data collection with a survey and individual interviews. All 118 students completed the survey and 11 students participated with individual interviews. Pearson's Product-Moment correlation (r), structural equation modeling (SEM), and thematic coding were used to analyze the data collected. This chapter includes a summary of the findings, implications, and recommendations for further research.

Summary

The research questions address whether or not there was a relationship between grit, mathematics self-efficacy, STEM career interest and achievement. The following research questions guided this study:

1. Is there a statistically significant relationship between grit and achievement for middle school students enrolled in Algebra I?
2. Is there a statistically significant relationship between mathematics self-efficacy and achievement for middle school students enrolled in Algebra I?

3. Is there a statistically significant relationship between student career interest in STEM and achievement for middle school students enrolled in Algebra I?

4. Is there a statistically significant relationship between grit, mathematics self-efficacy, STEM career interest, and academics achievement for middle school students enrolled in Algebra I?

5. How do middle school students perceive grit to influence their achievement in Algebra I?

6. How do middle school students perceive mathematics self-efficacy to influence their achievement in Algebra I?

7. How does the perception of STEM career interest influence achievement for middle school students in Algebra I?

Grit was measured using the *Short Grit Scale* (Grit-S). Mathematics self-efficacy and career interest were measured using the *Student Attitudes Toward STEM Survey* (S-STEM). Student achievement was measured using STAAR Algebra I End of Course (EOC) exam questions. The researcher examined the relationships between the constructs and academic achievement in Algebra I.

Research Question 1

The research question isolated the factor of grit to examine the relationship between grit and academic achievement. Quantitative analysis demonstrated the independent variable of grit did not have a relationship with academic achievement for students in Algebra I. When looking specifically at grit composite scores for students within the sub-scales for *Grit-S*, the researcher was able to determine students' self-perception of their grit. Student responses for the consistency of interests' sub-scale items did not strongly indicate students' self-perception of being committed to new ideas and projects over time. However, there was strong evidence within the students' responses for

the perseverance of efforts' sub-scale statements, which means the students perceive themselves to have grit as related to their perseverance of efforts. Moreover, even though the students lose interest over time when they are working, the students are committed to their efforts, working hard at what they are doing, and diligently finish projects they are involved in according to the grit survey composite scores. Christensen and Knezek (2014) indicated that when students are challenged with a level of difficulty, persisting through the challenge is a result of persevering and consistently focusing interest over time, which is grit.

There was not a statistically significant relationship between grit and academics achievement, consistent with the research of Khan (2018) who determined students with high levels of perseverance were found not to be high achieving in mathematics. Based on the quantitative findings from the current study, this suggests that student perception of grit was not a predictor of academic achievement for the students in Algebra I, although qualitative findings developed through this investigation suggests grit was a predictor of success for the students according to the students' interview responses. This premise is aligned with findings from the research which suggested the students believed their passion for a long term-goal was connected to their academic achievement in Algebra I.

One explanation for the difference in results could be that the Khan (2018) study was conducted with students in fifth through twelfth grades and the current study was conducted with seventh through eighth graders. Khan (2018) did report that there were age group differences in grit; moreover, students in sixth through eighth grades indicated the highest levels in perseverance compared to students in the higher grades with low levels of perseverance. The ages of the middle school students in the current study should have yielded results indicating a relationship between grit and academic achievement;

however, there are other factors to consider when explaining the disparity in the relationship between constructs.

Another explanation for the non-significant relationship between grit and academic achievement for this research could be due to the data collection on grit and academic achievement being collected at the end of the fall semester during the school year. The students had not had the opportunity to demonstrate perseverance towards the long-term goal of academic achievement based on a full school year with the content. At the time the data were collected, students had only one semester with the Algebra I content that was evaluated on the Algebra I EOC assessment questions and had only one semester for the opportunity to develop grit with the accelerated content of Algebra I. The research findings from this study were not consistent with Duckworth et al. (2007) research on grit as a predicting factor of academic achievement. Furthermore, Duckworth et al. (2007) research was based on persevering towards a long-term goal and grit is considered to be the predictor of academic achievement, specifically involving effort and interest, when an individual works towards long-term goals with goal directedness. The data analysis may have produced different results had the data been collected after a full year of enrollment in Algebra I for the middle school students.

Another explanation for the disparity in the relationship between grit and academic achievement for this study, could be due to the low level of grit indicated on the *Grit-S* subscale items for consistency of interests but not on the perseverance of efforts subscale data. On the students' responses for the consistency of interest items, the students indicated low levels of grit associated with the consistency of interest sub-scale items. In contrast, many responses from the students' interview responses indicated passion for a long-term goal, which Duckworth et al. (2007) believed to be the definition

for consistency of interests. Corroborating with Duckworth et al. (2007) research, other research in academic settings supports grit as a significant contributor to individual academic success because of the role self-interest plays (Lam & Zhou, 2019). Moreover, Duckworth and Gross (2014) proposed people with grit focus their individual interest toward clear goals and work hard continuously with commitment in wanting to achieve the goals. Based on the findings from the next research question, the students' indicated that mathematics was their worst subject. Perhaps the feelings of dislike for mathematics are congruent with the low interest in the Algebra I for the students in the current study. Additionally, if the students had an explanation of the alignment between their perception of passion and how consistency of interests is connected with passion or had the students been provided the definition and examples of grit prior to the data collection, the data analysis may have produced different results.

Research Question 2

In the current study, quantitative analysis demonstrated there was a statistically significant relationship indicated for mathematics self-efficacy and academic achievement for students in Algebra I. More specifically, as a student's mathematics self-efficacy increases, his or her mathematics achievement score increases. The students responded to statements from the *Mathematics Self-efficacy from the Student Attitudes Toward STEM Survey* (Mathematics Attitudes), which are based on an individual's attitude towards mathematics or mathematics efficacy. The findings from the current study are consistent with research supporting a significant relationship between mathematics self-efficacy and academic achievement (Peters, 2009; Taylor, 2018; McMillian, 2017; & Gates, 2015).

The current study's findings indicated most of the students perceive mathematics to be their worst subject and that mathematics is hard for them. Despite these perceptions of the challenges that accompany mathematics, the students noted they are good at mathematics, can do well in mathematics, can get good grades in mathematics, and can-do advanced levels of mathematics. Based on this research, the students' perceptions are aligned with having high self-efficacy in mathematics. Even though the students feel that mathematics is hard and that it is their worst subject, the students feel confident that they can be successful in the subject area.

Findings from this study are consistent with research on the relationship between mathematics self-efficacy and academic achievement. Research on self-efficacy was illuminated by Bandura (1997), who defined self-efficacy as an individual's beliefs of his or her own capabilities when performing as task. Furthermore, Bandura (1986) argued that when individuals are confident, they can produce desired outcomes because the individuals are self-incentivized to act to make the outcomes a reality. Consistent with Bandura (1986), further research notes that self-efficacy is a consistent positive predictor of academic achievement, including the mathematics domain of academics (Grigg et al., 2018). Substantiating research on mathematics self-efficacy, Peters (2009) noted mathematics self-efficacy was positively correlated with mathematics performance and self-efficacy contributes to mathematics achievement. In the current research study, not only did the quantitative analysis include findings indicative of a statistically significant relationship between the two constructs, but the interview responses provided by the students brought to light their personal feelings about the challenges of mathematics and their confidence to overcome the challenges in order to be successful in their Algebra I class.

Research Question 3

For the current study, the third research question isolated the variable of STEM career interest to determine if there was a relationship between STEM career interest and academic achievement for middle school students in Algebra I. Quantitative findings suggested there was not a statistically significant relationship between STEM career interest and academic achievement. The students were surveyed to determine their level of STEM career interest for 12 STEM fields. Overall, the Medical and/or Medical Science careers had the highest student interest indicated by the students. The lowest STEM career interest indicated by the students was within the fields of Earth Science, including Environmental Work and Energy fields. The overall findings demonstrated students are somewhat interested in STEM career fields based on their responses, which corroborates with item 2 on the mathematics attitude survey about STEM career interest.

There was not a statistically significant relationship between STEM career interest and academic achievement found within the current study. Although student STEM career interest in educational research is a heighted topic, there is limited research on STEM career interest and achievement for middle grades students. Research has shown positive educational outcomes that are a result of mathematics self-efficacy are likely to influence a student to want to take more advanced mathematics courses in the future and interest in particular STEM fields (Kwon et al., 2019). Furthermore, within STEM education research, self-efficacy, achievement, and STEM career interest are heightened areas of discussion and researchers believe the connections between student self-efficacy, achievement, and career interest are important to understand in order to increase the number of students pursuing STEM career paths (Kwon et al., 2019). Additionally, self-efficacy has been correlated with academic achievement, engagement, effort, and motivation in previous studies (Bandura, 1997; Webb-Williams, 2018; Wigfield &

Ecccles, 2000; Zimmermann, 2000) and self-efficacy in mathematics has been correlated with mathematics achievement (Kwon et al., 2019).

When looking specifically at STEM career interest and adolescence, it is important to note that the period of adolescence is a pivotal time in exposing students to possible STEM career paths (Diekman et al., 2015). Moreover, adolescence is a period of time where individuals are forming their identities and exploring the possibilities of future career paths. Effective interventions and exposure to STEM career fields are needed to develop more mathematically talented youth in order to build the STEM pipeline (Diekman et al., 2015). For the current study, the students' perception of STEM career interest was relatively low as indicated through survey results, this may have been contributed to the lack of relationship between STEM career interest and academic achievement in mathematics according to student perceptions.

Research Question 4

The fourth research question was answered using a structural equation model (SEM) to determine if there were correlations within all of the constructs, including grit, mathematics self-efficacy, STEM career interest, and student achievement in Algebra I. The operation of the structural equation model was useful in examining relationships among constructs and was intentional in exploring mediating effects of the constructs using a dynamic model. The only significant quantitative result that emerged from the SEM was a statistically significant correlation between grit and STEM career interest.

The findings of the correlation between grit and STEM career interest align with research contending that an individual who is determined to be successful in STEM field coursework is one who understands the challenges and problems to be solved through the process but is driven with persistence to solve problems presented in those specific educational opportunities (Sublett & Plasman, 2017). When examining the grit

component perseverance of efforts within the current study, the students' perception responses overall indicated high levels of grit as related to perseverance. Additionally, when examining STEM career interest, the participants were found to have some career interest in STEM fields. Therefore, the analysis of the SEM, when specifically examining the relationship between grit and STEM career interest for students, provides helpful information for understanding the students' perspective of the career field demands.

Although there is limited research related to grit and STEM career interest for middle school students, this study's findings of the correlation between the two constructs helps to understand student perceptions of the interconnectedness between the two constructs. When working in STEM career fields, like engineering and medical science, perseverance of efforts is necessary. Individuals working in these career fields utilize problem solving skills and face challenges head on; moreover, within the engineering and medical science fields, individuals need to be gritty to face the demands of the job. Grit, described as an individual's ability to possess sustained effort and passion towards long-term goals, is a significant predictor of outcomes and success (Duckworth et al., 2007; Strayhorn, 2013; West et al., 2016).

When looking at other constructs within the current study, the results did not indicate a statistically significant correlation between: (a) grit and mathematics self-efficacy or (b) grit and student achievement or (c) mathematics self-efficacy and STEM career interest or (d) mathematics self-efficacy and student achievement or (e) STEM career interest and student achievement. This is contrary to another research (Dixson et al., 2018; Brennan, 2015; Taylor, 2018; & Grigg et al., 2018). It is possible that the present study sample perceives the constructs differently than previously studied groups that were not composed of middle school students. Additionally, previous research supports mathematics achievement as a predictor of student success in mathematics and

persistence in STEM-related courses (Kwon et al., 2019). Furthermore, research in the area of mediating effects of mathematics self-efficacy on mathematics performance has been appealing to researchers in efforts to understand motivating factors of achieving goals in academic venues (Peters, 2009).

The final three questions of the current study composed the qualitative portion of the study. The questions were used to triangulate the data and to gain a deeper understanding of the constructs using student perspective. The questions are provided below.

Research Question 5

This research question provided the opportunity for students to describe their perceptions of grit and academic achievement in Algebra I based on their experiences during the first semester of the course. Qualitative analysis demonstrated the emergence of three themes including passion and positivity, pushing through goals, and personal success. Overwhelmingly, the idea of personal passion was an overarching theme as demonstrated through the students' responses to the interview question.

The researcher met one-on-one with each of the eleven students for their interviews and when discussing grit and academic achievement, the students were quick to respond with an underlying understanding of how their personal grit influences or has an effect on their performance in Algebra I. Students described how being passionate and working with a positive mindset had an impact on their mathematics experiences. Also, students described how they pushed through challenges to meet their goals. The students believe that Algebra I is challenging, and they must push through those obstacles in efforts to be successful. Furthermore, the students were aware and focused on personal success in their Algebra I class and beyond.

Qualitative analysis demonstrated through this research question supports previous findings from Duckworth et al., (2007) when looking at the components of grit. Grit is defined as an individual characteristic or skill encompassing determination, resilience, and perseverance in the face of long-term goals (Duckworth & Quinn, 2009). Although quantitative findings did not provide a statistically significant relationship between grit and academic achievement for the middle school students in Algebra I, qualitative findings provided a different perspective. The emergent themes revealed consistency with Locke and Latham's (1990) goal-setting theory.

The goal-setting theory is based on Bandura's (1986) research which suggested an individual's goal is (1) an efficient cause of behavior and an individual's performance is maximized when the set goal is specific and difficult and (2) the individual understands the behaviors that are required to reach the goal and feels competent in those behaviors (Gagne & Deci, 2005). The transition from interview questions related to grit into discussions on self-efficacy as related to the students' perceptions in Algebra I was seamless. The students demonstrated their ownership for their feelings towards mathematics during the qualitative phase of the research study.

Research Question 6

The sixth research question was intended to shed light on the students' perceptions of self-efficacy and academic achievement in Algebra I. Two themes emerged from the student's interview responses, including confidences and mathematics-based careers. As stated previously, overall, the students possessed a sense of confidence and ownership when speaking about their experiences in Algebra I. Confidence is a theme that easily emerged and is related to self-efficacy illustrating the interview participants perceive that personal success in Algebra I is a result of hard work, effort, and focus over time. Bandura (2012) supports self-efficacy as how an individual

perceives one's ability to adeptly engage in specific activities. Furthermore, when speaking with the students, the qualitative data revealed an alignment with research from Dixson et al., (2018) who determined academic self-efficacy to be a significant predictor of academic achievement.

The interview participants in the current study discussed the importance of being self-determined when working on their mathematics' challenges, specifically believing that Algebra I is a difficult subject. However, despite the challenges, the students were determined to do well in the course so they could continue onto their advanced coursework pathway in high school and beyond. Findings from the qualitative research portion were similar to research from Brennan (2015) who determined academic self-efficacy to have a positive correlation with achievement. Additionally, the findings support mathematics self-efficacy as a type of academic self-efficacy, which was determined to be positive correlated with mathematics achievement (Taylor, 2018).

When examining the qualitative findings related to mathematics self-efficacy and looking through the lens of self-determination theory (Deci & Ryan, 1985), it is evident the students are autonomously motivated during their experiences in Algebra I. Deci and Ryan (1985) developed the theory which suggests individuals are motivated to grow and become self-determined when their needs for competence, connection, and autonomy are satisfied. Self-determination theory (Deci & Ryan, 1985) supports autonomous motivation and intrinsic goals as predictors of performance in tasks that individuals are interested in or curious about.

The final theme that emerged from the interview responses in reference to the second qualitative research question was mathematics-based careers. The student responses corroborate the idea that academic self-efficacy beliefs are believed to be a factor that steers students' career expectancy and serve as predictors of students' career

trajectory expectations (Bandura et al., 1996, 2001). During the individual interviews, the seventh and eighth grade students spoke about the influence of achievement on their future career choice. Many of the students spoke directly about pursuing a mathematics-based career and felt their trajectory into mathematics-based careers was based on performing well in Algebra I and beyond in other advanced mathematics courses. Students' interest in STEM career fields that are mathematically based was a topic of conversation within the interviews for many of the students and naturally led into interview questions intended to address the final research question.

Research Question 7

This research question provided the opportunity for students to describe their perceptions of STEM career interest and academic achievement in Algebra I based on their experiences during the first semester of the course. Qualitative analysis demonstrated the emergence of two themes including STEM career interest and future unknown. Most of the students had determined their career trajectory into the STEM career fields, specifically within the engineering and medical science fields. A few of the students were unsure of their future career path, which aligned with research from Rogers et al. (2016) who argued career interest relies on the formation of a vocational identity and as adolescents are forming personal identity, it is not uncommon for adolescents to be uncertain of their vocational identity.

Moreover, career planning is considered to be a motivational strategy in an individual's career development and career planning is foundational in synthesizing information that students collect for themselves in order to develop a timeline based on actions for career trajectory. This is considered to be associated with goal-oriented thinking, according to Rogers et al. (2016). As adolescents are forming personal identifies and planning for high school, this goal-oriented thinking becomes essential in

efforts understanding the necessity of achieving within coursework that is associated with their potential career pathway.

When looking through lens of a theoretical framework for the qualitative analysis portion related to STEM career interest and academic achievement, the qualitative analysis in aligned with Locke and Latham (1990). The researchers supported goal setting as a predictor of work outcome, so when examining STEM career interest, students who are goal-oriented in STEM content areas may be likely to pursue a STEM career. Middle school students in Algebra I with mathematics self-efficacy may be motivated by their interest in mathematics content and the rigor of the content acceleration. Additionally, Deci and Ryan (1985) argued activities that are interesting to individuals are intrinsically motivating. The students' interview responses indicated interest in mathematics within Algebra I and although the students expressed the hard work that accompanies their success in the coursework, they expressed that they were motivated towards their work outcomes.

Qualitative analysis resulted in themes related to grit, mathematics self-efficacy, and STEM career interest emerging from the interview responses. The interview-based approach was valuable in gaining a deeper understanding of career interest development for the adolescents as supported by Lipstein and Renninger (2007) and Nolen (2007). Through the interview process with the 11 seventh and eighth grade students, student responses indicate that despite knowing or not knowing what the future holds for these students, they have their eyes on being successful in the future and understand the importance of achievement in Algebra I as related to their future plans whatever they may be.

Implications

As the results from this study are explored and examined, there are important implications for educators to consider related to non-cognitive factors that are interdependent and predictive of academic achievement for middle school students in advanced mathematics coursework, such as Algebra I. The results from this study illuminate the importance for educators to understand how middle school students perceive grit and self-efficacy to have a relationship with possible STEM career trajectory and their academic achievement in Algebra I. Additionally, the research brings light to students' feelings towards achieving success in an advanced mathematics course taken above grade level as associated with goal setting and being self-determined.

Implications for Educators

Students can be cultivated by teachers to understand that hard work, effort, and focus are essential when learning is challenging (Muenks et al., 2017). Moreover, educators, specifically teachers, play a vital role in helping students to stay persistent with goals when the challenges arise in accelerated classes, such as above grade level mathematics (Gates, 2014; Phillips-Martinez, 2017). As students push through rigorous coursework, the challenges become a natural part of the learning process that can be expected through the educational pathways that build and support the STEM workforce in the United States.

Smith (2012) described pedagogical thinking for educators as looking beyond teaching; furthermore, pedagogy is viewed as a practice of accompanying learners while bringing learning to life. The practice of pedagogy for educators provides a helpful relationship and involves exploring challenges with students based on reflection and action in order to make learning meaningful. As educators seek to understand the implications of working with students in STEM based coursework and while engaging

students through accelerated learning experiences, educators can guide students through the challenges associated with the learning.

Increasing the STEM pipeline with gritty students who have a high self-efficacy is necessary as the United States takes on the reoccurring obstacles the 21st century has to offer. Kincheloe, Slattery, and Steinberg (2000) stated, "Curriculum and instruction are the heart and soul of schooling" (p. 304). Students are presented with rigorous curriculum through accelerated mathematics coursework; however, careful consideration of pedagogical approaches within instruction, as related to grit and academic self-efficacy, is a necessary component of success development (Kim, Sinatra, & Seyranian, 2018). In Texas, students can take accelerated mathematics courses, including Algebra 1 and Geometry while enrolled in middle school. Within these mathematics courses, students engage in formulating responses while using mathematical discourse in order to fulfill constructed responses to address mathematical problems which required critical thinking. Furthermore, critical thinking at higher order levels is required in order for students to be successful in advanced coursework (Judson, 2017). Engaging students in accelerated mathematics coursework should be accompanied with providing opportunities where students utilize critical thinking and work through challenges towards successful outcomes.

Additionally, adolescence is a time period of complexity for students as this is when students are comparing themselves to others and show a tendency for self-examining with a fixed mindset (Dweck, 2008). Therefore, educators should recognize this complexity associated with adolescence and help students to discover self-determination in efforts of building confidence when facing challenges. This will help students become more self-determined and will help to build efficacy in students. Taking Algebra I as a middle grade student offers students the opportunity to engage in higher

order thinking at an early age to begin the rigorous course sequence that is a used to prepare for college level classes while in high school. Furthermore, a strong foundation and deep understanding of algebraic concepts, such as mathematical algorithms and complex computation tasks, are foundational in order for students to be successful in advanced mathematics coursework that continues on past Algebra I (Dougherty et al., 2015). Ketterlin-Geller et al. (2015) report that students enrolled in advanced levels of mathematics coursework and perform successfully in Algebra II are four times as likely to matriculate through college as students that take lower-level mathematics coursework in high school. Within STEM education reform and in regard to national economic success and global competitiveness, teachers should recognize the importance of mathematics achievement (Chazan, 2008; The College Board, 2000).

As society continues to face the demands for a global workforce within the realm of STEM, the need for students to perform successfully in STEM related coursework is critical (Reinking & Martin, 2018). Academic self-efficacy beliefs are believed to be a factor that steers students' career expectancy and serve as predictors of students' career trajectory expectations (Bandura et al., 1996, 2001). Therefore, educators should help students to develop their determination to be successful in STEM field coursework by understanding the challenges and problems to be solved through the process and by being persistent to solve problems presented in those specific educational opportunities.

Effective pedagogical practices, foundational in understanding of student development of grit and self-efficacy at high levels in accelerated mathematics coursework, draw on the critical importance for students to feel successful and perform successfully in a STEM course so the students will continue to feel successful for STEM career trajectory. Educators can help students develop determination, perseverance, and tenacity through actions and motivating language of support. The psychosocial factors,

grit and self-efficacy, contribute to success for students, specifically for middle school students who are enrolled in a STEM field course at an early age and educators that are dedicated to helping students to be successful help students understand that hard work, effort, and focus are critically necessary during accelerated mathematics coursework.

Recommendations for Future Research

Findings from this study involved obtaining feedback, quantitative and qualitative, from students. Although the findings provided data and information about students' perceptions, recommendations for future research will help expand the knowledge on this topic. The following recommendations are based on data and findings from this research study.

This study took place at two participating middle school campus with 118 students from a large suburban school district located in the southeast region of Texas, therefore results are only applicable to similar campuses and districts in terms of size and demographics. Data collection from a larger population and sample may produce different results. A recommendation for future research would be to include more middle schools. Another recommendation would be to conduct the study at the elementary and high school levels to determine how the perceptions of students change based on other educational levels as students' progress through other advanced coursework. Future research could include examining the relationship between grit and self-efficacy and how that relationship influences STEM career interest for students while using a much larger sample than 118 students. Additionally, future research should explore more students through the qualitative individual process. The interviews were very helpful for the researcher to understand student perception and perspective. Future research could focus on examining a larger quantity of students in efforts to examining student perception and perspective of the research constructs. This type of research could provide more insight to

educators regarding examining student's perceptions of grit, mathematics self-efficacy, STEM career interest, and academic achievement for students in advanced mathematics courses.

Conclusion

This study examined the relationships between non-cognitive factors and academic achievement for middle school students in Algebra I. Survey, interview, and achievement data were analyzed regarding students' perceptions of grit, mathematics self-efficacy, STEM career interest, and academic achievement. The data were analyzed with Pearson's r moment correlations and SEM to examine the relationships between the constructs. Quantitative analysis resulted in statistically significant relationships between mathematics self-efficacy and academic achievement and between grit and STEM career interest for the 118 middle school students in Algebra I. The findings did not indicate any other statistically significant relationships between or among the constructs. However, qualitative analysis illustrated the 11 seventh and eighth grade students' perceptions of how grit, mathematics self-efficacy, and STEM career interest are related to academic achievement in their Algebra I course. Emergent themes of passion and personal success, confidence, ownership of achievement, and mathematics-based careers were discovered through individual interviews with 11 students. The themes were important for gaining a deeper understanding of the research constructs according to student perceptions.

In conclusion, this study contributes to existing research on grit and the influence of academic self-efficacy, such as mathematics self-efficacy, STEM career interest, and academic achievement.

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APPENDIX A:

ASSENT OF MINOR TO PARTICIPATE

ASSENT OF MINOR TO PARTICIPATE IN EDUCATION RESEARCH

Student Researcher: **Faculty Sponsor:**

You are being asked to help in a research project called THE RELATIONSHIP OF GRIT, MATHEMATICS SELF-EFFICACY, STEM CAREER INTEREST, AND ACADEMIC ACHIEVEMENT FOR MIDDLE SCHOOL STUDENTS IN ALGEBRA I and the project is part of my doctoral dissertation at the University of Houston-Clear Lake. The purpose of this study is to examine the influence of grit, academic efficacy, and career interest in STEM fields on academic achievement for seventh-grade students in an accelerated mathematics course. You will be asked to participate in completing two surveys and focus groups. Your help will be needed for four weeks.

You do not have to help if you do not want, and you may stop at any time even after you have started, and it will be okay. You can just let the researcher know if you want to stop or if you have questions.

Please keep the upper part of this page for your information. Thank you for your assistance.

* *

_____ Yes, I agree to (allow my child to) participate in the study (THE RELATIONSHIP OF GRIT, MATHEMATICS SELF-EFFICACY, STEM CAREER INTEREST, AND ACADEMIC ACHIEVEMENT FOR MIDDLE SCHOOL STUDENTS IN ALGEBRA I)

_____ No, I do not wish to (allow my child to) participate in the study (THE RELATIONSHIP OF GRIT, MATHEMATICS SELF-EFFICACY, STEM CAREER INTEREST, AND ACADEMIC ACHIEVEMENT FOR MIDDLE SCHOOL STUDENTS IN ALGEBRA I)

Printed Name of Assenting Child

Signature of Assenting Child Date

Printed Name of Parent or Guardian/Signature of Parent or Guardian Date

Printed Name of Witness of Child's assent/Signature of Witness of Child's assent Date

APPENDIX B:

SHORT GRIT SCALE

Directions for taking the Grit Scale: Please respond to the following 8 items. Be honest – there are no right or wrong answers!

1. New ideas and projects sometimes distract me from previous ones.*
- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

2. Setbacks don't discourage me.
- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

3. I have been obsessed with a certain idea or project for a short time but later lost interest.*
- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

4. I am a hard worker.
- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

5. I often set a goal but later choose to pursue a different one.*
- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

6. I have difficulty maintaining my focus on projects that take more than a few months to complete.*

- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

7. I finish whatever I begin

- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

8. I am diligent.

- ❑ Very much like me
- ❑ Mostly like me
- ❑ Somewhat like me
- ❑ Not much like me
- ❑ Not like me at all

Scoring:

1. For questions 2, 4, 7 and 8 assign the following points:
   5 = Very much like me
   4 = Mostly like me
   3 = Somewhat like me
   2 = Not much like me
   1 = Not like me at all

2. For questions 1, 3, 5 and 6 assign the following points:

   1 = Very much like me
   2 = Mostly like me
   3 = Somewhat like me
   4 = Not much like me
   5 = Not like me at all

Add up all the points and divide by 8. The maximum score on this scale is 5 (extremely gritty), and the lowest score on this scale is 1 (not at all gritty).

Grit Scale citation

Duckworth, A.L, & Quinn, P.D. (2009). Development and validation of the Short Grit Scale (Grit-S). *Journal of Personality Assessment, 91,* 166-174. http://www.sas.upenn.edu/~duckwort/images/Duckworth%20and%20Quinn.pdf

Duckworth, A.L., Peterson, C., Matthews, M.D., & Kelly, D.R. (2007). Grit: Perseverance and passion for long-term goals. *Journal of Personality and Social Psychology, 9,* 1087-1101. http://www.sas.upenn.edu/~duckwort/images/Grit%20JPSP.pdf

APPENDIX C:

MATHEMATICS SUB SCALE OF STUDENT ATTITUDESTOWARD STEM SCALE

S-STEM

Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Math has been my worst subject.	○	○	○	○	○
2. I would consider choosing a career that uses math.	○	○	○	○	○
3. Math is hard for me.	○	○	○	○	○
4. I am the type of student to do well in math.	○	○	○	○	○
5. I can handle most subjects well, but I cannot do a good job with math.	○	○	○	○	○
6. I am sure I could do advanced work in math.	○	○	○	○	○
7. I can get good grades in math.	○	○	○	○	○
8. I am good at math.	○	○	○	○	○

APPENDIX D:

STEM CAREER INTEREST SURVEY

YOUR FUTURE SUBSCALE

STEM CAREER INTEREST

OF STUDENT ATTITUDES TOWARDS STEM SCALE

S-STEM

MISO

THE WILLIAM & IDA FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION
NC STATE UNIVERSITY COLLEGE of EDUCATION

Golden LEAF FOUNDATION

This project received support from The Golden LEAF Foundation.

Your Future

Here are descriptions of subject areas that involve math, science, engineering and/or technology, and lists of jobs connected to each subject area. As you read the list below, you will know how interested you are in the subject and the jobs. Fill in the circle that relates to how interested you are.

There are no "*right*" or "*wrong*" answers. The only correct responses are those that *are true for you*.

	Not at all Interested	Not So Interested	Interested	Very Interested
1. **Physics:** is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe. *(aviation engineer, alternative energy technician, lab technician, physicist, astronomer)*	○	○	○	○
2. **Environmental Work:** involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. *(pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer and maintenance technician)*	○	○	○	○
3. **Biology and Zoology:** involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. (*biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)*	○	○	○	○
4. **Veterinary Work:** involves the science of preventing or treating disease in animals. *(veterinary assistant, veterinarian, livestock producer, animal caretaker)*	○	○	○	○
5. **Mathematics:** is the science of numbers and their operations. It involves computation, algorithms and theory used to solve problems and summarize data. *(accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)*	○	○	○	○

	Not at all Interested	Not So Interested	Interested	Very Interested
6. **Medicine:** involves maintaining health and preventing and treating disease. *(physician's assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist)*	○	○	○	○
7. **Earth Science:** is the study of earth, including the air, land, and ocean. *(geologist, weather forecaster, archaeologist, geoscientist)*	○	○	○	○
8. **Computer Science:** consists of the development and testing of computer systems, designing new programs and helping others to use computers. *(computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)*	○	○	○	○
9. **Medical Science:** involves researching human disease and working to find new solutions to human health problems. *(clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)*	○	○	○	○
10. **Chemistry:** uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. *(chemical technician, chemist, chemical engineer)*	○	○	○	○
11. **Energy:** involves the study and generation of power, such as heat or electricity. *(electrician, electrical engineer, heating, ventilation, and air conditioning (HVAC) technician, nuclear engineer, systems engineer, alternative energy systems installer or technician)*	○	○	○	○
12. **Engineering:** involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. *(civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)*	○	○	○	○

APPENDIX E:

STUDENT INTERVIEW QUESTIONS

Question	Student Response
1. How would you describe the characteristic of grit?	
2. How do you feel that grit influences your achievement in Algebra I?	
3. What does success look like to you in Algebra I?	
4. How do you think that your achievement in mathematics influences your future career choice?	
5. How are you doing in Algebra I now?	
6. What endorsement do you plan on pursuing in high school? In other word, what career do you want to learn about in high school? Is it STEM related?	
7. What do you want to study in college? Is it in the STEM fields?	
8. (If STEM related) How do you feel that your achievement in Algebra I influences your career choice in the STEM fields?	

APPENDIX F:

STAAR ALGEBRA I BLUEPRINT

STAAR Algebra I Blueprint

Reporting Categories	Number of Standards		Number of Questions	
Reporting Category 1: Number and Algebraic Methods	Readiness Standards	2	**11**	
	Supporting Standards	11		
	Total	13		
Reporting Category 2: Describing and Graphing Linear Functions, Equations, and Inequalities	Readiness Standards	3	**12**	
	Supporting Standards	8		
	Total	11		
Reporting Category 3: Writing and Solving Linear Functions, Equations, and Inequalities	Readiness Standards	5	**14**	
	Supporting Standards	7		
	Total	12		
Reporting Category 4: Quadratic Functions and Equations	Readiness Standards	4	**11**	
	Supporting Standards	4		
	Total	8		
Reporting Category 5: Exponential Functions and Equations	Readiness Standards	2	**6**	
	Supporting Standards	3		
	Total	5		
Readiness Standards	**Total Number of Standards**	**16**	**60%–65%**	**32–35**
Supporting Standards	**Total Number of Standards**	**33**	**35%–40%**	**19–22**
Total Number of Questions on Test			**49 Multiple Choice 5 Griddable 54 Total**	

Texas Education Agency
Student Assessment Division
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