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Dissertation Title: Relationships between and Student Perceptions of Self-Efficacy, Growth Mindset, and Math Identity of Adolescents in a Rural South Georgia School District

This dissertation has been read and approved by the undersigned. It is recommended for acceptance to the University in partial fulfillment of the requirement for the degree of Doctor of Education in Curriculum and Leadership.

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Relationships Between and Student Perceptions of Self-efficacy, Growth Mindset, and Mathematics Identity of Adolescents in a Rural South Georgia Charter School

by
Carrie Cooper Pierce

A Dissertation
Submitted in Partial Fulfillment of the Requirements for
The Degree of Doctor of Education
In Curriculum and Leadership
(Curriculum and Instruction)

Keywords: self-efficacy, growth mindset, math identity, adolescents, grounded theory

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Dedication

This work is dedicated to my daughter, Sealy Annelle Pierce.

It is rare to observe one's legacy while still alive. However, as I watch you build your classroom practice and come into your own as an educator, I am blessed to be able to do so. You have always been my muse and gave me realistic yet encouraging advice, often from a student's perspective. Now you have grown up and become my peer and colleague. More than anyone else, you understand and respect my passion for my topic and my research. You encourage your students, help them to do hard things, and love them like Jesus does. You continually strive to grow and incorporate best practices to help your students learn content that is often not perceived as easy or useful.

I could not be prouder of the young woman you have become, and I'm so excited to watch God lead you down this path. He has amazingly wonderful plans for you, baby girl. I'm honored to watch you grow and walk in them.

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To my parents, thank you for the constant and unwavering love and support over these past years as I have pursued this degree. Thank you for loving and supporting me no matter what, through times good and bad. You have always had my back and believed in me, and I am who I am today because of your guidance.

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To the administration and faculty of the charter school that served as the location for my study, thank you for supporting me as I conducted my research. I appreciate how graciously you gave up your time for me. Whether gathering data, sending home and collecting forms, contacting parents, or helping me to track down students for interviews, you were always willing to help out. I am beyond grateful for all of you and thankful for this place. Our school is a very special place to work, and I am blessed to be here with you.

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Abstract

This mixed methods study investigated the relationships between the constructs of self-efficacy, growth mindset, and mathematics identity among middle school students at a South Georgia charter school. Constructivist grounded theory was used to investigate the strength of these constructs along with student perceptions of what factors make one a math person. The study was an explanatory sequential design consisting of an online survey followed by student interviews. Ninety-one students participated in the survey. Multiple linear regression was used to determine whether a correlation existed between the variables as well as among student subgroups. Self-efficacy was found to be a predictor of math identity for all subgroups except for students who were not white and students with below average math achievement. Growth mindset was found to be a predictor of self-efficacy for all subgroups except for students who were females, students who were not white and students with below average math achievement. Growth mindset was found to be a predictor of math identity for males. A MANOVA found no significant relationships between the student-level factors of gender, race, socio-economic status, or math achievement level and the dependent variable of self-efficacy, growth mindset, and math identity. Embedded sampling was used to select 30 students from the survey participants for one-on-one interviews to more deeply investigate student perceptions of these variables. Qualitative analysis found interest, content proficiency, and enjoyment of mathematics to be prominent factors in whether one is perceived as a math person for students of all levels of math identity.

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Chapter I: Introduction

"When am I ever going to use this?" This is a question that math students often pose to their teachers, usually when they are feeling frustrated and insecure with a topic. Many students fail to see a relevant connection between the content and their life experiences, so they whine or complain when they are required to replicate procedures that do not fit into the vision they imagine for their futures. Students do not seem to identify as "math people" or "doers of math" and push-back against the authority that requires them to learn or perform an unnecessary skill. However, the math required for success in the 21st Century is shifting from the curricula that was the focus of the space race that dominated the mid-20th Century. With the advent of handheld technology and a new focus on data science, the careers in which one might use mathematics are immensely broader than they were even 10 years ago (LaMar & Boaler, 2021; Youcubed, n.d.). Careers involving science, technology, engineering, and math (STEM) are some of the fastest growing, with mathematical science jobs projected to grow the fastest among all STEM occupational groups in the next 10 years (Zilberman & Ice, 2021). In order for the United States to be competitive on the world stage, it is vital that America have a strong STEM workforce, which cannot come to fruition until American students have a solid foundation in and appreciation for mathematics (Sutter & Camilli, 2018). Mathematics is more than rote repetition of meaningless procedures; it entails an understanding of relationships between variables and phenomena in the world around us (Boaler, 2016).

Mathematics is the technical foundation of science, technology, and engineering, and is a core subject required for success in all STEM careers, even the biological sciences (Mitts, 2016; Vilorio, 2014; Sutter & Camilli, 2018). Many students do not enroll in higher level math classes because they fear failure, particularly women and minorities, the target subgroups for STEM job encouragement (Brown et al., 2008). Students with a stronger mathematical identity are more likely to choose STEM careers (Cribbs et al., 2020). Additionally, mathematics self-efficacy beliefs affect students' willingness to pursue higher-level math courses beyond minimal requirements (Guo, et al., 2015; Wang, 2013).

Many school districts begin tracking students into accelerated or regular math courses in middle school (Faulkner et al., 2014). This tracking not only limits opportunities for advanced math courses in high school but can affect students' beliefs about their own abilities (Boaler, 2013a; Conway, 2021; Marsh et al., 2018). Middle school is a critical time for adolescent discovery of personal interests, identities, and the exploration of topics that may lead to future careers (National Middle School Association, 2003). The transition to middle school can be stressful as students shift from single teachers to multiple teachers with rotating classes. During this time, students often must re-establish a sense of self-efficacy (Bandura, 2005). Additionally, neurological research supports the claim that adolescents' mindsets are associated with academic motivation and achievement and can be fostered through interventions (Daly et al., 2019; Ng, 2018; Sarrasin et al., 2018; Schroder et al., 2017; Tirri & Kujala, 2016). This study investigated the relationships between adolescents' mathematical self-efficacy, growth mindset, and math identity.

Background of the Problem

Establishing student agency, the belief that one's actions can influence the course of events (Bandura, 2005), can be critical to increasing achievement and motivation (Silver & Stafford, 2017). When students possess a sense of self-efficacy and believe they can accomplish a difficult task, they are more likely to persevere when obstacles arise. Just like *The Little Engine That Could* (Piper et al., 1930), the ability to harness the power of positive thinking can often mean the difference between success and failure. Mindsets are an extension of self-efficacy and are a critical subset to student agency (Silver & Stafford, 2017). Similarly, identities, such as how one perceives oneself, play a role in determining whether learning will result in success or failure (Sward & Prusak, 2005b). While mathematical self-efficacy, growth mindset, and identity each play a role in determining whether a student will be successful, there is little research linking these three constructs.

This study will investigate the relationships between and further an understanding of adolescent perceptions of self-efficacy, growth mindset, and identity with respect to mathematics at a rural charter school in South Georgia. The charter school (hereafter called the Charter School) examined in this study has consistently scored below the state level of achievement on the End of Grade (EOG) assessment in Grades 6-8 mathematics. In 2018 and 2019, approximately 43% of Georgia middle school students scored at the proficient or distinguished level in mathematics content mastery, while only 34-35% of students at the Charter School met the proficiency level (Georgia Department of Education, 2021).

Figure 1 illustrates a 3-year comparison of Grades 6 – 8 EOG Mathematics content mastery for the state of Georgia and the Charter School (Georgia Department of Education, 2018, 2019, 2021). Scores for the 2021 EOG assessment were obtained from the Charter School. State assessments were not administered in 2020 due to the mandated COVID-19 quarantine. Participation in EOG testing was optional in 2021 and many Georgia parents opted out of allowing their children to participate. As a result, caution should be used when interpreting the 2021 Georgia scores as only 64% of students enrolled participated in the EOG assessment (Georgia Department of Education, 2021). The Charter School had 100% participation.

Achievement levels are as follows: L1 is considered beginning learner, L2 is developing learner, L3 is proficient learner, and L4 is distinguished learner.

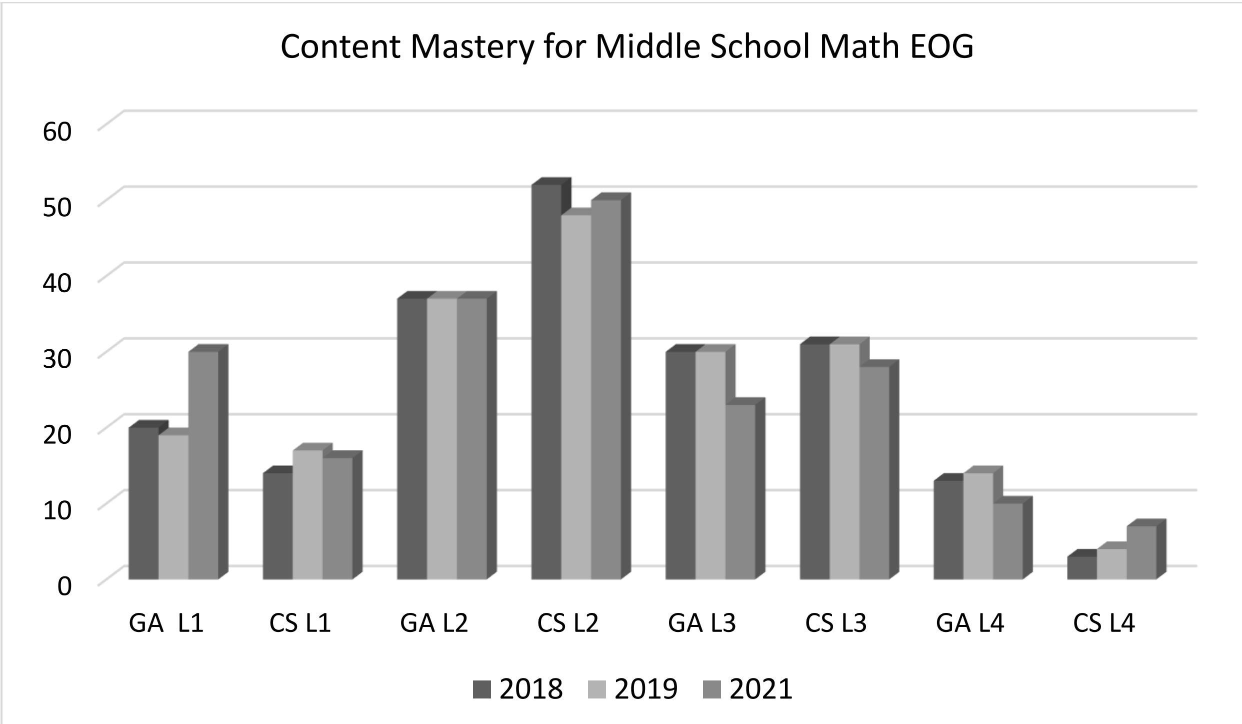

Figure 1. Mathematics Content Mastery for Middle School EOG

School administrators were seeking ways to support student learning and foster an environment which encourages critical thinking and exploration. The results of this study will help school administrators understand the relationships between mathematical self-efficacy, growth mindset, and mathematical identity. Additionally, an understanding of how certain populations of students perceive and internalize efficacy and mindset messages will assist teachers in building a more positive learning environment thus potentially fostering stronger mathematical identities for students.

Statement of the Problem

There is limited understanding as to the roles that mathematical self-efficacy and growth mindset play in the development of adolescents' mathematical identity. This study will contribute to the body of knowledge needed to address this problem by exploring the relationships between the math self-efficacy beliefs, growth mindset and mathematical identities of adolescents. There is a need for further extension in the literature as to the relationship between growth mindset and mathematical identity of middle school students. Additionally, there is a limited body of knowledge regarding the relationship between self-efficacy and math identity for students at the middle school level (Radovic et al., 2018; Usher, Ford, et al., 2019).

Purpose of the Study

The purpose of this study was to examine the effects of mathematical self-efficacy and growth mindset on the development of mathematical identity of middle school students at a rural South Georgia charter school. Additionally, the study investigated whether differences existed in mathematical self-efficacy, growth mindset, and math identity based on student gender, ethnicity, socio-economic status, or math achievement level. A mixed methods explanatory-sequential design was utilized. The quantitative portion consisted of a survey developed to examine the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students in a rural South Georgia charter school. The qualitative portion consisted of individual semi-structured interviews with students to investigate how students with different mathematical identities interpret and perceive mathematical self-efficacy and growth mindset.

Research Questions

Research Question 1 (RQ1): What is the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students?

Research Question 2 (RQ2): What are the differences in students’ math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level?

Research Question 3 (RQ3): How do student perceptions of self-efficacy, growth mindset, and mathematical identity differ based on math identity level?

Theoretical Framework

The theoretical framework used for this study was constructivist grounded theory (Charmaz, 2008). The grounded theory method of research was first conceived by Glaser and Strauss in the 1960s as they investigated the experiences of terminally ill patients with different understandings of their health status (Tie et al., 2019). Grounded theory is inductive research, with questions and data collection methods continually evolving as data analysis occurs. The goal of grounded theory is to use specific examples and experiences to formulate a general assumption. In the original sense, grounded theory is objective research where the researcher has no preconceived assumptions or opinions and allows data to speak for themselves (Charmaz, 2008). Constructivist grounded theory takes this lack of objectivity into account and advocates incorporating prior knowledge, preconceived biases, contextual situations, and viewpoints of both the researcher and participants (Charmaz, 2008). Constructivist grounded theory considers data as an integral part of the research process, not simply the product of objective observations. As such, the researcher considered self-efficacy and growth mindset theories during analysis of the qualitative data. The researcher's prior knowledge of and experience with self-efficacy and growth mindset constructs contributed to the compilation and formation of themes as data emerged to form the overarching theory for this study.

Methodology Overview

Research Design

This study was conducted using a constructivist grounded theory mixed methods design. An explanatory sequential design was used to allow the researcher to collect quantitative data and then to use qualitative methods to investigate more deeply the "why" behind the data (Creswell & Creswell, 2018). Students first completed an online survey, the results of which were used by the researcher to select an embedded sample of participants with whom to conduct individual semi-structured interviews. Interviews included students who were ranked with all levels of math identity and were a representative sample of the school population.

Sampling Procedures

Participants were a convenience sample of 91 Grade 8 and 74 Grade 7 students from a rural South Georgia charter school. Students whose parents have granted consent to participate in the study completed the survey instrument via Google Forms during homeroom class. After the survey data was analyzed, the researcher used purposeful sampling to select 30 students to participate in individual interviews. Interview participants included a sampling of students relative to the demographic population of the school. Approximately half of the interviews included students who possessed a strong math identity and half included students with a weak math identity.

Data Collection Instruments

The instrument used in this study was a combination of items that have been previously used to measure mathematical self-efficacy, mathematical growth mindset, and mathematical identity. Mathematical self-efficacy and mathematical growth mindset were measured with Likert-style questions derived from Huang et al. (2019). Mathematical identity was measured with Likert-style questions followed by a short answer "why?" response derived from Bohrnstedt et al. (2020). Student demographic data were obtained from the school registrar. Spring 2022 MAP Growth scores were obtained from the middle school principal and used to determine math achievement level. Qualitative data were collected through individual semi-structured student interviews.

Data Analysis

Quantitative. First, a multiple linear regression was run to determine the relationships between mathematical self-efficacy and growth mindset and whether these constructs were predictive of strong or weak mathematical identity. Next, a factorial MANOVA was used to investigate the effects of gender, ethnicity, socio-economic status (SES), and math achievement level on the combined dependent variable of mathematical self-efficacy, growth mindset, and math identity. Then, a series of simple linear regressions were conducted to determine the predictive nature of the three variables among specific student subgroups.

Qualitative. Transcripts from the individual semi-structured interviews were analyzed using In Vivo and focused coding (Saldaña, 2013) to search for common themes of student perceptions of mathematical self-efficacy and mathematical growth mindset and how these constructs were linked with students' mathematical identities.

Implications

Results of this study show how math self-efficacy and growth mindset influence the mathematical identity of middle school students at the Charter School. Administrators may wish to use these findings when planning professional development so that teachers can implement strategies to help foster positive mathematical identities in their students. Additionally, results from this study provided math teachers at the Charter School with vital information about how different subgroups of students form their mathematical identities based on their perceptions of self-efficacy and growth mindset. Teachers may wish to use these results to target specific subgroups of students with different interventions to foster more positive mathematical experiences in the classroom.

Future Research Directions

Future researchers may wish to do a longitudinal study from grades 6-12 years to investigate how math identity evolves from early to late adolescence. Future researchers may also wish to use a larger sample of participants in a more urban population with more ethnic diversity.

Delimitations and Limitations

This study will be delimited to students enrolled in Grades 7 and 8 at the school in question. One limitation of this study will be the grouping arrangements of the students. Students are homogeneously grouped due to the requirements of special education and gifted services. Prior criteria based on academic performance had been set to determine which math class the students would be enrolled in, so randomization was not possible. A second limitation of the study will be that the data is self-reported. Additionally, these results are limited to demographic populations similar to the school in this study. A further limitation of the study is the relatively small sample size, given the population of the Charter School. This school is located in a rural area of South Georgia and the results of this study are generalizable to other populations.

Definition of Terms

Academic self-concept (ASC) – a view of oneself built upon a retrospective evaluation of one's behavior and how other influential persons have perceived that behavior (Marsh et al., 2019). For the purposes of this study, self-concept and identity are considered to be a measure of the same construct.

Adolescence – the time of development (approximately from ages 10-18) when a child passes through puberty to become an adult.

Agency – a person's belief that they can influence the course of events through their individual actions (Bandura, 2005).

Big-fish-little-pond-effect (BFLPE) – Theoretical framework that states students tend to have lower self-concepts when attending schools where the average ability of classmates is high and higher self-concepts when the average ability of classmates is low (Marsh et al., 2008).

Constructivist Grounded Theory (CGT)- a branch of grounded theory research which considers the researcher and participants as co-constructors of the experiences being studied (Charmaz, 2017).

Fixed Mindset- an implicit belief that intelligence is fixed and unchangeable. (Dweck and Leggett, 1988).

Growth Mindset – an implicit belief that personal qualities are malleable and can be developed over time through persistence and effort (Dweck & Leggett, 1988; Dweck, 2006).

Grounded Theory (GT) – a cyclical approach to inductive research that focuses on objectivity of the researcher and uses the constant comparison of collected data to generate new data collection and subsequent data coding. The aim is to generate a theory that is grounded in collected data (Birks & Mills, 2015; Glaser, 2007; Tie et al., 2019).

Identity- "a dynamic view of self, negotiated in a specific social context and informed by past history, events, personal narratives, experiences, routines, and ways of participating…who one is in a given community…both individually and collectively defined" (Bishop, 2012, p. 38). For the purposes of this study, self-concept and identity are considered to be a measure of the same construct.

Mathematical Identity – a perspective of how one views oneself as a "doer of mathematics" (Cobb et al., 2009, p. 44) based on prior interactions in context as well as the perception of others formed through "…a reciprocal and developmental process between oneself and significant others over time" (Bohrnstedt et al., 2020, p. 173). For the purposes of this study, mathematical self-concept and math identity are considered to be a measure of the same construct.

Entity Theory of Intelligence – the belief that intelligence is a fixed and uncontrollable trait (Dweck & Leggett, 1988).

Expectancy value theorem (EVT) – motivational theory which states individuals' expectancies for success, value they place on succeeding, and the cost of effort required play a role in determining the amount of motivational effort expended on the task (Wigfield, 1994).

Implicit Theories – different theories about one's intelligence, either fixed or incremental, that orient one towards either performance or mastery goals (Dweck & Leggett, 1988).

Incremental Theory of Intelligence – the belief that intelligence is an increasable and controllable quality (Dweck & Leggett, 1988).

Low socio-economic status (SES) – Low SES was determined by whether a student was eligible for free or reduced lunch based on family household income. Parents must complete a worksheet at the beginning of each school year disclosing up-to-date family income and the number of people in the household. (Georgia Department of Education School Nutrition Program, 2022).

Math Achievement Level – percentile rankings based on results of Spring 2022 MAP Growth assessment: below average, average, or above average. Students were considered below average if their scores fell into the 1st – 39th percentile, average if they were in the 40th – 60th percentile, and above average if they scored in the 61st percentile or higher.

Self-concept – more general than self-efficacy, self-concept includes feelings of self-worth associated with one's ability (Pajares & Miller, 1994). Self-concept is usually based on evaluation of prior achievements (Marsh et al., 2019). For the purposes of this study, self-concept is considered to be a measure of the same construct as identity.

Self-efficacy – The perception of whether one will be able to accomplish a particular task (Bandura, 1977).

Typical SES- designation given to students who do not qualify for free or reduced lunch based on family household income (Georgia Department of Education School Nutrition Program, 2022).

Significance of the Study

As a new Algebra 1 teacher to this school, the researcher was assigned the responsibility to plan supplemental support instruction for Grade 9 students to reduce gaps in learning due to COVID interruptions in the 2019-2020 and 2020-2021 school years. The results of this study will be considered when scheduling support classes and intervention activities for future rising Algebra 1 students.

In addition, this study can help educators understand how middle school students perceive themselves as mathematical thinkers and doers based on their mathematical self-efficacy and mindset. This study offers insights into perceptions adolescents have of mathematical self-efficacy, growth mindset, and factors that help shape their math identity. Furthermore, this study investigated whether student-level demographic factors influence students' mathematical efficacy, mindset, and math identity. Administrators may use the results when selecting professional development opportunities for teachers to implement more diverse and inclusive learning opportunities. Teachers may use the results of this study to better understand student perceptions of these constructs and then plan lessons which foster positive interactions and increase mathematical self-efficacy, mindset, and math identity among their students.

Summary

In summary, many students do not pursue more advanced mathematics courses necessary for successful STEM careers. There is evidence in existing research that low math efficacy, fixed mindsets, and negative mathematical identity are factors which contribute to low mathematics achievement levels and the unwillingness of students to pursue math further (Blotnicky et al., 2018; Brown et al., 2008; Cribbs et al., 2020; van Aalderen-Smeets & van der Molen, 2018; Verdin et al., 2018; Watt et al., 2017). This grounded theory study investigated the relationships between mathematical self-efficacy, growth mindset, and math identity of students in Grade 7 and Grade 8 in a rural South Georgia charter school. Additionally, this study explored how students' perceptions of mathematical self-efficacy and growth mindset help shape their math identities. This study also determined whether relationships existed between these constructs and the student-level factors of gender, ethnicity, socio-economic status (SES), and math achievement level. Based on the results of this study, school leaders may choose to incorporate research-based strategies into the curriculum that build student self-efficacy and foster a growth mindset thus encouraging a stronger math identity among students. Furthermore, information about the student level factors examined will help teachers better understand their students' perceptions of mathematical self-efficacy, mindset, and math identity and may be used by teachers when planning differentiation strategies for small groups or subgroups. It is possible such interventions will strengthen students' math identities and foster an interest in further pursuing more advanced mathematics courses.

Chapter II: Review of Literature

The science of mathematics is the technical foundation for STEM (Viloria, 2014). Mathematics teaches students to look for patterns, use mathematical concepts to generalize relationships, and draw conclusions from abstract logic and data (Boaler, 2016). When one begins to search for the reasons behind the lagging interest in STEM careers, various factors such as parental education, gender, race, and socio-economic status emerge (Bandura et al., 2001; Blondeau & Germine, 2018; Lent et al., 2018; Volodina & Nagy, 2016). However, one common theme that appears time and again is that many students lack the self-efficacy to believe that they would be successful in the upper-level math classes required to pursue a major in a STEM field (Ahmed, 2018; Blotnicky et al., 2018; Brown et al., 2008; Schoffner et al., 2015). Self-efficacy in specific domains such as mathematics or science may predict whether a person chooses to pursue a career which uses those subjects (Huang et al., 2019; Lent et al., 1994). Additionally, researchers have shown that having a growth mindset has been linked to stronger mathematics self-efficacy (Huang et al., 2019), predicted higher task values in mathematics (Degol et al., 2018), and increased mathematics achievement (Blackwell et al., 2007; Grigg et al., 2018; Lee et al., 2021; Yeager et al., 2019). Furthermore, students with a stronger math identity are more likely to experience higher achievement in mathematics, enrolling in the higher-level math classes that are required to pursue a STEM career (Cribbs et al., 2020; Verdin et al., 2018).

This study will investigate the relationship between the mathematical self-efficacy beliefs, growth mindsets, and the mathematics identity of middle school students. This chapter begins with an explanation of the theoretical framework used to shape this study. The chapter will then present a discussion on the components of self-efficacy and various factors that influence the mathematical self-efficacy beliefs of adolescents. Next, the implicit theories of growth and fixed mindsets will be explored with an emphasis on mathematical mindsets. Then, the chapter will examine existing empirical literature in order to understand environmental and person-input factors that affect the mathematical identity of adolescents. The chapter concludes with a discussion of the relevance of this study to the current setting at the middle school under investigation.

Theoretical Framework

The theory guiding this study was constructivist grounded theory. Grounded theory (GT) was first developed by Glaser and Strauss in the 1960s while examining the experience of terminally ill patients. The researchers used an iterative and cyclical approach to collect data while investigating how patients dealt with the knowledge that they were dying. During this collaboration, Glaser and Strauss developed a constant comparative method to organize and analyze the qualitative data while remaining objective observers throughout the process (Charmaz, 2008; Tie et al., 2019).

A grounded theory study uses a cyclical iterative approach that compares collected data and then uses the results from prior data analysis to drive subsequent waves of data collection (Birks et al., 2019; Lingard et al., 2008). In a true grounded theory study, the researcher remains objective and simply reports themes and observations that emerge from the data. In fact, Glaser (2007) rejected Charmaz's proposition of constructivist grounded theory (CGT) on the grounds that grounded theory can use any existing data and that his oft quoted statement "All is Data" (p. 93) is not applicable to qualitative data analysis (QDA). Glaser (2007) went on to state "Grounded theory is about concepts not accurate descriptions" (p. 96) and that "only people who can conceptualize should do grounded theory" (p. 98). Glaser continued his rebuttal by asserting that Charmaz had not used objective grounded theory to construct data through QDA so much as she had remodeled the grounded theory position, “correcting nothing that needs correcting” (p. 101). Constructivist grounded theory is a different method, not better than grounded theory, due to the loss of objectivity that occurs when interviews are conducted during QDA. From an objectivist grounded theory point of view, the researcher’s impact on the data must be considered another variable that may emerge as relevant upon analysis (Glaser, 2007).

As posited by Charmaz (2008), constructivist grounded theory (CGT) allows researchers to incorporate their personal views as well as those of participants into data collection and analysis in a specific context (Charmaz, 2008, 2017; Mills et al., 2006; Tie et al., 2019). Constructivist grounded theory acknowledges the researcher’s role in data collection and allows for preconceived bias of both the researcher and the participants as part of the data collection process (Charmaz, 2008; Mills et al., 2006). Additionally, CGT considers all collected data an integral part of the research process, not merely an observed product of it as true objective GT would. Charmaz (2008) stated that constructivist grounded theorists attend to *what* and *how* questions within the specific context of their research and understand that participants’ perceptions and voices are an integral part of the qualitative data analysis.

Examples of grounded theory studies in empirical literature that are similar to the current research questions under investigation include an investigation of the relationships between math self-efficacy and competence among math challenged engineering students (Moran-Soto & Benson, 2018), an investigation into pedagogical practices evident in culturally responsive math classrooms (Bonner & Adams, 2012), and an investigation into how preservice primary teachers with math anxiety perceive their mathematical identities (Wilson, 2010).

Self-efficacy and growth mindset theories were also incorporated into the constructivist grounded theory that guided this study. The first theoretical framework considered was the social cognitive theory of self-efficacy (Bandura, 1977). Bandura (1986) defined self-efficacy in his social cognitive theory as a person's judgements of his or her capabilities to attain certain tasks. Bandura believed that a person's self-efficacy develops from four primary sources: mastery experience, vicarious experience, social persuasions, and physiological or emotional states (Bandura, 1977; Lent et al., 1994). Self-efficacy is a dynamic set of beliefs that evolves as one experiences success in different contextual environments. Although self-efficacy is often associated with ability or achievement, self-efficacy does not necessarily predict ability. Likewise, achievement is not necessarily a by-product of self-efficacy. A person with a strong sense of self-efficacy may persist at a difficult task even when uncertain about the outcome.

Growth mindset is an implicit construct that is part of goal orientation theory (Cook & Artino, Jr., 2016). The notion of fixed and growth mindsets was first conceived by Carol Dweck in the 1980s (Dweck, 2006) and has recently moved to the forefront of motivation research. In short, learners either possess a fixed mindset believing that intelligence is static, or a growth mindset believing that intelligence is malleable. Competence and performance beliefs such as efficacy and mindset factor into the development of one's math identity (Cribbs et al., 2015). This study will use a constructivist grounded theory approach (Charmaz, 2008) to determine what effect, if any, self-efficacy and growth mindset have on the formation of the mathematical identities of middle school students.

Self-Efficacy

Self-efficacy is a concept that was first conceived by Albert Bandura (1977) to clarify the psychological processes and motivation behind a person's actions and expected outcomes of behavior. Bandura (1977) theorized that a person's efficacy expectations influence behavior which is then influenced by outcome expectations to produce an outcome. Efficacy expectations, convictions that the behavior can be successfully executed, occur first, followed by outcome expectations, a person's perception that a given behavior will lead to a certain outcome. Self-efficacy not only has a direct influence on choices and behavior, but also influences the amount of effort one expends and how long one will persist when faced with a difficult task (Bandura, 1977).

Bandura (1977) posited four main influences on self-efficacy: prior mastery experience, vicarious experience, verbal/social persuasion, and emotional/physiological state. The most effective way to create a strong sense of self-efficacy is through mastery experience. Once a person has successfully accomplished a task, they are more confident in their ability to succeed at similar tasks in the future. A second way to build self-efficacy is through vicarious experiences. People are encouraged when others that exhibit similar traits are successful. Vicarious experiences are especially important for those that lack prior experiences of their own (Pajares, 1997). Seeing the success of their peers helps students believe that they too can be successful. Social or verbal persuasion is a third way of building a sense of self-efficacy. When a teacher or peer verbally encourages a student, that student is more likely to put forth a larger effort towards accomplishing a challenging task. The fourth way of modifying self-beliefs of efficacy is to reduce stressors that are associated with a task. Physiological states and moods such as anxiety, fatigue, or stress can alter one's belief in one's ability to be successful (Pajares, 1997).

Bandura (1994) defined perceived self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives (p.71)." He stated that self-efficacy beliefs determine not only how people feel and think, but also how people motivate themselves and behave. In other words, self-efficacy can be considered as one's perceptions of one's capability to produce a desired level of performance on a specific task. People with a higher self-efficacy tend to view challenging tasks as things to be mastered instead of things to be avoided. An efficacious outlook builds intrinsic interest and engagement in activities (Bandura, 1994). On the contrary, people with a low sense of self-efficacy tend to dwell on their shortcomings and obstacles, and often give up easily when faced with tribulation. People with a high sense of self-efficacy attribute success to sustained effort instead of ability. People with a less efficacious sense of self attribute failure to lack of ability rather than effort.

A person's self-efficacy can affect major cognitive and motivational processes (Bandura, 1977). A person with a higher self-efficacy will set higher goals and is more likely to persist in pursuing those goals. These individuals are better able to control the cognitive processes that enable one to envision success and plan strategies to achieve that success (Bandura, 1977). Individuals with a lower sense of self-efficacy have difficulty overcoming doubts, exhibit more erratic analytic thinking, and tend to lower their aspirations. Since motivation is a by-product of self-regulatory cognitive processes, a person's motivation is often affected by a person's self-efficacy. Beliefs of ability affect the choices that people make, how much effort they choose to expend on a task, how long they persevere, and how resilient they are in difficult situations (Pajares, 1997).

Efficacy beliefs are also a factor in a person's affective processes such as stress and anxiety (Pajares, 1997). People with a low sense of self-efficacy tend to exhibit higher levels of stress and anxiety in difficult situations. Instead of focusing on their strengths and envisioning what could go right, they focus on their shortcomings and on what could go wrong. In turn, anxiety is increased by a perceived inability to control negative thoughts. The idea that thoughts are unable to be controlled is more distressing than the negative thoughts themselves (Bandura, 1997). These beliefs often produce stress, depression, and a limited view of how to solve a problem. In short, individuals with a higher self-efficacy are better able to anticipate favorable outcomes than those with a lower sense of self-efficacy. One's outcome expectations are a factor of what one believes one can accomplish (Pajares, 1997).

Mathematics Self-Concept

Pajares and Miller (1994) conducted one of the first studies to investigate the relationship between self-efficacy and self-concept on mathematical problem solving. Self-efficacy and self-concept were differentiated through the understanding that self-efficacy was a context-specific judgment of one's capability to perform a certain task while self-concept was more general including beliefs about one's self-worth associated with perceived self-confidence. The researchers (Pajares & Miller, 1994) were the first to use the perspective of social cognitive theory. Path analysis was used to determine whether Bandura's (1986) hypotheses of mathematical self-efficacy had a greater effect on mathematical problem-solving than mathematical self-concept, anxiety, perceived usefulness, prior experience, and gender. The researchers (Pajares & Miller, 1994) also investigated the mediating effect of self-efficacy with the roles of gender and prior experience on performance. The participants in the study were 350 undergraduates in a large university located in the southern United States. Approximately one-third of the participants were education majors; about two-thirds of the participants were women.

During one class period, participants completed separate assessments on self-efficacy, perceived usefulness of math, self-concept, and anxiety. Next, the participants were asked to rate their confidence in solving certain math problems. After these confidence forms were collected, the actual problems were distributed for students to solve. Pajares and Miller (1994) hypothesized that gender would influence all these variables with a mediating relationship between high school mathematics level and college mathematics experience. The researchers also expected math self-efficacy would mediate the prior influence on performance task, math self-concept, math anxiety, and perceived usefulness, which in turn were hypothesized to directly influence performance.

Upon analyzing the effects of the path analysis, Pajares and Miller (1994) reported that high school experience had a significant effect on college math credits ($\beta = .159$, $t = 3.00$, $p < .01$) and math self-efficacy ($\beta = .419$, $t = 9.07$, $p < .001$). The researchers also noted that math self-efficacy had stronger direct effects on perceived usefulness ($\beta = .158$, $t = 2.51$, $p < .01$), math self-concept ($\beta = .466$, $t = 9.65$, $p < .001$), and math problem-solving performance ($\beta = .545$, $t = 10.87$, $p < .001$) than any of the other variables tested. After examining the direct and indirect effects of math self-efficacy and math problem solving performance, the researchers observed high school experience had the strongest effect on math self-efficacy, and math self-efficacy had the strongest effect on math problem-solving performance. When gender differences were examined, men had higher math self-efficacy and performance, while women reported higher anxiety levels. The researchers (Pajares & Miller, 1994) also noted that students tended to overestimate their problem-solving ability, as predicted by social cognitive theory.

The researchers stressed the implication that a person's beliefs about their ability were an important predictor of future performance. The researchers also suggested that early assessments of self-efficacy would aid teachers with insights about student performance and that schools could plan interventions when necessary. Pajares and Miller (1994) also noted that ability was not used as a predictor variable in this study and suggested that future research include an ability measure as well as investigating the role that prior knowledge and problem-solving strategies may have on self-efficacy judgments.

In an effort to better understand the subtle differences between self-efficacy and self-concept, Marsh et al. (2019) examined the jingle-jangle fallacy of whether these two similar sounding concepts may in fact measure different constructs. The researchers used prior literature to distinguish between self-concept, self-efficacy, and outcome expectations. Marsh et al. understood self-concept to embody a persons' self-perceptions that have been formed through experiences with and interpretations of his or her environment relying heavily on the concept of evaluating one's actions and comparing results to others. In short, self-concept is built upon a retrospective evaluation of one's behavior and how other influential persons have perceived that behavior. In contrast, self-efficacy was defined as a distinction between the motivation to perform a particular behavior and perceptions of one's capability to do so (Bandura, 1994). Marsh et al. (2019) focused on three key characteristics that distinguished self-efficacy from self-concept. Self-efficacy is descriptive, prospective, and subject/task specific, while self-concept is evaluative, retrospective, and generalizable to other content areas.

In a longitudinal study of over three thousand German middle school students Marsh et al. (2019) used gender, socio-economic status (SES), fourth grade math achievement, fourth grade reading achievement, standardized tests, and average school achievement as predictor variables. The outcome variables used were eighth grade math and reading scores, standardized math test scores in ninth grade, and math aspiration in ninth grade. Data on math self-efficacy, math outcome expectations, and math self-concept were collected during fifth through eighth grade. Test-related math self-efficacy was collected in fifth and sixth grades. Functional math self-efficacy, a domain-based measure that covers broader content than a specific task, was collected during sixth, seventh, and eighth grades. Data were from a secondary analysis obtained from the Project for the Analysis of Learning and Achievement in Mathematics (PALMA), a large-scale longitudinal study of math achievement and related beliefs in Bavaria. Participants were selected from a random stratified sample of schools, the same process that is used for PISA selection. The researchers used multi trait-multi time point (MTMTP) to quantitatively analyze the factor structures of the data.

In all, the researchers (Marsh et al., 2019) investigated four hypotheses to determine the correlations between five math self-belief constructs in the categories of mathematics self-concept and mathematics self-efficacy. Mathematics self-concept, outcome expectancy, and generalized mathematics self-efficacy were considered self-concept-like constructs, while test-related mathematics self-efficacy and functional mathematics self-efficacy were considered self-efficacy-like constructs. The researchers hypothesized: (a) the three self-concept-like factors would correlate strongly enough so as to be indistinguishable from one another; (b) frame of reference effects (social and dimensional comparison effects) self-efficacy items would be descriptive, while self-concept items would be both descriptive and evaluative; (c) self-efficacy would be future-oriented, while self-concept would be based on past accomplishments; (d) the three self-concept-like factors could be represented by a single higher order factor of math self-concept.

Upon analysis, Marsh et al. (2019) confirmed the first hypothesis that the belief constructs of generalized self-efficacy, outcome expectations, and self-concept were practically indistinguishable from one another with correlations greater than 0.9. In regard to the frame of reference effects of the second hypothesis, the researchers found that all paths had a strong negative correlation for self-concept-like factors and reported a non-significant effect for all self-efficacy-like factors but one, which was significantly positive. There was also strong evidence that self-concept was more correlated with math post-test outcomes than were the self-efficacy measures. These results supported the third hypothesis that self-efficacy is more of a prospective construct, while self-concept is based on past experience. Taken together, the researchers interpreted the results to support the fourth hypothesis that the three self-concept-like factors could be combined into a single higher order factor. In other words, generalized math self-efficacy, math self-concept, and outcome expectations are a measure of the same construct: math identity. Additionally, the researchers concluded that use of generalized, non-subject/task specific self-efficacy was not a true measure of self-efficacy in the purest form of Bandura's widely accepted definition.

Limitations of this study included the German population of students. These results may not be generalizable to other populations in other countries. The researchers also noted that future researchers may wish to use other instruments to measure the relationship between test-related self-efficacy, functional self-efficacy, generalized self-efficacy, academic self-concept, and outcome expectations.

Mathematics Self-Efficacy in Middle School

While mastery experience has been shown to be the strongest predictor of mathematics self-efficacy (Butz & Usher, 2015; Pajares & Miller, 1994; Usher, 2009; Usher, Ford, et al., 2019; Usher & Pajares, 2006), the salience of verbal/social persuasion and vicarious experiences should not be overlooked for adolescents. Usher and Pajares (2006) investigated how the four theorized sources of self-efficacy: mastery experience, vicarious experience, social persuasions, and emotional states (Bandura, 1977), affected the academic and self-regulatory beliefs of sixth grade students entering middle school. The participants in this study were ability grouped by reading level: above, on, or below, and were enrolled in a public middle school in the Southeastern United States. The school was considered middle class, with only 17% of students qualifying for free or reduced lunch. Sixty percent of students were White, 20% were Black, 6% were Hispanic, and 14% were Asian or another ethnicity. The researchers only considered White and Black students when comparing results of ethnicity, the two largest racial groups at the school.

The researchers (Usher & Pajares, 2006) used ANOVA tests to compare data from three instruments to examine sources of self-efficacy, academic self-efficacy, and self-efficacy for self-regulation by gender, ethnicity, and reading ability level. The data were collected during one class period, where students were homogeneously grouped by reading level. Each of the sources of self-efficacy correlated with each other, with academic self-efficacy, with self-efficacy for self-regulation, and with the measure of achievement. When the results were examined by gender, the researchers (Usher & Pajares, 2006) concluded that for females, social persuasions had a stronger effect on academic self-efficacy and self-efficacy for self-regulation than mastery experience. Social persuasions did not predict the academic self-efficacy of males. Vicarious experience predicted self-efficacy and self-efficacy for self-regulation for males, but mastery experience accounted for the greatest variance.

When the researchers (Usher & Pajares, 2006) examined the results by reading level, they observed that mastery experience predicted the academic self-efficacy and self-efficacy for self-regulation for above-level and on-level readers. Social persuasions were also a predictor for on-level students. Physiological state predicted self-efficacy and self-efficacy for self-regulation for above-level students but had a negative correlation for students that were below-level who reported higher anxiety. The students that were grouped into the lower-level class also reported fewer mastery and vicarious experiences. Upon examining the results for ethnicity, the researchers reported mastery experience and physiological state predicted self-efficacy and self-efficacy for self-regulation for White students. Vicarious experience and social persuasions predicted self-efficacy for self-regulation for White students. Mastery experience and social persuasions predicted academic self-efficacy beliefs of Black students; mastery experience also predicted self-efficacy for self-regulation for these students.

The major take-away from this study (Usher & Pajares, 2006) was the importance of social persuasive messages for females and Black students. The researchers suggested that future investigators explore how students receive, interpret, and evaluate these messages to affect their self-efficacy beliefs. The researchers also noted the lack of generalizability of this study to other content areas as Bandura's (1977) sources of self-efficacy are best utilized in a domain-specific context.

Usher (2009) expanded on the work of Usher and Pajares (2006) by conducting a qualitative study that explored the sources of mathematics self-efficacy among middle school students. Participants were selected from a group of students that had recently taken part in a larger quantitative study. The researcher (Usher, 2009) selected students from each of four subgroups: African American girls, African American boys, White girls, and White boys. Two students were selected from each group, one ranked with high math self-efficacy, and one ranked with low math self-efficacy. A series of semi-structured interviews were conducted with the students, their parents, and their teachers. The interviews were designed to explore the following queries: How do students with high or low math self-efficacy interpret and internalize self-efficacy information and does this differ based on gender or ethnicity? What insights could parents and teachers offer about the sources of the students' math self-efficacy beliefs? What other factors (self-regulated learning) might be related to the students' self-efficacy beliefs?

Usher (2009) noted that themes resulting from these interviews supported the work of Usher & Pajares (2006) in that students with high self-efficacy possessed mastery experiences that influenced their self-esteem. For the boys with high self-efficacy, math had always come easily to them, and they believed themselves to be "math people" gifted with an innate ability to perform well in mathematics. One of the girls with high self-efficacy had failed the previous year's math class and was placed in Pre-Algebra in 8th grade. However, she performed so well that her teacher suggested she move up to algebra. The researcher (Usher, 2009) noted that the boys possessed a fixed view of their mathematics ability, analogous to Dweck's fixed mindset, while this particular girl possessed a growth (mindset) view in which she believed that her ability was due to factors under her control such as effort and hard work. The other high self-efficacy girl commented on her teacher's way of presenting lessons in small incremental steps that allowed her to experience mastery of the content a little at a time. The students with low math self-efficacy did not have positive mastery experience to pull from and had struggled with math most of their lives. They seemed to interpret the amount of effort required as a sign of their inefficacy. Two of them were struggling in algebra and transferred to a lower math class where they were able to experience some success. One of the girls with a low efficacy ranking chose to remain in the algebra class, even though she was struggling. The fourth student experienced little success, even though he was already in the lowest math class.

Additionally, the students with high efficacy drew from the vicarious experiences of their parents, peers, and selves. Their parents pushed them to compete and encouraged them to challenge their abilities. They enjoyed doing better than their peers in class and had internal motivation and dialogue encouraging them to succeed. The students with low self-efficacy mentioned their parents' shortcomings in math. They did not have positive mathematical role models at home and tended to compare themselves to their better performing peers and focus on their shortcomings. Students with high self-efficacy also reported more incidents of receiving encouraging messages through social persuasion than the students with low self-efficacy. Students with low self-efficacy rarely received messages of encouragement and commented on how they received little or no positive feedback. When reporting on the physiological states exhibited by the students, the researcher (Usher, 2009) noted that students with high self-efficacy felt comfortable in math class, showing little anxiety when presented with a new topic. Conversely, the students with low self-efficacy reported feelings of apathy, stress, depression, and even some anger in math class. While all students experienced some form of anxiety during math class, only the students with low self-esteem interpreted this as a lack of competence. Students with high self-esteem used the cognitive dissonance as a challenge to persevere in learning new concepts. Usher (2009) also reported that students with high self-efficacy had an easier time self-regulating their learning.

As in prior studies (Pajares & Miller, 1994; Usher & Pajares, 2006), mastery experience was once again found to be a major factor in math self-efficacy. Usher (2009) suggested that teachers create opportunities for students to master authentic experiences, no matter how small, to build self-efficacy. Additionally, the researcher reported how students with high self-efficacy were able to use their physiological state in ways to self-motivate and positively influence their success, while students with low self-efficacy seemed unable to overcome the feelings of anxiety and distress. These findings led Usher (2009) to conclude that internal dialogues students have with themselves reinforced their beliefs about their mathematics capabilities. These dialogues were influenced not only by internal messages, but also by parents, teachers, and existing learning structures over which students had no control. Factors such as course placement sent messages to the students about their perceived ability. As a result, the Usher (2009) suggested that adults be more aware of the messages they send to students about their ability level. For example, praising a student for having the good fortune to be born with a natural math ability suggests that ability is a fixed trait and can have motivational consequences when students encounter struggle or failure.

Gender differences were also observed in how students interpreted sources of self-efficacy. Females placed more emphasis on vicarious experience and social persuasions whereas males placed more value on personal mastery experience. Additionally, the researcher reported that the adults in the study tended to attribute girls' success in mathematics to hard work rather than ability and expressed surprise at how the boys could remain successful despite poor work habits. Furthermore, Usher (2009) reported that social persuasions tended to influence the self-efficacy of African American students.

Butz and Usher (2015) expanded on prior research (Usher, 2009) to investigate the factors that affected upper-elementary and middle school students' self-efficacy in the domains of reading and math. Approximately 2500 students from seven elementary and middle schools in a southeastern city completed online surveys. The surveys included self-efficacy rating scales as well as open-ended questions such as "what makes you feel more confident about yourself in reading/math?" The researchers used exploratory factor analysis to analyze the rating scales and coded the open-ended responses for emerging themes. The data were then further organized into groups based on demographic factors such as grade-level, gender, and level of self-efficacy.

Students whose self-efficacy levels were greater or less than one standard deviation from the sample mean were coded as high or low, respectively.

As expected, mastery experience was reported as the most powerful predictor of math self-efficacy (Butz & Usher, 2015). However, the researchers observed significantly more comments from girls regarding social persuasions (21.5% compared to 15.91%) and vicarious experiences-social comparison (6.03% compared to 4.78%) than boys. The researchers also recorded that more boys (5.33% compared to 3.19%) said “nothing” made them feel more confident, though it was unclear as to whether this response indicated that the boys could not recall a specific incident or whether there was simply not a way for them to feel more confident in math.

When the researchers compared codes from students with low self-efficacy to high self-efficacy, they noted mastery experience was significantly more common among students with high self-efficacy (46.09%) than low self-efficacy (40.64%). Students with high self-efficacy also reported more vicarious experiences (9.18%) than students with low self-efficacy (2.46%). Course placement was also observed to be a significant factor for students with high self-efficacy (4.49%) when compared to students with low self-efficacy (1.725%). In response to an item that queried “what makes you feel confident in math?” the researchers noted that “nothing” was reported twelve times more often among students with low self-efficacy (12.81%) than high self-efficacy (1.76%). The researchers interpreted these responses to mean that students who stated “nothing” could make them feel more confident were in fact thinking of what made them feel less confident. They were either not interested in the topic or didn’t see the relevance, so there was no point in trying to be more efficacious.

Due to much of the existing self-efficacy research being conducted in urban areas, Usher, Ford, et al. (2019) attempted to address some of these limitations. Usher, Ford, et al. (2019) investigated sources of math and science self-efficacy in a rural Appalachian community. The researchers noted that much existing research took place in urban or suburban areas with post-secondary students. Often students in rural areas have closer community ties, and many students live in two-parent households, unlike many urban students. The researchers used a convergent mixed methods design in a high poverty area of a Central Appalachian region. Participants were 673 students attending one middle school and one high school. All students qualified for free/reduced lunch and 98% were White. Students were administered surveys during their math and science classes over a period of three years. The first survey was administered in spring and collected data on the sources of self-efficacy: mastery experience, vicarious experience, social persuasions, and physiological states. The second survey was administered in the fall of the next school year and measured student self-efficacy. Qualitative data were obtained by student responses to open-ended questions in October and January of the next year.

Usher, Ford, et al. (2019) used the initial surveys to determine if predictive relationships correlated with actual self-efficacy. The researchers expected social persuasion to be predictive of self-efficacy as in prior studies (Usher & Pajares, 2009) due to the close-knit nature of the community, but this was not observed. Mastery experience ($\beta = 0.402$, $p < .05$) and physiological state ($\beta = -0.214$, p > .01) were significant predictors of math self-efficacy. Girls reported more vicarious experiences in math than did boys which supported prior research (Butz & Usher, 2015; Usher, 2009). After coding and analyzing the open-ended responses, the researchers reported that direct experiences of mastery were referenced more often in math (35.84%) than in science (26.59%) and that social comparison tended to lower students' math confidence. When the researchers compared data by gender, they reported that girls associated their confidence with social experiences and felt more confident when help was available, confirming the previous research of Butz and Usher (2015). Additionally, girls also tended to relate their level of confidence to their ability level, stating a lack of ability lowered their confidence. On the contrary, boys tended to report feeling confident due to a presence of ability. Similar to the results of Butz and Usher (2015), boys tended to report "nothing" made them feel more self-confident with comments such as "If I can do it, then I can do it; if I can't, then I can't." The researchers (Usher, Ford, et al., 2019) suggested these gender differences may be due to the boys holding a fixed view of their ability level, an observation that was also noted by Usher (2009).

Tracking

When students are grouped into math classes by their ability level, it is impossible to avoid social comparisons, such as the "smart" class or the "dumb" class. Tracking, the process of homogeneously grouping students of similar ability together for academic classes, has been shown to have consequences on students' social identity, academic identity, self-efficacy, motivational beliefs, and long-term self-concept (Boaler & Selling, 2017; Dweck, 2006; Marsh & Seaton, 2015; Legette, 2020; Legette & Costes, 2021a; Legette & Costes, 2021b; Tereshchenko et al., 2019). Many students' first experience with tracking is in middle school math. Legette and Kurtz-Costes (2021a) investigated how accelerated tracking affected the math self-concept of Grade 6 students enrolled in honors and regular math in a Southeastern school district. The researchers controlled for prior achievement and hypothesized that students in honors classes would report increased school belonging and that academic identity would mediate the relationship between track placement and school belonging. Students completed surveys in September (Time 1) and May (Time 2) of their sixth-grade year to provide data on their perception of school belonging, academic identity, academic grades, and demographics. The researchers analyzed the data using multiple linear regressions to estimate the associations between the variables. The researchers reported that students' track placement predicted perception of school belonging in May ($\beta = .14$, $p < .05$, and students in honors classes felt a stronger sense of belonging than students on the regular track. Additionally, when Time 1 school belonging was controlled, academic identity predicted Time 2 belonging ($\beta = .27$, $p < .001$). These results led the researchers (Legette & Kurtz-Costes, 2021a) to conclude that tracking shapes students' academic identity which in turn affected their sense of school belonging.

In a different data set collected from the same study, Legette and Kurtz-Costes (2021b) sought to determine whether students in honors math would report a higher self-concept than students in regular math and how students in each math track would report change in self-concept over the course of the school year. Although self-concept and self-efficacy are different constructs (Pajares & Miller, 1994; Marsh et al., 2019), they are practically indistinguishable from one another. Legette and Kurtz-Costes also investigated how students' perceptions of their teachers would predict their math self-concept. ANCOVA and multiple linear regressions were used to investigate correlations and differences between the means. After analysis of the data, the researchers found that students in honors classes reported significantly higher self-concepts over the course of the year than students in regular classes. Additionally, student perceptions of teacher expectations were found to be a predictor of increased self-concept. Taken together, these results led the researchers to conclude that math self-concept is influenced by academic track placement and positive expectations from teachers.

The effect of tracking on students' self-concept is evident in the big-fish-little-pond effect (BFLPE) theory. Herbert Marsh first reported in 1984 how a students' comparison of their ability to that of their peers had an influence on their self-concept (Marsh et al., 2008). Big-fish-little-pond-effect theorizes that the academic self-concept of high-ability students will be lower when they are grouped with students whose average ability is high, and the academic self-concept of lower-ability students will be higher when grouped with students where average ability is low (Herrmann et al, 2016; Marsh & Seaton, 2015). At the advent of middle school, many gifted and high-achieving students are homogeneously grouped into math classes for purposes of content acceleration. According to BFLPE, this ability grouping can inhibit the academic self-concept of these students. The gifted/high achievers become little fish in a big pond, where it is harder for one's achievement to rise above the norm since the norm is already above average. In a study of 44 gifted students ranging from Grades 5-11 participating in a summer program, the students reported having lower self-esteem when grouped homogeneously due to their lower class rank (Adams-Byers et al., 2004). In contrast, these students reported the more relaxed atmosphere of heterogeneous grouping as an advantage, even though they viewed the slower pacing and less-challenging coursework as disadvantages. Big-fish-little-pond effect is a pan-human phenomenon and has been documented across countries and cultures with international TIMMS and PISA data (Marsh & Seaton, 2015).

Homogeneous grouping may send a message that some students are better than others due to their placement in the "smart" class. Students may also come to feel that they are better than their peers due to their enrollment in advanced content classes belonging to a high-ability group. Herrmann et al. (2016) investigated the strength of the "assimilation effect," the idea that simply belonging to a high-ability group may increase student confidence and perceptions of ability. The researchers (Herrmann et al., 2016) were interested to know if assimilation effects would be strong enough to offset the insecurities suggested by BFLPE. The researchers investigated the math and verbal academic self-concepts (ASC) of 1,330 Grade 5 German students in regular and gifted ability classes and controlled for prior ASC in both groups. Students completed surveys to provide data on ASC in the math and verbal domains, as well as completing a commonly used German intelligence assessment. After analysis of this quantitative data, the researchers reported the assimilation effect compensated for negative BFLPE for students' math ASC and had no effect on ASC in the verbal domain. Thus, Herrmann et al. (2016) concluded that BFLPE had no negative effect on ASC for these high-ability students.

But what about average-ability and low-ability students? Tereshchenko et al. (2019) reported on qualitative data collected as part of "Best Practice in Grouping Students," an on-going large-scale study in England to explore students' perceptions and experiences with different grouping settings. In order to better understand student views on mixed-ability classes, the researchers collected interview and focus group data for 85 Year 7 students representing a variety of ability levels and socio-economic backgrounds. Three-quarters (76%) of the lower attaining students held positive views of mixed groups, 14% held a negative view and 10% had mixed views. Over half (51%) of high attaining students had positive views of mixed groupings; 23% held negative views and 26% held mixed views. However, the views of middle attaining students were split, with 41% holding a positive view, 45% holding a negative view, and 4% having mixed views of heterogeneous groupings. High attaining students valued the social inclusivity of the mixed grouping and found the mixed classes interesting due to diversity that is often not present in homogeneous groups. Although many high achieving students recognized the benefits of mixed groupings for lower ability students, several cited behavioral reasons and lack of challenges as reasons for their preference of homogeneous groupings.

Likewise, lower achieving students acknowledged the opportunities that belonging to a mixed ability class offered. Academic opportunities as well as social opportunities existed in the mixed classes that would not have been present in same-ability classes. Collaboration in math classes allowed the struggling students opportunities to shine due to all students bringing different abilities. The researchers (Tereshchenko et al., 2016) also noted the ability to help others was a perceived benefit for *all* students, not just high-achieving students. The collaboration and community-learning atmosphere influenced and empowered the learner identities of all students in the mixed ability classes. Low-achievers tended to recognize this and were grateful for opportunities to work with their higher-ability peers, although a small number were reluctant to work with high-achievers due to pre-conceived learner identities that had been formed in primary school due to homogeneously grouped classes.

Middle attainers had mixed reactions to the mixed-ability groups. While they recognized how working with other students encouraged equitable opportunities for all students, many felt frustrated due to work they felt was "above their level" or the "show-off" attitudes of high attainers in their groups. A few even grew irritated at low attainers for asking questions and slowing down progress and attempted to distance themselves from these students. These qualitative data led the researchers to conclude that attitudes towards mixed groupings are related to prior ability levels. As expected, low-attaining students appreciated the mixed groupings, with high- and middle-attainers understanding the benefits of the practice as well.

Self-Efficacy Summary

In summary, self-efficacy grows out of mastery experiences, verbal/social persuasions, vicarious experiences, and social-emotional states. Self-efficacy is a dynamic construct that not only plays a role in how confident one is that one will be successful when performing a given task, but also influences motivation and can be predictive of achievement (Bandura et al., 2001). Self-efficacy is also a descriptive construct, tending to be prospective and subject/task specific (Marsh et al., 2019). Students with a higher self-efficacy tend to have more mastery experiences and positive interactions with teachers and peers while students with lower self-efficacy have fewer positive experiences to pull from and often receive less encouragement (Usher, 2009). Minorities tend to have fewer mastery experiences and therefore base their self-efficacy on vicarious experiences and social persuasions (Usher, 2009; Usher & Pajares, 2006). Structural practices such as tracking limit the positive interactions for students in lower ability classes and can affect the self-efficacy of students in regular and honors classes (Boaler & Selling, 2017; Dweck, 2006; Marsh & Seaton, 2015; Legette, 2020; Legette & Costes, 2021a; Legette & Costes, 2021b; Tereshchenko et al., 2019). Female self-efficacy was based more on social persuasion and those with high self-efficacy tended to credit their ability to hard work while males with high self-efficacy held a more fixed view believing that they were math people (Butz & Usher, 2015; Usher, 2009; Usher, Ford, et al., 2019). These studies suggest that females' math self-efficacy is based on more of a growth mindset while males tend to subscribe to a fixed mindset.

Growth Mindset

Growth mindset is an implicit theory which subscribes to the belief that intelligence is malleable (Dweck & Leggett, 1988). The concept grew out of the social-cognitive theory of motivation and personality as it seeks to identify specific mediators of behavior. The idea originated during a conversation that Carol Dweck was having with one of her doctoral students, Mary Bandura, the daughter of Albert Bandura (Dweck, 2006, 2017). The two were discussing why some students struggled to prove their ability, while others persevered to improve. Some students avoided challenges and gave up when faced with difficulty, while others with equal ability sought challenges and persisted in the face of adversity. Efforts to explain this difference led to a discussion of the types of goals that individuals set for themselves. Dweck and Leggett (1988) identified two types of goals: performance goals and learning goals. These two theories are manifestations of two fundamentally different ways of representing one's self-concept. Those with an entity theory for their self-concept hold fast to performance goals and believe that traits are fixed and can be measured and evaluated. When they are unable to meet these goals, their self-esteem suffers, and they feel inadequate. However, individuals with an incremental theory of their self-concept believe they possess qualities that are malleable and will evolve in time through effort and persistence (Dweck & Leggett, 1988). Self-esteem for these individuals is established and fostered through the attainment of learning goals.

Students with a fixed or entity mindset focus on performance goals to prove their ability and often become frustrated when they are unable to reach those goals. These students believe their intelligence is static and unchangeable. They subscribe to the idea that you are either smart or you are not. They tend to view struggle and difficulties as failures that are due to their low ability (Dweck & Leggett, 1988). On the other hand, students with a growth or incremental mindset view struggles as opportunities for learning and challenges to be mastered. They can focus on setting learning goals and persist in attempting to master new knowledge and skills. These students view failure as an opportunity to learn and put forth increased effort to reach their goals (Cook & Artino, Jr., 2016; Dweck, 2006, 2017; Dweck & Leggett, 1988; Grant & Dweck, 2003).

Different types of people seem to subscribe to each type of goal. Dweck posited that one's mindset is an implicit part of one's personality (Dweck, 2006, 2017; Dweck & Leggett, 1988). However, recent brain research indicates neurological evidence to support the importance of growth mindset when making mistakes. Ng (2018) found that students that exhibited a growth mindset showed heightened awareness and attention to mistakes when monitored on electroencephalogram (EEG). Schroder et al. (2017) conducted a neurological study of school-aged children to examine the relationship between growth mindset and the neural correlates of error processing. While the researchers observed that growth mindset was positively correlated with age, a relationship between mindset and error processing was also observed. Children exhibiting growth mindsets performed with higher accuracy after making mistakes (Schroder et al., 2017). Functional magnetic resonance imaging (fMRI) has also been used to show that growth mindset is associated with areas of the brain used during error monitoring and regulating strategies (Myers et al., 2017).

Recent years have seen a surge of mindset research in respect to academic motivation and achievement goals (Binning et al., 2019; Blackwell et. al., 2007; Priess-Groben & Hyde, 2017; Yeager & Dweck, 2012; Yeager et al., 2019) and the role of implicit theories in adolescents (Dweck, 2017; Romero et al., 2014; King, 2020). Research is also emerging that suggests growth mindset interventions may reduce math anxiety (Huang et al., 2019), increase math self-efficacy (Boaler, 2013a, 2016; Bostwick et al., 2017; Huang et al., 2019; Hwang et al., 2016), and increase achievement (Yeager et al., 2019).

Mindsets and Academic Achievement

Bostwick et al. (2017) integrated growth mindset along with self-based growth goals and task-based growth goals to comprise an attribute called growth orientation factor. Self-based growth goals focus on personal improvement, or personal best, as their target. They are continually modified and specific to encourage self-improvement. Task-based growth goals use task criteria to focus on future development and improvement. The researchers (Bostwick et al., 2017) recognized these three constructs, taken together, may be an indicator of one's growth orientation and be associated with academic outcomes. For the purpose of the study, academic outcomes were defined as academic engagement and achievement in the area of mathematics. The participants included 4,411 Australian students in Grades 7-9 from 19 schools. Schools were located in both urban and rural areas and included Catholic, single-sex, and coed schools. Participants were slightly above average in SES with an average age of 13.5 years. Students were administered surveys which included items to measure their growth mindset, self-based growth goals, and task-based growth goals. Engagement was measured with three self-reported items and academic achievement was measured with a 10-item numeracy quiz. Bostwick et al. (2017) used student-level information such as grade, gender, background language, SES, and prior numeracy level as control variables.

The researchers (Bostwick et al., 2017) used confirmatory factor analysis (CFA) and structural equation modeling (SEM) to investigate the relationships between the tested variables. The researchers confirmed the theory that growth mindset, self-based growth goals, and task-based growth goals proved to be a good fit for student growth orientation with $p < .001$ for all variables. The hypotheses that students' growth orientation would predict academic engagement ($\beta = .69$) and achievement ($\beta = .20$) were also confirmed after controlling for the student-level factors of grade, gender, native language, SES, and prior numeracy. Additionally, the researchers noted that male students reported greater engagement ($\beta = .12$) and that female students reported higher achievement ($\beta = -.08$). A positive association between SES and achievement ($\beta = .10$) was observed as well as positive associations between prior numeracy and growth orientation ($\beta = .25$), engagement ($\beta = .20$), and achievement ($\beta = .38$). Although the data collected for this study consisted of only one time-point, the demographic diversity of the participants led the researchers to conclude that these results are generalizable to other populations. In summary, Bostwick et al. concluded students' growth orientation was positively associated with both academic engagement and achievement in mathematics.

Yeager et al. (2019) reported the results of the *National Study of Learning Mindsets* (NSLM), which investigated the effect of a short, online, growth mindset intervention in a nationally representative sample of American high schools. A professional research company was contracted to select high schools that would generalize to the entire population of Grade 9 students attending public schools in the United States. Sixty-five high schools participated in the study; data were collected from a stratified random sample of 12,490 ninth grade students during the 2015-2016 school year. Students participated in either the mindset intervention or the control condition. The interactive sessions were administered online about four weeks apart as early in the school year as possible (Yeager et al., 2019). Although the content of both sessions was similar, the control condition focused on brain function while the growth mindset intervention included information on malleable intelligence that aimed to reduce the negative effort beliefs that many students possess. The mindset intervention informed students of the concept of growth mindset, then described ways that effort and strategy could help students alter their behaviors to develop abilities and reach their goals.

The NSLM used self-reported mindset scales, GPAs, and course enrollment in the tenth grade to investigate the effect of the growth mindset intervention on academic achievement (Yeager et al., 2020). Of the 12,490 students that participated in the study, 6,320 were classified as lower-achieving relative to their peers due to GPAs that were lower than the school median. The growth mindset intervention significantly reduced the fixed mindset beliefs among these students, who earned higher GPAs in their core classes at the end of ninth grade relative to comparable peers in the control condition. Additionally, students who experienced the intervention saw an increase in their math and science GPAs. The researchers also reported that GPAs were larger in schools with peer norms that supported the treatment message. In fact, even the high-achieving schools which did not exhibit as great of an effect showed meaningful increases in the GPAs of their low-achieving students that received the intervention (Yeager et al., 2020). The researchers also reported that students who received the growth mindset intervention were more likely to enroll in advanced math courses in tenth grade.

Growth mindsets have also been shown to temper the effect of poverty on academic achievement. Claro et al. (2016) conducted a study using a nationwide sample of Chilean high school students to determine whether growth mindsets were predictors of academic achievement. The researchers used existing data from the Chilean Department of Education that were collected in 2012 from students in Grade 10. The data not only included student demographics and standardized test scores, but the 2012 student survey also collected information regarding students' mindsets about the malleability of intelligence. Analyses included all students who had answered at least one mindset question and had taken the math or language standardized test. The data collected represented about 75% of all 10th graders in Chile with 98% of all public schools represented. Pearson correlations were used to determine the relationships between key variables and standardized test scores. The researchers observed strong correlations between poverty index (r = -.412 for language and r = -.520 for mathematics) and students that possessed a growth mindset (r = .427 for language and r = .513 for mathematics).

Next, the researchers (Claro et al., 2016) used hierarchical linear regression models to investigate the robustness and generalizability of these results. The researchers concluded that students with growth mindsets achieved at higher levels than those with a fixed mindset regardless of socioeconomic status ($\beta = 0.203$, $SE = 0.002$, $p < .001$ for language and $\beta = 0.138$, $SE = 0.002$, $p < .001$ for mathematics). The researchers also tested for reverse causation, to determine if success in school fostered a growth mindset. This relationship remained significant when controlling for student and parental expectations and whether students liked each subject and thought it was important ($\beta = 0.171$, $p < .001$ for language and $\beta = 0.119$, $p < .001$ for mathematics). Claro et al. (2016) also reported that students from lowest income households were twice as likely to endorse a fixed mindset than students from higher-income families and schools. However, students with a growth mindset from the lowest 10% of income-level had comparable test scores with fixed mindset students from the upper (80%) of income-level. In fact, at every socioeconomic level, students possessing a growth mindset outperformed their fixed mindset peers. Based on these results, the researchers suggested that mindset may be an even more important predictor of academic success than socioeconomic level. Claro et al. (2016) suggested that psychological factors such as implicit theories may reveal ways to support students facing inequitable structural barriers due to their socioeconomic status.

However, these results were not supported in a subsequent study by Destin et al., (2019). Using a representative sample of approximately 7,500 Grades 8 and 9 students from schools across the United States, the researchers sought to understand whether there was a link between SES and mindset. The researchers also investigated how SES and mindset were associated with achievement and the extent to which differences in mindset could explain the achievement gap. The researchers used existing data from the National Study of Learning Mindsets (NSLM; Yeager et al., 2019) and selected students who were part of the control group that did not receive the mindset program. The primary measure of SES was maternal education (4,828 students), with free/reduced lunch status (2,872 students) used as a secondary measure. Mindset was determined with a two-item scale and student achievement was measured using course GPAs for core academic classes.

Destin et al. (2019) used correlational analyses to determine that students with a higher SES were less likely to have a fixed mindset. These results were similar when controlling for gender and ethnicity. However, although the researchers found that both SES and mindset were independent predictors of academic achievement, with SES being the stronger predictor, the data did not support an interaction between SES and mindset in predicting achievement, even when controlling for gender and ethnicity. In fact, the researchers reported a lesser fixed mindset was associated with a higher GPA for both high SES and low SES students in the population sample. Next, the researchers used structural equation modeling to determine the extent to which mindset explained the relationship between SES and achievement. When prior achievement was considered, only 2% of the difference in achievement of high SES students to low SES students could be explained by mindset. These results were contradictory to the work of Claro et al. (2016) and led the researchers to claim that mindset alone is insufficient to explain the differences in achievement based on SES. As a result, the researchers suggested that other unmeasurable aspects such as psychological factors, structural inequities, or different educational opportunities contribute more to the achievement gap than fixed mindset.

Mathematical Mindsets

Fostering a growth mindset in mathematics allows students to make mistakes, learn from those mistakes, and feel confident when presented with more challenging problems. Boaler (2016) stressed the importance of mistakes in mathematical learning. It is during the periods of struggle that the brain is able to create new synapses and strengthen connections that have previously been made (Moser et al. 2011). Boaler (2016) suggested that teachers incorporate mindset strategies into instruction, presenting mathematical ideas in such a way as to encourage questions and curiosity from students rather than introducing concepts that require procedures and algorithms to find an answer.

Daly et al. (2019) took the neurological research a step further to investigate the effect that mathematical mindset (MM) instruction (Boaler, 2016) has on student motivation. Mathematical mindset problems are structured as open-ended problems that allow students to offer multiple representations and pathways to solutions. The problem is posed, often with a visual component, prior to teaching the method, and students are encouraged to ask questions, be skeptical, and offer justifications for their reasoning (Boaler, 2016; Daly et al., 2019). Twenty-three undergraduate students, 13 of whom were female, were recruited via email from the University of Essex to participate in this study. Emails were sent to students enrolled in the first or second year of study in the Department of Mathematical Sciences. Each participant was presented with ten math problems in either a traditional format or an MM format. Prior to being presented with each problem and again after solving each problem, participants reported their motivation levels using a 5-point Likert scale. Problems were presented in random order, with each participant receiving either the traditional or MM version. Each participant was presented with five problems of each style. The study was blind in that participants had no knowledge of MM theory before the experiment; nor did the researchers inform the participants of MM theory during the experiment. Daly et al. (2019) found that participants reported significantly more motivation to solve the problems that were presented in MM format. EEG evidence also indicated greater prefrontal asymmetry when participants were presented with MM format problems. This EEG result indicated that participants were experiencing greater levels of motivation, even though they had not been made aware of the MM theory being tested. The researchers also reported no significant difference between student ability and motivation. Taken together, these results led Daly et al. (2019) to conclude that presenting math problems in an MM format led to an increase in motivation to solve the problems.

These findings were somewhat contradictory to prior results from Priess-Groben and Hyde (2017) which investigated the long-term effect that implicit theories, expectancies, and values had on math motivation through high school and into college. Priess-Groben and Hyde (2017) followed a cohort of high school students into their college years to investigate the effect that implicit theories of ability and expectations and utility value of mathematics had on predicting long-term mathematical motivation and behaviors. Participants were part of the longitudinal Wisconsin Study of Families and Work (WSFW) whose mothers were recruited while they were pregnant. The 165 participants were 92.1% White and 47% female. Data were collected during the summers after Grade 9, Grade 12, and the summer after sophomore year of college. Participants completed surveys assessing implicit theory of mathematics, self-concept of mathematics ability, and utility value of mathematics. After running descriptive statistics and correlational analysis of multi-path models to determine the strength of the relationships between the tested variables, the researchers concluded that self-concept of ability was a stronger predictor of long-term mathematics motivation than the implicit theories that students held in Grade 9. Although ninth grade students that possessed more incremental theories of intelligence (i.e., growth mindset) in mathematics held higher expectations of success and had a greater intent to take mathematics courses at the college level, most of these associations did not hold once the researchers controlled for prior achievement. However, the researchers reported that mathematics self-concept of ability was a more important predictor of future mathematics course-taking, course-taking intentions, and utility value of mathematics through high school and college than implicit theories even when controlling for prior achievement. With respect to gender, the researchers reported no significant differences in gender for any of the variables tested.

Priess-Groben and Hyde (2017) noted the use of a community sample and variability in mathematics achievement levels made the results generalizable to other populations, although the small size and racial homogeneity of the sample were limitations. The researchers suggested that future studies include a larger sample with more ethnically diverse participants. Additionally, Priess-Groben and Hyde only investigated two perspectives regarding motivation and behavior and recommended future studies investigate the origins and development of implicit theories more in depth.

So, who benefits from growth mindset thinking? There is evidence that growth mindsets are beneficial for subgroup populations that are underrepresented in STEM fields and careers. Hwang et al. (2016) investigated the effect that implicit theories had on the mathematics achievement of subgroup populations. The researchers used pre-existing data collected as part of the Education Longitudinal Study (ELS) to determine the extent to which gender, ethnicity, SES, and achievement-level differences played a role in a fixed mindset in mathematics. The ELS was a nationally representative survey of Grade 10 students conducted in 2002 by the National Center for Education Statistics. The data was collected in two waves, first in 2002 when the students were sophomores and again in 2004. In all, Hwang et al. (2016) used data from a nationally representative sample of 10,850 students. The researchers also sought to determine whether the associations between fixed mindsets and math achievement varied across subgroups. After running regression analyses to determine whether correlations existed between variables, Hwang et al. (2016) concluded that there was no difference between males and females endorsing a fixed mindset. However, the researchers reported that African American and Hispanic students were significantly less likely to endorse a fixed mindset than White students. The researchers also noted that students with a lower SES background were less likely to hold a fixed mindset belief. Grade 10 math achievement levels did not influence whether students held a fixed mindset belief or a growth mindset belief. The data analyzed by Hwang et al. (2016) did not indicate associations between mindset and later math achievement for any of the subgroups investigated. In other words, holding an entity theory of intelligence was no more harmful to females, minorities, or low SES students than it was to males, Whites, and higher SES students. Similar to the findings of Priess-Groben and Hyde (2017), these results led the researchers to suggest that prior math achievement may play more of a role in whether low-achieving students possess more of a fixed mindset and attribute their lack of achievement to lack of ability instead of lack of effort. The researchers advised caution when interpreting these results, as a single survey question was used when measuring fixed mindset. The researchers suggested that future studies use multiple items to determine the degree of implicit theories of intelligence. Hwang et al. (2016) also suggested that prior performance be included in future studies to more accurately reflect the strength of the mindset associations on later achievement.

Growth Mindsets in Middle School Math Students

Blackwell et al. (2007) conducted two studies to investigate the effect that implicit theories have on the mathematics achievement of students in Grade 7. The first study followed 373 students entering junior high school during four consecutive years at a public school in New York City. Due to the small sample size available each year, data from the four cohorts of students were merged into one set for analysis. The ethnicity of the sample was varied, with 55% African American, 27% South Asian, 15% Hispanic, and 3% East Asian and European. The students had an average sixth grade math score at the 75th percentile and 53% of participants were considered low SES. Student achievement was measured using the Citywide Achievement Test (CAT) with baseline data collected at the beginning of fall term in Grade 7. Follow-up data were collected four additional times: the end of fall term in Grade 7, in the spring of Grade 7, fall term of Grade 8, and spring term of Grade 8. Motivational data were collected through surveys measuring implicit theories of intelligence, goal orientation, beliefs about effort, and attributions to determine a student's responses to failure. In order to understand the effect of implicit theories through the junior high transition, Blackwell et al. (2007) used growth curves to analyze the trajectory of mathematics achievement over the course of Grades 7 and 8. The researchers noticed that achievement of students possessing an incremental theory of intelligence increased significantly ($\beta = .53$, $t = 2.93$, $p < .05$) over the two-year time period, while the achievement of students with an entity theory of intelligence slightly decreased. Next, the researchers sought to investigate the effect that learning goals, positive effort beliefs, low helpless attributions, and positive strategies may have in mediating these results. Blackwell et al. used exploratory factor analysis to investigate the roles of mediating factors in their results and concluded that mediation was significant (z-scores ranged from 2.14 to 8.56, $p < .05$) Based on these results, the researchers noted that junior high school students with a malleable theory of intelligence had stronger affirmations of their learning goals and were more likely to believe that effort is necessary for achievement than students with a fixed theory of intelligence. These students were also more likely to have positive beliefs and less likely to attribute failure to a lack of ability, instead viewing setbacks as an opportunity to work harder next time.

The second study conducted by Blackwell et al. (2007) mimicked the first with a new, lower-achieving sample of students over a shorter period of time. However, the researchers provided an intervention to teach incremental theory to half of the students during the spring term. Participants for this study were 99 students at a different school in New York City. They were 52% African American, 45% Latinx, and 3% White and Asian. The average Grade 6 math Citywide Achievement Test (CAT) score was in the 35th percentile; seventy-nine of the students were considered low SES. The sample included 49 females and 50 males. Five students did not attend the intervention sessions regularly, so they were removed from the data analysis. The researchers (Blackwell et al., 2007) administered the same questionnaire as in Study 1 to assess the motivational profiles of the students at the beginning of fall term in Grade 7. Interventions took place over an 8-week period during the students' previously assigned advisory classes. Each existing advisory group was randomly assigned to be part of either the experimental group or the control group. Both groups participated in similar workshops, facilitated by graduate research assistants, which included information study skills, information about how the brain works, and anti-stereotypic thinking. However, the experimental group also received instruction on the malleability of intelligence and strategies to cultivate a growth mindset. Three weeks after the interventions ended, students were again assessed with the Theory of Intelligence questionnaire. The teacher was also asked to record in writing how student motivational levels had changed after the workshop. The teacher had no knowledge of which students received which intervention. Blackwell et al. (2007) coded the teacher comments to determine whether the teacher noted a positive or negative change in each student's motivation and then used ANOVA to determine what differences existed between the experimental and control groups. The researchers (Blackwell et al., 2007) reported that the level of content learning was equivalent across both groups. The researchers next used paired samples *t* tests to show that students in the experimental group possessed more of an incremental theory of learning more strongly after participating in the intervention (4.36 preintervention vs. 4.95 postintervention, Cohen's $d = .66$, $t = 3.57$, $p < .05$) while participants in the control group did not change (4.62 preintervention vs. 4.68 postintervention, Cohen's $d = .07$, $t = .32$, *ns*). Moreover, the teacher reported 27% of students in the experimental group showed positive motivational changes while only 9% of the control group increased in motivation. These results were also significant ($\chi^2 = 4.72$, odds ratio = 3.26, $p < .05$).

Taken together, the results of these two studies led Blackwell et al. (2007) to conclude that students who possess a more incremental theory of intelligence (growth mindset) have more positive beliefs about effort, stronger learning goals, and choose more positive effort-based strategies when experiencing setbacks. Therefore, these students experience higher mathematics achievement during the transitions of Grades 7-8. Moreover, students who were taught that intelligence is malleable showed greater motivation than students who were not exposed to the concept of growth mindset. The researchers interpreted these results as an indicator that students' theory of intelligence is a key factor in their achievement motivation. However, these results are limited due to each study taking place in only one school and limited to the demographics and student-level factors of the participants in New York City public schools. Blackwell et al. (2007) suggested that future studies include participants from multiple schools, for longer periods of time, and perhaps should include both parents and teachers in the motivational analysis.

In a subsequent study, Romero et al. (2014) investigated the role that implicit theories play on the academic and emotional functioning of suburban middle school students. The researchers wanted to know whether a growth mindset predicted higher grades and enrollment in more challenging math classes over time. Romero et al. (2014) also investigated whether a belief in the malleability of emotions would predict fewer depressive symptoms and a greater sense of well-being. Participants consisted of 115 middle school students at a suburban public school. Sixty-seven percent of the participants were female, 37% were White, 36% were Asian-American, 6% were Latinx, 16% Multi-racial, and 2% were Black; 9% of students at the school were classified as low-SES. The researchers also collected information on the mother's educational level as a predictor of SES. Students were given surveys four times during the three years in middle school and were assessed on their theories of academic and emotional intelligence each time. Grades were collected from the school registrar.

Romero et al. (2014) used hierarchal linear models to determine the effect of implicit theories of intelligence and emotions over time. Although the researchers found no significant gender differences in average intelligence theories, emotion theories, well-being, depressive symptoms, or GPA, between-race differences were noted for intelligence theories, GPA, and math level taken. The researchers reported that students with a malleable view of intelligence in the 6th grade had not only higher grades at all time points but were also more likely to enroll in higher math classes. These results supported the previous findings of Blackwell et al. (2007) in which students with growth mindsets not only had higher achievement but also took more difficult math classes. Romero et al. (2014) also reported that students who believed that emotions were malleable were better able to manage their emotions during times of struggle.

In spite of these promising results, Romero et al. (2014) warned of the limitations that exist in their findings. Due to the small sample size, Romero et al. recommended interpreting the differences with caution. Although this particular sample reflected the diversity of the school, one cannot assume the generalizability of these results to a larger sample of middle school students. Not all students were present at all time points of data collection, and the emotional functioning assessment was self-reported. Future researchers may wish to include data from parents or teachers. Romero et al. (2014) also recommended that future researchers investigate the causality of the findings in this study, perhaps with an experimental design of targeted interventions.

Growth Mindset and Self-Efficacy

There is emerging research that suggests a correlation between growth mindset and self-efficacy. Huang et al. (2019) tested a framework to investigate how math anxiety and growth mindset affect math self-efficacy and STEM career interest. The researchers (Huang et al., 2019) theorized that implicit theories of intelligence would affect the career interest for middle school students. The researchers also expected that math anxiety and growth mindset would affect self-efficacy, which would in turn affect STEM career interest. Additionally, the researchers sought to determine whether math anxiety mediated the effect between math self-efficacy and career interest by gender.

Huang et al. (2019) surveyed 152 Grade 7 students in a rural middle school in the United States. This middle school had test scores above the district average, with 65% scoring proficient or distinguished on the state assessment, whereas the district average was about 51%. Half of the participants were male and 85% were Caucasian. Surveys consisted of items from established instruments to measure math anxiety, math self-efficacy, implicit theories of intelligence, and math/science career interest. Teachers administered the surveys the last week of spring semester. An analysis of covariance (ANCOVA) was used to analyze the results of the surveys. After analyzing the results, the researchers (Huang et al., 2019) reported girls exhibited higher math anxiety and boys held higher growth mindsets. No gender differences were reported for math self-efficacy or math/science career interest. However, the researchers reported growth mindset for boys had a significant correlation with math self-efficacy ($r = .42$, $p < .01$) and math/science career interest (*r* = .48 *p* < .01). The correlations were not significant for girls (*r* =.20, *p* = .075) for mathematics self-efficacy nor for math/science career interest (*r* =.11, *p* = .324) . Additionally, the researchers reported no significant correlation between math anxiety and growth mindset for either boys or girls. Next the researchers controlled for math level to test the mediating effect of self-efficacy on math/science career interest. For boys, math level significantly predicted growth mindset (β = .327, *SE* = .097), which predicted math self-efficacy (β = .384, *SE* = .081), which predicted math or science career interest (β = .250, *SE* = .126). However, for girls, math level did not predict growth mindset, but growth mindset significantly predicted math self-efficacy (β = .171, *SE* =.088). Math self-efficacy did not in turn predict math or science career interests for girls.

As a result of these data analyses, Huang et al. (2019) concluded that boys with growth mindsets are likely to possess higher self-efficacy, which predicts math or science career interest. Additionally, the researchers reported that for girls, math anxiety, growth mindset, and career interest tend to develop independently of their math performance.

However, these findings were contradictory to an analysis of the results of the Self-efficacy Intervention to Improve STEM Performance (SIISP; Beatty et al., 2019). The SIISP was a four-year National Science Foundation (NSF) funded project developed to test the effectiveness of a growth mindset intervention to increase the STEM self-efficacy of college students. NSF researchers hypothesized that an intervention which teaches students about growth mindset would allow them to enact it, increasing their sense of self-control over their academic success which in turn would increase their STEM self-efficacy.

This quasi-experimental design was implemented in Physics courses at three demographically diverse universities in North Carolina. Students were given a survey which measured STEM self-efficacy, growth mindset, and perceived academic control. The survey was administered three times: at the beginning of the semester, a few weeks after the intervention, and again late the following semester. The intervention consisted of short videos explaining the growth mindset, how it might apply to a STEM course, how to focus on productive struggle and the learning process. The researchers followed the initial intervention with another about four weeks later. The second session consisted of a handout containing highlights of growth mindset, productive struggle, and the applicability to a STEM course. In contrast, students in the control group watched videos about the diversity of the STEM workforce and skills necessary for cultural competence. The experiment was conducted three times at each school over a period of three semesters during 2016-2018.

The researchers (Beatty et al., 2019) used hierarchical linear modeling to analyze the effect the intervention had on students' self-efficacy, growth mindset, and perceived academic control. Researchers reported that growth mindset scores for the treatment group increased from pre-test to post-test by 0.213 standard deviations, a medium effect size with high significance. However, no significant differences were reported between the intervention and control groups in perceived academic control. In fact, the perceived academic control scores decreased from pre-test to post-test. The self-efficacy scores increased from pre-test to post-test, but the increase was not statistically significant. There was no observed effect of treatment on final course grades. Based on these results, the researchers concluded either there were gaps in the conceptual model and that increasing growth mindset does not lead to higher self-efficacy or that the one-semester study was too brief to allow students the mastery experiences necessary to foster positive self-efficacy.

In a similar study, Samuel and Warner (2019) investigated the effect of growth mindset messages and mindfulness interventions on first-year college students taking a required statistics course at an urban community college. The participants were enrolled in *Statistics A*, the first of a two-semester course requirement designed for students that require more support in math than those more proficient in mathematics who enroll in the standard one-semester Statistics course. Two cohorts of students were selected for the study, one of which received the intervention. The intervention on the second day of the class consisted of definitions and videos related to mindfulness and principles of growth mindset theories. Subsequently, the instructor led the class in daily mindfulness affirmations at the beginning of each class. Phrases such as: “Today’s lesson might be challenging, but I’m up for the challenge” or “I expect to make mistakes today and then fully learn from those mistakes,” (p. 5) were recited at the beginning of each day’s class period and then reinforced by the instructor during the daily lessons. Additionally, the researchers collected pre- and post-test data to assess math anxiety levels and math self-efficacy. On the final day of classes, a randomly selected focus group from the treatment group participated in an interview.

Samuel and Warner (2019) used independent samples *t*-tests to look for significant differences within each group and between the two groups. No significant difference in math anxiety levels was observed from pre- to post-test for the control group, but the researchers reported a decrease in math anxiety (M=2.93, SD = .833), $t(16)$ = 2.825, p = .012, d = .686 from pre- to post-test, a medium effect size, for the treatment group. However, when researchers compared the post-test scores between the two groups, no significant difference in math anxiety was reported. The researchers (Samuel & Warner, 2019) also used paired samples *t*-tests to look for differences in self-efficacy from the beginning of the semester to the end of the semester. No significant differences in self-efficacy were observed for either group when comparing pre-test to post-test scores. The focus group data was analyzed using themed content analysis. Samuel and Warner (2019) reported emergence of the following themes: instructor led the intervention, deep breathing is a calming start to class, saying affirmations makes you believe them, sense of control, and routine.

Due to attrition, the two cohorts of *Statistics A* were combined into one course of *Statistics B* for the following semester. The researchers (Samuel & Warner, 2019) repeated the treatment procedures with the students, some of whom were receiving them for the first time. Once again, pre- and post-test instruments were administered to measure math anxiety and math self-efficacy. While no difference was reported for the students that were not part of the initial treatment, a significant decrease in math anxiety, $t(7) = 2.494$, $p = .41$, $d = .88$, a large effect size, was observed for the students that received the intervention both semesters. With regards to self-efficacy, no differences in between pre- and post-test data were observed for either the year-long intervention group or the second-semester-only group. However, the researchers noted an anomaly with one self-efficacy item which referenced a final grade in statistics. Upon closer examination of this item, the researchers (Samuel & Warner, 2019) reported that confidence in statistics increased significantly for both cohorts from fall pre-tests to spring post-tests. This observation supports the assertion that self-efficacy is best measured in a specific context relevant to current circumstances rather than a general setting (Bandura, 1977; Pajares & Miller, 1994). Taken together, these results led the researchers to conclude the growth mindset/mindfulness interventions both decreased math anxiety and increased subject-specific self-efficacy of the participants.

Komarraju and Nadler (2013) investigated the relationship between self-efficacy and other motivational variables in a group of undergraduates enrolled in an introductory psychology course. Approximately 50% of the students were male. Sixty-five percent were European-American, 22.6% were African American, and 11.2% belonged to other ethnic groups. The researchers (Komarraju & Nadler, 2013) hypothesized that higher self-efficacy would correlate positively with an incremental theory of learning and that students with a high self-efficacy would prefer learning/mastery goals. The researchers also expected to find that highly motivated and successful students would have well-developed cognitive coping strategies, making effective use of their time and resources, and would therefore report a higher grade point average (GPA). Participants completed a survey consisting of items assessing motivational constructs, cognitive and metacognitive learning strategies, resource management strategies, mindset beliefs, and achievement and mastery goals. The researchers analyzed the data with MANCOVA, correlational analyses, and regression analyses. When the data were analyzed, the researchers were able to confirm the hypotheses that students with higher self-efficacy were more likely to possess an incremental theory of learning, to set challenging academic goals, and to earn higher GPAs. Additionally, the researchers confirmed the hypothesis that students with higher self-efficacy possess the self-control and metacognitive strategies necessary for successful academics and that students with low self-efficacy tended to hold fixed theories of intelligence supporting Usher (2009). The researchers (Komarraju & Nadler, 2013) noted that a limitation of the study was the self-reported data, and suggested future researchers conduct studies to investigate the causal inferences between motivational constructs, cognitive strategies, self-beliefs, and performance.

Student expectations and outcome beliefs also factor into motivation. Degol et al. (2018) sought to determine whether gender differences in mathematics mindset predicted motivational beliefs, math achievement, and career aspirations. The researchers defined motivational beliefs through expectancy-value theory (EVT) first posited by Eccles (2009). Expectancy-value theory states that educational choices are influenced by expected outcomes and task-value beliefs. The researchers surveyed 1449 high school students from 12 public schools in Pennsylvania. Freshmen, sophomores, juniors, and seniors were approximately equally represented, and half of the students were female. Seventy-five percent of the students were European American, 18% African American, 2% Asian American and about 20% received free or reduced lunch. Data were collected when the students completed a survey during their regular math class assessing mindset beliefs, motivational beliefs, expectancy beliefs, task value, and cost. The researchers also collected demographic data from the schools as well as student end-of-year course grades.

Degol et al. (2018) used structural equation modeling to determine the correlations between the variables. Upon analyzing the results, the researchers observed mindset positively predicted task value but did not predict expectancy or cost. Additionally, task value did not predict grades, but was associated with mindset and career aspirations. There was no difference in task value by gender, but males were more likely to have higher expectancies than females, which was associated with higher grades. However, the researchers (Degol et al., 2018) reported that although both males and females with fixed mindsets had comparable grades, females endorsing a growth mindset had higher grades than males with a growth mindset. The researchers concluded this difference was a result of the higher expectancy belief of females possessing a growth mindset and noted the importance of a growth mindset for female math achievement. Additionally, Degol et al. reported that neither growth nor fixed mindset had an effect on task value or perceived costs for either gender.

Growth Mindset Summary

In summary, growth mindset is an implicit theory that states intelligence is malleable (Dweck, 2006). Neurological evidence exists to support the claim that possessing a growth mindset allows students to learn from mistakes, therefore performing with higher achievement on future tasks (Ng, 2018; Schroder et al., 2017). Additionally, mathematical mindset instruction has been shown to increase student motivation and achievement (Blackwell et al., 2007; Daly et al., 2019; Dweck, 2008). Moreover, studies have shown that growth mindset interventions may increase student motivation and interest in mathematics, leading to higher achievement and creating an opportunity for students to take higher level math classes that are required for STEM careers (Blackwell et al., 2007; Romero et al., 2014; Samuel & Warner, 2019; Yeager et al., 2019).

Additionally, empirical evidence exists to support the notion that there is a link between self-efficacy and mindset. Students with higher self-efficacy tend to hold an incremental theory of learning while less efficacious students tend to believe that intelligence is a fixed entity that is unalterable (Huang et al., 2019; Komarraju & Nadler, 2013; Samuel & Warner, 2019). There is also evidence to suggest that growth mindset interventions can decrease math anxiety therefore allowing students to visualize success on a future task (Samuel & Warner, 2019). These interventions increase self-efficacy by allowing students to alter the internal dialogues they hold with themselves about their capabilities. It is possible that embracing a growth mindset may increase student self-efficacy therefore fostering a stronger mathematics identity.

Identity

Gee (2001) defined identity as the kind of person one is perceived as being in a time, place, and context. Gee described four types of identity: nature, institution, discourse, and affinity that interact at varying levels to create one's perceived identity within a certain context. Identity as nature (N-identity) comes from the circumstances into which we are born. Identity as institution (I-identity) is derived from the position one holds as part of an institution. Identity as discourse (D-identity) is more of a personality or individualistic trait that one may possess. Discourses give rise to core identity which evolves as one individualizes and narrates the journey through social experiences. Identity as affinity (A-identity) is based on experiences that one has had, often shared with a group that has similar experiences. In the school setting, A-identities are developed as each classroom represents a unique community of practice (Wenger, 1998).

Eccles (2009) took an expectancy value perspective on identity and argued that identities have three components: a value component, a content component, and an efficacy or expectancy component. The value component is derived from the importance of specific individual characteristics or groups of which one is a member. The content component is based on beliefs one has about tasks and behaviors that are associated with success. The efficacy component includes one's beliefs about his/her ability to be successful. These identities are dynamic, ebbing and flowing over the course of one's lifetime with accordance to the context of the moment. Additionally, Eccles (2009) stated that identity is a motivating factor which often influences behavioral choices.

Mathematical Identity

Although the number of published research studies in the field of mathematical learner identity (MLI) has steadily increased in the last 20 years, research on the MLI of adolescents is still in the infancy stage (Radovic et al., 2018). Researchers have investigated the root causes of how students develop mathematical identities and how to best categorize them. In fact, the "vagueness of the identity concept and lack of clarity around its operationalization" (Graven & Heyd-Metzuyanim, 2019, p.363) are prevalent themes among critiques of existing research. In simplest terms, math identity can be defined as whether one perceives oneself as a math person. However, opinions of how this perception is formed vary among theorists, studies, participants, and settings (Darragh, 2016; Fellus, 2019; Radovic et al., 2018).

Boaler et al. (2000) identified three components of identity: a sense of belonging in a group, a sense of achievement within the norms of the group, and particular behaviors associated with belonging to a group. Taken together in the context of a mathematics classroom, these three aspects can be more broadly viewed as a community of practice (Boaler et al., 2000; Wenger, 1998) as students work together to learn content and, in the process, develop a sense of who they are as mathematical learners and thinkers. The researchers (Boaler et al., 2000) reported on data from interviews with 48 Advanced Placement (AP) calculus students from six public schools in California and 72 students from six schools in the United Kingdom to understand student confidence in mathematics as well as classroom expectations and routines. Data analysis indicated that students who participated in discussion-based classes and had opportunity to work in groups with their peers formed a different perspective on math learning than students enrolled in more traditional classes. These students enjoyed the open-ended nature of the teachers' instruction and the opportunity to discuss solution possibilities with their peers. Conversely, many U.S. students that were successful in their procedurally based math classes reported not liking the subject because they felt math did not offer opportunities for creative thinking that was found in other subjects. Students in the United Kingdom that reported liking math did not identify with the mathematics itself, but rather with the satisfaction they received from their success in the subject or their perception that the content would be useful in their future. These results led the researchers to conclude that although students desired success, they did not identify with mathematics in such a way as to perceive themselves as mathematicians. Success in mathematics was simply viewed as a stepping-stone to the next level of education, instead of a desired result in and of itself.

Boaler and Greeno (2000) noted the importance of developing identities as they investigated the mathematical confidence of 48 students in AP-calculus classes in Northern California. The researchers interviewed four students, two girls and two boys, that their teachers had identified as confident, and four students, two girls and two boys, that had been identified as lacking confidence from each of the six classes studied. Four of the classes encouraged individual environments, didactic classrooms with the expectation to practice and repeat procedures that the teacher demonstrated. However, two of the classes had teachers that encouraged student discussion and expected students to work on problems in groups. Boaler and Greeno (2000) discovered that students in the didactic classrooms saw themselves as passive receivers of pre-determined knowledge. The students that enjoyed these classes did so because of the rigidity and structure of mathematics that always had a certain answer. When asked about their plans to continue study of mathematics, many students in the didactic classes declined stating the practices in which they had been engaged conflicted with their developing identities. They felt that math did not offer opportunities for creativity or self-expression and limited their sense of agency, their ability to be in control of their own learning. In contrast, of the 16 students interviewed from the discussion-based classrooms, 94% claimed to enjoy mathematics and 80% planned to continue with further mathematics courses. Students in the discussion-based classrooms were able to contribute more of their own creativity and developed a stronger sense of agency as they discovered and explored mathematical relationships. Based on these results, the researchers concluded that mathematics learners are better able to author their own identities as learners when learning practices allow students more conceptual agency.

Boaler (2002) later expanded on the results of this study, proposing a triangular relationship between knowledge, practice, and identity, in which each construct had a reciprocal relationship with the other two. Boaler (2002) stated that students need not only possess the knowledge to practice mathematics; they must also possess the disciplinary relationship that allows them to appropriate their knowledge. Students must be able to use their knowledge in different situations, and the identities that they develop as learners allow them to do so.

Anderson (2007) combined the social learning theories of Gee (2001) and Wenger (1998) to conceive the notion of math identity as a tetrahedron with four interconnected faces. In a study of students in Grades 11 and 12 at a rural high school in a northwestern state, the researcher conducted semi-structured interviews to investigate facets of students' mathematical identities. Fourteen students were divided into two groups: those taking advanced math and those not taking a math class that year. All students had previously taken the math courses required for graduation and all were taught with traditional mathematics instruction through which the teacher demonstrated procedures and methods that students were expected to replicate. Based on the results of student interviews, Anderson (2007) identified the four interconnected faces of the math identity tetrahedron as engagement, imagination, alignment, and nature.

Engagement represents the degree to which students identify with and participate in classroom activities. Anderson (2007) reported that students who felt math was a simple repetition of procedures felt less engaged and did not perceive math as offering an opportunity to make sense of the set of rules and construct their own meaning. One student commented on how math was not like her art class, where she was encouraged to be creative. Imagination reflects how students may see themselves using mathematics in a broader community context in their future experiences. The students in the advanced math classes were able to imagine that they would need math in their post-secondary classes, while students not taking math did not envision a need for the content in their future. Alignment occurs when students can imagine their futures and set goals to meet requirements necessary for success. The students that planned to go to college knew that taking advanced math classes would look good on college applications, while students that did not plan to use math in their lives saw no reason to pursue the subject further or to identify as a "learner of math." Nature consists of circumstances we are born into and cannot control, such as gender, race, or socioeconomic status. Anderson (2007) stated that the nature face of the tetrahedron is possibly the most inhibiting due to messages that learners often receive from their parents, community, or even their teachers. One college-bound student stated that being good at math must be genetic, because she "just gets it." Two students that were not planning on college felt differently. One stated that he was "not a math guy" and another said "Math just doesn't work for me. I can't get it through my head." Based on these results, Anderson (2007) recommended teachers need to be aware of how students view themselves as learners of mathematics and should focus on developing the engagement, imagination, and alignment faces of the tetrahedron in order to build and develop mathematical identity. Usher (2009) would later report a similar finding on importance of vicarious messages in a study of the formation of students' mathematics self-efficacy.

In a similar qualitative study, Solomon (2007) investigated how first-year undergraduates at an English university perceived their mathematics identities. The researcher conducted this study using a sociocultural perspective of identity; specifically investigating Wenger's (1998) three modes of belonging: engagement, alignment, and imagination as part of a community of practice. Semi-structured interviews were conducted with 12 students, all of whom were either majoring or minoring in mathematics. Solomon noted how these students were part of several different communities of practice: first-year students, the undergraduate community, as well as the mathematics department community. Seven of the students were male, and five of the students were female. Ten of the students were ages 19-20, one male was 23, and one female was 34. All of the students were pursuing degrees in mathematics or dual degrees in mathematics combined with other subjects. The students were asked to bring work samples to the interviews. They brought something from a topic they found easy and were proud of and something from a topic they found challenging or difficult and struggled with. The researcher then discussed their mathematics histories, how college math was different from high school math, their perceptions of different teaching strategies, strategies for persevering when they felt stuck and were struggling, their views on what kind of approach would lead to success in mathematics, their perceptions on research in mathematics, and how they viewed themselves as mathematicians.

Solomon (2007) analyzed the transcripts of the interviews and reported emergence of themes in the data. Several students experienced negative alignment in which they felt disengaged from the topic of mathematics because they viewed it as following a set of predetermined rules. This finding was counterintuitive because even though the students were successful, they did not feel ownership in the content. Solomon (2007) reported that this feeling did not seem to bother the male participants but led the female participants to feel marginalized from the broader mathematics community. However, some students showed imagination in that they could picture the purpose mathematics had for their futures. Only one participant, a female, felt true engagement. She enjoyed looking for patterns and felt satisfaction when she arrived at the solution to a problem.

Several of the participants reported fixed-ability beliefs, stating that math was either something you understood or something you did not understand (Solomon, 2007). These students also maintained the perception that good students were quick problem solvers. However, Solomon reported that the females with this perception struggled to maintain a positive math identity even given their imagination and engagement. These students viewed math as something that was “done to” them rather than “done by” them. The instructional practices at the university did not allow for students to participate in and create their own conceptual understanding. While most of the students felt this way, only one male student seemed bothered. The researcher also reported that the female students stated a preference for working in groups, where they found reassurance when they were struggling with a topic. The male participants rarely mentioned group dynamics. The women in the study often voiced a feeling of exclusion due to their fixed ability beliefs and lack of personal connection with the content. Although the men in the study felt the same lack of connection, they did not express a feeling of excluded identities and were more accepting of the state of not belonging. These results led Solomon (2007) to conclude that some potentially successful students can develop negative mathematical identities when they feel marginalized. These feelings can discourage students from pursuing mathematics further.

In an effort to understand how perceptions of recognition, interest, and competence/performance are related to mathematics identity, Cribbs et al. (2015) conducted a quantitative study using data from the Factors Influencing College Success in Mathematics (FICSMath) survey project, a national study which surveyed students enrolled in single-variable calculus classes at U.S. colleges in 2009. Recognition was interpreted to a be a measure of how students believed others perceived them. The researchers considered competence/performance to be analogous to self-efficacy: Did the students believe that they could be successful and perform well? Since calculus is required for many different majors, Cribbs et al. (2015) were able use data from a large sample of student majors, both those that identified with mathematics as well as those that did not. About 60% of respondents were male, 34% were female, and 6% did not report their gender. Approximately 70% identified as White, 4% as African American, 11% Asian, and 7% Hispanic. Students completed a questionnaire containing items such as “I enjoy learning math” or “I look forward to taking math” or “Do you see yourself as a mathematics person?” Confirmatory factor analyses were conducted to determine goodness of fit among the variables. The hypothesized framework was supported by the data in that interest (β = 0.290) and recognition (β = 0.742) had significant direct effects on identity, and competence/performance had an indirect effect on identity which was mediated through recognition and interest. After analyzing the results, Cribbs et al. (2015) reported performance/competence had the strongest effect on recognition (β = 0.720). In other words, the more belief students have in their ability to do math, the more likely they are to perceive that others view them as a math person. Cribbs et al. (2015) also observed a significant effect on interest from competence/performance (β = 0.594); the more self-efficacy students exhibit, the more likely they are to be interested. However, the researchers reported that recognition had the strongest effect on a positive math identity. Additionally, the researchers reported that interest had a significant positive effect on identity (β = 0.742).

Math Identity of Middle School Students

Wenger’s sociocultural theory suggests that identity is developed from communities of practice. Students belong to several different social communities at home, with their peers, as well as at school. Wenger (1998) stated “Building an identity consists of negotiating the meanings of our experience of membership in social communities” (p. 145). Each middle school student is a member of several learning communities such as different academic classes, exploratory classes, and grade level. Identity is cultivated in one’s community of practice through engagement, imagination, and alignment (Wenger, 1998). Students become active members in their communities, identifying with other participants through engaging in shared activities. Additionally, students must be able to imagine themselves as part of a community so that they can align their actions, interests, and goals with other community members.

According to Erikson’s psychological perspective of identity (Hamann & Hendricks, 2005), the adolescent years from ages 12-18 are a period of identity creation and confusion during which students experiment with and develop identities and roles of who they wish to become. However, traditional school learning takes place in a social setting through which students interact with their social environments and develop identities as a result of these ongoing interactions (Boaler & Greeno, 2000). For this reason, mathematical identity is understood to be developed from belonging to various communities of practice that constitute the social development of one’s identity (Wenger, 1998). Wenger (1998) posited four components of learning: meaning, practice, community, and identity. Through experiences, learning takes on meaning. Practice creates learning through doing. We learn where we belong as part of a community, and it is through identity that we evolve into who we will become. In order to perceive oneself as a “math person,” one must be able to become engaged in mathematical activities, imagine a future self as a doer of math and subsequently align one’s interests and goals to make that happen (Boaler and Greeno, 2000).

In an effort to better understand how a classroom community can shape mathematical identity, Bishop (2012) used discourse analysis to investigate the differing mathematics identities of two female Grade 7 students in Texas. The students were participating in a technology-based unit of the math curriculum. Bishop's (2012) definition of mathematics identity was formulated using a synthesis of prior research: "a dynamic view of self, negotiated in a specific social context and informed by past history, events, personal narratives, experiences, routines, and ways of participating…who one is in a given community…both individually and collectively defined" (p. 38). Data was collected through video recordings and field notes taken as the researcher observed peer-to-peer interactions as the students interacted with the teacher, each other, and the curricular software. The researcher also conducted interviews with the two focal students and collected artifacts of their work.

Bishop (2012) reported the girls enacted their mathematical respective identities through use of authoritative voice, by making statements of superiority or inferiority, using face-saving moves, building solidarity, providing encouragement, and controlling problem-solving strategies. The girls' discourse tended to support the statement made by one, "She's always been the smart one; I've always been the dumb one" (p. 66). Based on these observations of micro-level structural patterns of the interactions between the two students, the researcher concluded the discourse played a salient role in the mathematical identities the students enacted during class.

The importance of discourse and teacher expectations of student participation was supported by Cobb et al. (2009) in a study which sought to develop an interpretive scheme to describe the mathematical identities that middle school students develop as they engage in classroom activities. The researchers noted three ways in which students participate in classroom mathematical activities: identifying with the activity, merely cooperating with the teacher, or actively resisting the activity. Based on these observations, Cobb et al. (2009) focused on the microcultures that were established in particular classrooms and how students developed mathematical identities in those classrooms. Over a 14-week period, the researchers observed 11 Grade 8 students that participated in two different math classes in an urban middle school. One class was a traditional algebra class taught by a teacher with 25 years of experience. The other class was a design experiment class taught by a co-researcher on the research project. The algebra class was bound to district curricula requirements, while the design class was free from these constraints. The goal of the design class was to develop students' skill in analyzing bivariate data and to produce effective data-based arguments. Classroom obligations and expectations as doers of math were different between the two classes. In the traditional algebra class, students were expected to take notes and reproduce methods that were demonstrated by the teacher. Mastery of the mathematics was demonstrated by reproducing solution methods previously demonstrated by the teacher. On the contrary, in the design class, students were expected to explain and justify their reasoning as they supported or disagreed with analyses posited by their peers. Mastery was demonstrated as students explained their reasons for the displaying of data in a certain way and justifying the *why* of solutions that were presented as a result of their analysis.

The researchers (Cobb et al., 2009) investigated two forms of identity during the study. Normative identity represented a collective notion that was derived from responsibilities and practices of what it meant to be an effective doer of mathematics in a particular classroom. On the other hand, personal identity was based on the extent to which individual students cooperated with or resisted classroom expectations and obligations that were required to be an effective doer of math in a particular classroom. The researchers reported that the normative identities created by the two classes were different. Students in the traditional algebra class created disciplinary agency, as they reproduced algebraic notations while the teacher retained authority. In the design class, students were encouraged to exercise their own conceptual agency as they were given freedom to create representations of data and justify their reasons for doing so. Based on these observations, Cobb et al. (2009) concluded that students' personal identities are related to their perceptions about how a classroom works and their status in the classroom microculture that constitutes the context of their mathematical development. Students in the algebra class understood their primary obligation was to produce correct answers using prescribed methods. The teacher served as the authority to determine if their solutions were acceptable. However, students in the design class perceived their primary obligation to be identifying trends and patterns in data they were investigating. Additionally, they viewed authority in the classroom as being widely distributed and therefore saw themselves as successful learners due to their contributions to class discussions. The researchers (Cobb et al., 2009) stated that students in the design class did not have to "give up part of themselves" in order to identify with the mathematical activity of the lesson.

Cobb and Hodge (2011) later expanded on the research of Cobb et al. (2009) to include a third identity construct: core identity. Core identities are developed as students explore who they are and who they want to become. Core identity represents the kind of person one is recognized as being (Gee, 2001) and is often assigned based on ethnic group or cultural affiliations. Additionally, core identity can evolve throughout one's life as learning experiences shape normative and personal identities. Students' core identities can harmonize with normative identities as doers-of-math in the classroom or may be recognized through broader goals which require success in math class, such as college or employment opportunities (Cobb & Hodge, 2011). However, some students may not be able to reconcile their core identity with their normative classroom identity, thus creating inner conflict ultimately leading to alienation from math activities (Boaler & Greeno, 2000; Cobb & Hodge, 2011; Nasir, 2002).

Teaching practices and instructional methods can help shape students' mathematical identities (Boaler & Greeno, 2000). Grootenboer and Edwards-Groves (2019) wondered how mathematical identities could be understood as a process of engaging in mathematical practices. In a case study analysis, the authors viewed a recording of a Grade 6 math lesson in Australia to see how various teaching and learning strategies incorporated connections between learning, identity, and practice. The lesson observed was on decimals and fractions. The authors viewed a video of the lesson and transcribed the dialogue looking for themes. Five interconnected themes were identified: learning as being stirred into practices, learning as participating in practices, learning practices as identity forming, identities displayed in agentic practices, and mathematics identities as displayed intersubjectively in mathematics practices. The researchers noted teaching practices such as reinforcing students' prior correct answers and providing positive feedback followed by "is that what you are saying?" helped shape learner identities and allowed students to experience agency even though they were in a classroom of learners. The teacher and students were co-participants in activities of meaning-making which was necessary for the building of identity. Through discussion and dialogue, the teacher invited students to answer questions and encouraged them to provide feedback for each other. The teacher acknowledged correct answers and used questioning to encourage students to refine their answers when necessary. These actions helped to build student agency and math identity. Based on their observations, Grootenboer and Edwards-Groves (2019) concluded that mathematical identity, agency, and learning practices are inter-related dynamic processes that develop over time. Mathematical identities are influenced by what is being learned as well as how it is learned.

This research (Grootenboer & Edwards-Groves, 2019) was supported by Ruef (2020). A case study of a Latina sixth-grade student at a diverse San Francisco Bay Area middle school, investigated how students formed identities as doers of math. In this particular classroom, the teacher helped students form a new normative identity of what being “good-at-math” meant. Instead of answering questions quickly and correctly and reproducing procedures demonstrated by the teacher, these students were taught that being good at math meant being brave, sharing their thinking, being able to help others, asking questions when necessary, and committed to helping classmates understand. Quantitative survey data were collected, classroom observations were conducted, student interviews were held, and field notes were taken for the class. The researcher (Ruef, 2020) then selected one Latina student called Lauren to use as a case study and created an identity portrait for her. In another class, Lauren might have been considered a trouble-maker due to her strong personality and penchant for comedy. However, in the structure of this class in question, she emerged as a leader. The teacher fostered students’ normative identities by encouraging them to be brave, share their thinking, help others when they understood, and to ask for help when they did not understand. This classroom culture allowed Lauren to maintain aspects of her core personality while developing her individual identity as a doer of math. These results led Ruef (2020) to conclude that when students’ personal identities are woven together with their emerging identities as doer of math, they will thrive.

In an effort to further understand how instructional practices influenced identity and motivation, Miller and Wang (2019) used expectancy value theory (Eccles, 2009) to investigate student beliefs of whether (a) they were good at math, (b) math was useful to them, (c) math was interesting, (d) math was important to them, and I learning math was worth the effort. The authors also used the Classroom Assessment Scoring System-Secondary Framework (CLASS-S), a theoretical model of classroom quality that focuses on the types of interactions that adolescents have daily within their learning environment, to focus on specific instructional practices that may influence math motivation and identity. Participants were sixth-grade students from Mid-Atlantic schools enrolled in a longitudinal STEM research project designed to examine factors on engagement in learning. Approximately 49% of the participants were male, and the sample was both economically and ethnically diverse. The students were presented with an online survey during their regular math class which presented questions about their mathematics identity, classroom instructional practices, and their expectancy-value beliefs regarding mathematics.

The researchers (Miller & Wang, 2019) conducted quantitative analyses to find the results of the student surveys. As expected, the teaching practices of sensitivity, giving quality feedback, and providing interesting learning opportunities were positively associated with math identity through expectancy and task value beliefs. Adolescents' perceptions of higher teaching quality were associated with higher expectancies and task value, as well as lower utility cost. Both expectancy beliefs and task values were positively associated with math identity. However, teaching quality did not directly impact participants' math identity development. Although teaching quality indirectly impacted math identity through expectancy value beliefs for both White and Black students, the researchers (Miller & Wang, 2019) reported slight differences in the sizes of the effect. A larger effect size was reported for expectancies among White students ($\beta = 0.16$, $SE = 0.05$, $p < 0.001$) than Black students ($\beta = 0.13$, $SE = 0.04$, $p < .001$) while a larger effect size for task-value was reported for Black students ($\beta = 0.12$, $SE = 0.06$, $p < 0.05$) than for White students ($\beta = 0.10$, $SE = 0.03$, $p < 0.001$). These results led the researchers to conclude that expectations of success more strongly influenced the identities of White students while task-value was a stronger influence on the identities of their Black peers. Contradictory to their hypotheses and to prior research (Eccles, 2009), Miller and Wang reported no association between teaching quality and mathematics identity through utility cost for either ethnic group.

Cultural Considerations

When researchers investigate sources of self-efficacy or identity, student-level data is often included in the analysis. Researchers are interested to know if self-efficacy differs by gender, ethnicity, and socio-economic status. Often several ethnic populations are included in the analysis where Caucasian is the majority group, African American population is the next largest (rarely the majority), and Hispanic, Asian, Native American, or Mixed ethnicities form a small percent, if any, of the participants. Usher (2018) encouraged researchers to acknowledge their Whiteness when attempting to understand motivational processes and to accept that a universal theory of motivation cannot be formulated without accepting that the majority of existing research has been conducted with Eurocentric samples and contexts as the norm.

Berry (2008) used critical race theory (CRT) in a phenomenological approach to understand the middle school experiences of eight African American boys enrolled in Algebra 1. The participants were selected from a pre-college program's database which included approximately 1,000 students from Grades 6-12 in a southeastern state. The selected students all attended four middle schools in the same urban district. The study also included a math teacher from each school. Although 55% of the students at these schools were Black, the racial make-up of the Algebra classes did not reflect the school demographics. Out of a total of 161 Algebra 1 students at the four schools, only 15 were Black. Data were collected through a series of interviews with students, parents, and teachers, observations, questionnaires, and a review of documents which included students' mathematical autobiographies. The use of CRT allowed the researcher to place race and equity issues at the center of analysis. Additionally, the researcher was an African American male with experience teaching middle school mathematics. These commonalities allowed him to establish a relationship with the students and their parents as well as with the teachers.

Five themes emerged from the data analysis: early educational experiences, recognition of ability, support systems, positive mathematical and academic identity, and alternative identities. All but one of the boys had early exposure to educational materials from parents and recognized a connection between knowing multiplication tables early and being placed in an advanced group. Five of the boys were placed in advanced groups by fourth grade, but four of them would not have been had it not been for parental advocacy. These four boys exhibited behavior not perceived as appropriate for advanced classes. Their mothers believed they were discriminated against by White teachers and principals who did not believe they were capable of doing more difficult work. As a result, seven of the boys' parents did not trust their son's schools so they became involved with school related activities to advocate for, protect, and support their children. Additionally, the parents set a standard of high academic expectations for their sons, and many of them were able to assist with homework. All of the boys had positive role models through their parents or other family members. Seven of the boys had positive mathematical identities. Berry (2008) defined mathematical identity as having four components: strong belief in ability, positive self-definition, motivation to succeed, and having a teacher who motivated and encouraged them. One of the boys, Andre, listed science as his favorite subject. While he preferred science, he still strived to achieve in mathematics recognizing its importance to achieving his future goals.

In spite of being one of few Black boys in their Algebra class, Berry (2008) reported that the boys did not develop identities assimilating them into White culture. Instead, they used racial identities and parental discussions to develop identities in religious activities, athletics, or other academic pursuits. The researcher reported the salience of advocates that helped the boys move up to advanced content classes and encouraged them to succeed. Berry also noted the importance of educators willing to build relationships with their students in such a way as to foster mathematical thinking and make connections with their everyday lives.

In a subsequent study, Berry et al. (2011) sought to determine factors that academically successful Black males had in common. In a study of rising fifth through seventh graders participating in a two-week summer algebra program, the researcher investigated how these Black boys contrasted their racial identities and mathematical identities, and the link between racial and mathematical identities of the participants. The participants were all considered above average successful math students according to academic criteria and attended a rural-suburban school district in which Black students comprised 12% of the population. Many of the boys were the only Black student in their math classes. The authors used focus group interviews, school documents, observations during the summer program, and student math autobiographies to collect data and gain insights into the development of the boys’ racial and mathematical identities.

Upon analysis of the artifacts, several themes emerged. Berry et al. (2011) found that computational fluency by third grade and extrinsic recognition through grades, test scores, tracking, or gifted identification helped to shape the boys’ mathematical identities. Relational connections between teachers, families, and extracurricular activities contributed as well. The boys used words like complex, challenging, requiring concentration to describe math and spoke of the pride they felt when persevering to completion. Students enjoyed the opportunity to solve problems and use multiple strategies, all the while interacting with their peers and making connections to other disciplines. Perceptions of others' school engagement helped form their racial identities, as they spoke of how teachers treated different students or groups of students differently based on race, gender, or ability. Additionally, the fact that many of the boys had no Black peers in their math classes led to a sense of isolation and "otherness." However, the sense of otherness shifted during the summer program when the boys were given the opportunity to engage with other Black math students like them. Having the opportunity to experience the summer camp with peers that looked like them helped shape the boys' identities in a positive manner. After reviewing their data, the researchers suggested that teachers provide a learning environment consisting of challenging work and high expectations coupled with scaffolding and support, when necessary, to foster the development of the mathematical identities of Black boys in their classrooms.

In a similar study, Berry et al. (2014) conducted a qualitative meta-synthesis of studies seeking counternarratives of Black students that had experienced success in mathematics. The researchers identified three common themes: awareness and access, images, and agency. Students gained awareness, often through reflection, of instances where access was either denied or restricted. Access issues included not only access to advanced curricula and classes, but also higher teacher expectations. In each case, the students perceived that access had been restricted due to their race. Berry et al. (2014) defined images as learners' self-identities and their perceptions of how they were viewed by others. Often, academic identity was at odds with racial identity, to the point that several studies considered the intersection of being both Black and a mathematician as an anomaly. Students felt that it was necessary to continually prove their worth. The degree to which students internalized access inequities and were able to reconcile their identities as both Black and successful mathematicians led to the development of student agency. Students that developed a strong sense of agency tended to persist and experience success while learners with a low sense of agency tended to struggle and follow the default pathway for Black learners in low-track courses. Based on these analyses, the researchers (Berry et al., 2014) concluded that curriculum reform and a slogan such as “mathematics for all” is not enough to create equitable educational opportunities for Black learners.

Martin (2012) emphasizes two key ideas: the diversity among Black students in the United States and the resiliency displayed by these same students. There is ample evidence to support the claim that Black students do not perform as well mathematically as their White peers (Georgia Department of Education, 2019; National Center for Education Statistics, 2019). However, blackness is not the most salient aspect of children’s development, therefore this claim should not be accepted without an examination of the reasons for this achievement gap. Martin (2012) states research is needed to investigate the phenomenal realities of Black learners’ mathematics self-efficacy and identities. What does it mean to “learn mathematics while Black?” The author suggested that future research explore how knowledge base, heuristics, metacognition, beliefs, and practices form mathematics socialization and identity experiences for Black students.

In an attempt to explain the achievement gap, Kotok (2017) investigated the effects that self-efficacy and mathematical identity had in relation to the achievement/opportunity gap. Using archival data from the High School Longitudinal Study of 2009 (HSLS:09), Kotok (2017) collected data on the relationships between student self-efficacy and mathematics identity for White, Asian, Black, and Latinx students. After analyzing data from high-achieving students, Kotok (2017) reported that Black students had the highest self-efficacy, but the lowest measure of mathematical identity. Asian students held a significantly higher math identity ($\beta = 0.64$, $p < .001$) than their White peers but the lowest self-efficacy. Although Latinx students had significantly lower math identities than their White peers ($\beta = .55$, $p < .001$), self-efficacy was comparable between the two groups with a non-significant relationship. Kotok noted that significantly more Asian students ($\beta = .83$, $p < .001$) were on an advanced math track and suggested that lower self-efficacy may be due to more difficult coursework. Fewer Black and Hispanic students were on the advanced math track than their White peers, although this finding was only significant for Hispanic students ($\beta = .62$, $p < .01$). The researcher suggested that a positive association between achievement and self-efficacy existed but noted that the effects of self-efficacy varied with ethnicity. Whites and Hispanics exhibited higher achievement in 11th grade when they had higher self-efficacy, but Blacks scored lower in spite of holding a high self-efficacy. Kotok (2017) suggested this may be due to BFLPE, where students experience an above-average efficacy due to matriculating in a below-average environment.

Links Between Self-Efficacy, Mindset, and Identity

Brenner et al. (2018) examined the relationship between self-efficacy and identity theory in an effort to explain why racial and ethnic minorities “leak” from the STEM pipeline. Specifically, the researchers wanted to know how encouraging science self-efficacy in under-represented minority (URM) college students would increase their perception of a stronger science identity. The data were collected as part of The Science Study, a national panel study following URM college students in STEM fields and had 1,420 participants. Participants completed one survey each semester over the course of four semesters. Participants were 72%

female. Forty-nine percent of the respondents were Black and 39% were Latinx. All participants were majoring in a STEM field or other science-based major.

The researchers (Brenner et al., 2018) hypothesized that role-specific self-efficacy would be positively related to science student identity. Additionally, Brenner et al. (2018) hypothesized that the inverse would be true, that science identity would be positively related to role-specific self-efficacy. After structural model analyses, the researchers reported that both hypotheses were confirmed. A reciprocal relationship was observed between self-efficacy and science identity, with no clear antecedent as each construct influenced and contributed to the growth of the other.

While investigating the ontological perspectives of high school students' STEM identities, Verdin et al. (2018) found that students associated being a math person or a physics person as an innate trait or ability that one either possesses or lacks. The researchers conducted interviews with 17 students from three mid-western high schools, all of whom had some prior experience in a physics class, to learn how the students described what it meant to be a math, physics, or science person. The students repeatedly described a math person or science person as having a natural ability as well as possessing the capability to communicate and transmit knowledge to one's peers. Additionally, students stated that one must be interested in the subject to be considered that type of person. When asked about perceived access to STEM identities, students discussed math and science as being linked to innate abilities but also believed that anyone could be a math or science person if they worked hard enough or was interested in the subject. However, the students viewed physics and engineering as requiring extensive knowledge held only by super smart people. The researchers noted how student perceptions of math and science as subjects that anyone could be successful at if they try hard enough while physics and engineering seemed available for only an elite few with innate ability, were similar to fixed and growth mindsets (Dweck, 2006). These findings led the researchers (Verdin et al., 2018) to suggest that growth mindset practices in the classroom may help foster and develop students' STEM identities.

Another important predictor of college attendance and success in STEM fields is high school math achievement (Cribbs et al., 2020). In an effort to understand the effects that the motivational factors of identity, self-efficacy, and interest have on Grade 12 NAEP mathematics achievement, Bohrnstedt et al. (2020) analyzed data from the High School Longitudinal Study (HSLS:09). Data from approximately 3,200 students were collected during the 2009-10 school year when students were freshmen and again two years later when they were in 11th grade. These data were then cross-referenced with participants' math achievement on the NAEP assessment that students took in Grade 12. The HSLS:09 included items to measure the motivational factors of mathematical identity, self-efficacy, and interest as well as collecting demographic data from the participants. The researchers used structural equation modeling to examine the relationships between the variables. After analysis, the researchers reported Grade 9 achievement was related to Grade 11 identity ($\beta = 0.18$) and self-efficacy ($\beta = 0.11$). Additionally, Bohrnstedt et al. (2020) reported that although the percent with a strong math identity was small, it was stable (15.7%) at both time points. A strong relationship existed between mathematics identity at Grade 9 and Grade 11 ($\beta = 0.57$), as well as between math self-efficacy in Grade 9 and math self-efficacy at Grade 11 ($\beta = 0.25$). A reciprocal relationship was noted between math identity at Grade 9 and math self-efficacy at Grade 11 ($\beta = 0.27$) and math self-efficacy at Grade 9 and math identity at Grade 11 ($\beta = 0.13$).

Upon analysis of the demographic variables collected, the researchers (Bohrnstedt et al., 2020) reported females scored lower on math identity ($\beta = -0.29$) as well as felt less efficacious

(β = -0.36). When compared to Whites, Asian/Pacific-Islanders (β = 0.51), Blacks (β = 0.25), and Hispanics (β = 0.17) all scored higher on the identity rating, though the relationship was not significant for Hispanics. Additionally, Blacks (β = 0.44) and Asian/Pacific Islander (β = 0.43) reported feeling more self-efficacious than Whites. Socio-economic status (SES) was related to both identity (β = 0.10) and self-efficacy (β = 0.13).

Bohrnstedt et al. (2020) reported a strong correlation between math identity in Grade 9 and math identity in Grade 11. Grade 11 math identity (β = 0.27) and Grade 9 algebra achievement (β = 0.52) were strong predictors of Grade 12 NAEP math achievement. The researchers noted the relationship between Grade 9 self-efficacy and Grade 11 identity, which was the only variable of the three motivational constructs tested to strongly predict Grade 12 achievement. Additionally, the researchers were surprised to observe that neither Grade 9 self-efficacy, identity, nor interest had an effect on the difficulty of courses taken in Grade 11. Grade 11 course difficulty (β = 0.11) and Grade 11 educational expectations were also significant predictors of Grade 12 NAEP achievement. The researchers concluded by suggesting identity education for students to develop academic identities and thus help them achieve their academic goals. Perhaps with stronger mathematical identities, students will be more willing to take more difficult math classes and in turn will be better prepared to pursue STEM based college majors.

Identity Summary

In summary, one’s mathematical identity is whether one perceives oneself as a math person or not. A student’s mathematical identity arises from experiences, interests, and motivational factors that take place in the various communities to which he/she belongs (Anderson, 2007; Boaler, et al. 2002; Boaler & Greeno, 2000; Solomon, 2007). Mathematics instruction that allows students to form their own questions and retain a sense of agency helps to foster positive mathematical identity (Boaler & Greeno, 2000; Miller & Wang, 2019). Additionally, students develop stronger mathematical identities when they are able to imagine mathematics as relevant and necessary to their future and are able to align their academic identities with the identities of the communities of which they are members (Berry, 2008; Berry et al., 2014; Cobb et al., 2009; Cobb & Hodge, 2011; Cribbs et al., 2015; Wegner, 1998).

Summary of Literature Review

The focus of this chapter was to explore existing research relating to the key variables key in the research questions posed in this study. Self-efficacy is defined as one's beliefs about one's ability to accomplish certain tasks, such as being successful in math class. Prior mastery experiences have the strongest influence on self-efficacy (Usher, 2009; Usher & Pajares, 2006; Usher & Pajares, 2009). For lower achieving students that don't have as many mastery experiences, vicarious experiences and social messages from others are a key influence (Butz & Usher, 2015; Usher, 2009; Usher & Pajares, 2006; Usher, Ford, et al., 2019). Additionally, evidence exists to suggest that self-efficacy levels affect the achievement and motivation of adolescents (Grigg et al., 2018; Komarraju & Nadler, 2013).

Growth mindset refers to the implicit belief that intelligence and abilities are malleable and dynamic (Dweck, 2006). It is possible to encourage a growth mindset through interventions (Blackwell et al., 2007; Samuel & Warner, 2019; Yeager et al., 2019). Additionally, growth mindset interventions have been shown to increase student motivation and achievement, especially for lower-achieving students (Komarraju & Nadler, 2013; Yeager et al. 2019). Furthermore, growth mindset has been shown to predict self-efficacy (Huang et al., 2019).

Mathematics identity is a complex concept influenced by prior knowledge, interest and engagement, alignment with core personal identity, and a sense of belonging (Anderson, 2007;

Boaler et al., 2000; Boaler 2002). Students with a positive mathematics identity tend to view themselves as valuable members of a larger mathematics community in which they have established agency (Boaler et al., 2000; Anderson, 2007; Wenger, 1998). Additionally, there is evidence to suggest a reciprocal relationship between self-efficacy and mathematical identity (Bohrnstedt et al., 2020).

However, a gap in the knowledge persists as to how mathematical self-efficacy and growth mindset interact with each other as well as how these two constructs affect the development of mathematical identity in middle school students. Much of the existing research focuses on urban or suburban populations (Usher, Ford, et al., 2019) or students at the secondary level. This study contributes to the body of knowledge by examining the relationship between these two variables and investigating the effect that they have on the mathematical identity of adolescents in a rural South Georgia charter school.

Table 1 summarizes key points in the existing research on self-efficacy, growth mindset, and math identity.

Table 1

Key Points in Existing Literature

Self-Efficacy and Growth Mindset				
Authors	Purpose	Participants	Design/ Analysis	Outcomes
Marsh et al. (2019)	To determine whether self-efficacy and self-concept are the same.	3350 German students in Grades 4-8.	Quan- SEM	• Generalized self-efficacy, outcome expectancies, & self-concept were the same (*r* > .9). • Self-efficacy looks ahead and self-concept is based on past experiences. • Generalized self-efficacy is distinct from (task specific) test-related and functional self-efficacy.
Usher (2009)	To determine sources of middle schoolers math self-efficacy.	Eight Grade 8 students in a suburban public middle school in the SW U.S.	Qualitative- Interviews	• High self-efficacy also had high achievement. • Low self-efficacy struggled. • Males' self-efficacy was from mastery experiences • Females and minorities self-efficacy were from vicarious/social messages • Internal dialogues affected self-efficacy, similar to mindset messages. • Messages from parents and teachers can affect students' perceptions of their capabilities.
Butz & Usher (2015)	To investigate what makes students feel more confident in reading and math.	2511 in Grades 4-8 in small eastern city. 50% female 53% White 30% Black 10% Hispanic 53% SES	Mixed- Qual -> Quan Qual- coding of open-ended Qs to fit Bandura's 4 constructs of SE Quan- took responses and coded with 4 SE constructs. Then did Quan analysis	• Mastery experiences and social persuasion were prominent sources of self-efficacy. • Girls reported social contexts more than boys. • Students made social comparisons with their peers. • Teachers were a primary source of confidence for both high- and low- self-efficacy students.

(continues)

Table 1 *(continued)*

Authors	Purpose	Participants	Design/ Analysis	Outcomes
Usher et al. (2019)	To examine experiences that affect SE in students in a rural high poverty area.	673 students in Grades 6-12. 98% White. 100% F/R lunch	Mixed- Quan→Qual	• Mastery experience (positive) & psychological state (negative) were significant predictors of self-efficacy. • Social persuasions did not affect self-efficacy. (Quan) • Girls reported more vicarious experiences and reported social experiences as having an effect on their confidence. • Boys seemed to have a fixed mindset, thinking either they could do the work or not.
Blackwell et al. (2007)	To examine the link between implicit theories and achievement.	HS school students in a public school in NYC	Quan→Quan Path analysis, Experimental ANCOVA	• Mindsets can be developed through interventions • Students with a growth mindset had stronger learning goals which lead to increased achievement. • Teaching incremental theory led to increase student motivation.
Huang et al. (2019)	To test a model of math/science career interest from math anxiety, math SE, and implicit theories while controlling for math ability level. Also, to see if these variables differed by gender.	152 7th grade students in a rural middle school in U.S. Mostly White 35% F/R lunch	Quan- Pearson correlations ANCOVA Path analysis	• Self-efficacy and growth mindset had significant correlation for boys but not girls. • No correlation between math anxiety and growth mindset for boys or girls. • When controlling for math level, growth mindset predicted self-efficacy for girls and boys. • Math level predicted growth mindset for boys, but not girls.
Komarraju, M., & Nadler, D. (2013)	To determine how motivational constructs, cognitive strategies, and resource management predicted achievement.	407 Undergrads enrolled in an Intro to Psychology course	Quan- Surveys analyzed with MANCOVA	• Positive correlation of self-efficacy and growth mindset for boys but not girls. • Math self-efficacy is negatively correlated with math anxiety for boys & girls. • Math self-efficacy is positively correlated with math/science career interest for boys and girls. • Growth mindset does not correlate with math anxiety.

(continues)

Table 1 *(continued)*

Authors	Purpose	Participants	Design/ Analysis	Outcomes
Kotok, S. (2017)	To explore achievement gaps that widen for high performing students of different ethnicities as they go through high school	Data from HSLS:09	Quan- multi-level modeling.	• Students with higher self-efficacy have better achievement and are better able to self-regulate. • Students with low self-efficacy tend to have fixed/entity theory of intelligence. • Students with high self-efficacy pursue mastery goals instead of performance goals.
Yeager et al. (2019)	To reports on the results of the National Study of Learning Mindsets: which investigated whether a growth mindset intervention increased academic achievement.	12,490 Grade 9 students randomly sampled from 65 public high schools that participated in the study.	Quantitative	• Growth mindset interventions increase achievement, especially among low achievers. • Growth mindset increased likelihood of taking more advanced math courses. • Growth mindset effects on GPA were stronger in mid- and low achieving schools than in higher achieving schools. • The intervention promoted higher grades in schools where peer norms were supportive of intellectual challenges.
Usher, E., & Pajares, F. (2009)	To develop a survey to measure math self-efficacy of middle school students	3 Phases- First just with 6th graders, next two with 6.7.8 grades. All in upper/middle class suburban middle schools in SE U.S.	Confirmatory Factor Analysis	• Teaching practices (feedback, sensitivity, and activities) were associated with SE through expectancy and task beliefs. • Expectancies had a larger effect on self-efficacy for White students. • Task value had a larger effect on self-efficacy for Black students. • Motivation was positively linked to teaching practices for Black students. • Cost and math self-efficacy were not significant.

(continues)

Table 1 *(continued)*

Math Identity				
Authors	Purpose	Participants	Design/ Analysis	Outcomes
Verdin et al. (2018)	To see how students develop and perceive STEM identities	17 students from the Midwest and Mountain Regions	Qual- student interviews	• Four sources of self-efficacy correlated significantly with math self-efficacy and with motivation constructs of math self-concept, invitations, task goals, and optimism. • Mastery experience was the most powerful form of self-efficacy. • Math person or science person needs to be smart • Interest in a subject is important to be "that kind of person"
Cribbs et al. (2015)	To understand how students' perceptions of interest, competence, performance, and recognition influence their math identity.	9000 college calculus students across the U.S.	Quan- SEM	• Interest and recognition had a direct effect on math identity. • Competence/performance had an indirect effect through recognition & interest. • Competence/performance effect was strongest through recognition (vicarious messages). • Recognition had the strongest effect on math identity.
Miller & Wang (2019)	To investigate teaching practices that influence math identity	525 Grade 6 students that were part of a STEM study across Mid-Atlantic states	Quan- surveys analyzed with Structural Equation models	• Teaching practices were assoc. with math identity through expectancy & task value. • White through expectancies & Black through task value. • Expectancy beliefs also predict math identity.
Bohrnstedt et al. (2020)	Longitudinal analysis of math identity, self-efficacy, interest & relationship to math achievement.	Overlap sample of data from HSLS:09 & NAEP (2013)	Quan- SEM	• Self-efficacy in 9^{th} was sig. predictor of math identity in 11^{th}. • Math identity in 9^{th} was sig. predictor of self-efficacy in 11^{th}. • Math identity in 12^{th} had a direct effect on achievement. • Higher SES predicted stronger Math identity, self-efficacy, and interest. • Math identity of males > females • Math identity of Asian and Blacks > Whites

Chapter III: Methodology

Adolescence is a time of much physical, emotional, and mental growth. (NMSA, 2003). It is during these formative years that students begin to develop a sense of personal agency and establish their own identity (Bandura, 2005; Hamman & Hendricks, 2005; Weil et al., 2013). Little evidence exists in the literature as to the effect that mathematical self-efficacy and growth mindset have on the mathematical identity of adolescents. Additionally, most of the research has been conducted in urban or suburban settings with students at the secondary or post-secondary level (Usher, Ford, et al., 2019). This study contributes to the body of knowledge by investigating whether a correlation exists between mathematical self-efficacy, growth mindset, and math identity of students in a rural South Georgia charter school. Additionally, this study investigated whether differences exist between these constructs for students with different demographic backgrounds and math achievement levels.

End of Grade (EOG) assessment scores for students at the Charter School have consistently been below the state average. There is evidence that growth mindset interventions increase student self-efficacy and achievement (Blackwell, et al., 2007; Samuel & Warner, 2019; Yeager et al., 2019). It is possible that by better understanding the relationships between the variables under investigation, administrators and teachers at the Charter School may be able to incorporate strategies to strengthen the math identities of middle school students (Miller & Wang, 2019).

The purpose of this study was to examine the effects of mathematical self-efficacy and growth mindset on the development of math identity of middle school students at a rural South Georgia charter school. Additionally, the study investigated whether differences exist in mathematical self-efficacy, growth mindset, and math identity based on student gender, ethnicity, socio-economic status, or math achievement level (MAP Growth score). This chapter begins with an explanation of the constructivist grounded theory that will guide the data collection in this explanatory sequential study. Next, the role of the researcher is explained in the context of this study. Data collection procedures are outlined with supporting empirical evidence. Data analysis methods are then presented for both the quantitative and qualitative portions. The chapter concludes with a brief summary of the methodology used to shape the study.

Research Design

This constructivist grounded theory study utilized a mixed methods explanatory-sequential design. Explanatory sequential design was selected by the researcher because it allows the researcher to first gather quantitative data which are then analyzed and used to guide participant selection for qualitative data collection (Cresswell & Cresswell, 2018). Qualitative data analysis allows the researcher the opportunity to investigate participant responses and explain the quantitative results. Expanding on Glaser's (2007) "all is data" maxim, many grounded theory researchers choose to begin data collection with a quantitative survey and use the results to identity participants with purposeful sampling for the interview portion of qualitative data analysis (QDA; Birks et al., 2019). Explanatory sequential design is appropriate for constructivist grounded theory studies as the first round of quantitative data analysis will be used to refine qualitative data collection. This study began with a student survey developed to examine the relationships between mathematical self-efficacy, growth mindset, and math identity of middle school students in a rural South Georgia charter school. Additionally, the researcher integrated student-level demographic data to investigate whether patterns existed within certain subgroups. Qualitative data was collected through individual semi-structured interviews with students to help the researcher understand how students' perceptions and interpretations of their mathematical self-efficacy and growth mindset influenced the development of their mathematical identities. Once themes emerged from the qualitative data collection and analysis, the researcher triangulated the data to form a grounded theory.

The questions that this study aims to answer are:

Research Question 1 (RQ1): What is the relationship between the mathematical self-efficacy, growth mindset, and mathematical identity of middle school students?

Research Question 2 (RQ2): What are the differences in students' math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level?

Research Question 3 (RQ3): How do student perceptions of mathematical self-efficacy, growth mindset, and math identity differ based on math identity level?

First, a Google Form was used to create a student survey collecting quantitative data for RQ1. Survey data then was then merged with student demographic data (RQ2). The researcher used a spreadsheet to analyze student responses to formulate additional interview questions for semi-structured interviews to explore RQ3. Guiding questions for the interviews are listed in Appendix D. The researcher selected thirty students for individual interviews: thirteen with weak mathematical identity, five with typical math identity, and twelve with strong math identity. While the quantitative data determined whether correlations existed between mathematical self-efficacy, growth mindset, and mathematical identity, the qualitative data allowed the researcher to better understand the *why* of these relationships. The researcher was able to dig deeper into student perceptions and discover factors that may reinforce or diminish students' mathematical identity, including the student-level factors.

Role of the Researcher

The researcher's role in this study was that of an observer. The researcher was not acquainted with participants due to the structure of the Charter School. The 2021-2022 school year was the first year the researcher has been employed by the Charter School, and the researcher serves as a high school Algebra teacher. The researcher was careful to not interact with or form pre-conceived biases of middle school students or teachers prior to data collection. The Charter School does not currently utilize vertical alignment professional learning opportunities, so the researcher had no interaction with middle school teachers pertaining to instructional strategies or the variables under investigation before the commencement of the study. Additionally, the researcher avoided exposure to middle school students and teachers so as not to form bias regarding participant perceptions of mathematical efficacy, mathematical mindset, or mathematical identity. However, the participants will likely have the researcher as an instructor in the future, so care was taken to ensure objectivity. Letters of intent/consent (Appendix B) were presented in a Google Form and emailed to parents and participants. The consent form outlined the procedures the researcher used to maintain data confidentiality. Confidentiality was ensured through the use of four-digit student lunch (PIN) numbers. The consent form also assured parents and participants that any data collected would not bias the researcher towards students in future academic classes in which the researcher may be assigned as instructor of record. Reported results were generalized to avoid any future bias towards particular students. Student names were not attached to survey results or demographic data. The researcher is the only person who had access to the confidential survey results and all data will be deleted within a year of the completion of the study.

Constructivist grounded theory assumes researcher bias throughout the data collection process (Charmaz, 2008; Mills et al., 2006). During the course of this study, the researcher took care while facilitating the interviews to not guide student responses based on pre-conceived opinions. Initial interview questions are presented in Appendix D. The interviews were semi-structured to allow the researcher to follow-up on student responses in real time.

The researcher also acted as an investigator during the course of data collection, subsequent analysis, and integration. The researcher met with the School Administrator to explain the purpose and procedures of the study as well as to request permission to access student demographic data. The researcher followed appropriate procedure to ensure participant safety, confidentiality, and privacy in accordance with the Family Educational Rights and Privacy Act (FERPA) during the course of the study. All student information was coded using students' 4-digit PIN. The researcher maintained a separate password protected spreadsheet with names and PINs for the purpose of identifying students for interviews, but all survey and demographic data was identified with PIN only. The researcher was the only person with access to the merged survey, demographic, and math achievement level data. Upon completion of the study, the researcher served as an advisor when presenting results to administrators along with implications for student growth and improvement.

Participants

The participants for this study were a convenience sample of Grade 7 and Grade 8 students at a rural South Georgia charter school. The sample was selected due to the researcher serving as a teacher in the high school of the Charter School and at the request of school administration to better understand adolescent perceptions of mathematical self-efficacy, mathematical growth mindset, and mathematical identity.

The sample for RQ1 and RQ2 was composed of 91 students: 47 students from Grade 7 and 44 students from Grade 8 students. An *a priori* G*Power analysis indicated that a minimum sample size of 96 participants would be sufficient to achieve a power of 0.80 with a *p*-value of 0.05 and an effect size of 0.0625. Each grade level was composed of one “team” of teachers. Four classes of students rotated through four academic teachers: science, math, ELA, and social studies. Students also participated in physical education and connections classes such as agriculture, computer coding, or drama. With the exception of connections, students were homogeneously grouped with students of similar ability level for all four academic courses for the duration of middle school. Ability level was determined by multiple criteria including but not limited to Georgia Milestones Assessment scores, prior years’ performance on the normed MAP Growth assessment, final yearly average in class, and teacher observations and recommendations. Due to limited special education staff on campus, students that required special education services were grouped together into one section. Similarly, students that required gifted services were grouped together. Class size was also a factor in grouping students; administrators aimed to keep the numbers balanced in each course section.

Participants for qualitative data collection (RQ3) were composed of an embedded sample from the 91 survey participants. First, the researcher used quantitative data collected from the student survey to select students to participate. A spreadsheet was created that sorted students by grade level and identified them only by their 4-digit PIN. The composite scores for self-efficacy, growth mindset, and math identity were listed. The researcher then used the descriptive data for the composite scores for self-efficacy and growth mindset to determine whether students possessed a weak, typical, or strong measures of self-efficacy and growth mindset. Values one standard deviation below the composite mean were considered to be weak and values one standard deviation above the composite mean were considered to be strong. To determine math identity level, students with a composite rating of 4 – 6 on the math identity survey items were considered to have a strong math identity, while students with a composite rating of 0 – 1 on the math identity survey items were considered to have a weak math identity. Students with composite math identity ratings of 2 – 3 were considered to possess median or typical math identity. The researcher then used color to code values that represented weak (red), typical (yellow), and strong (green) scores for each of the three constructs measured. From this list, the researcher looked for anomalies, such as students scoring high on one measure and low on the others. Additionally, the researcher used scatter plot graphs of the data sets to be sure that any students whose data represented outliers were included in the qualitative data collection. The researcher also looked for students whose cells were all red or all green. The researcher sought to select about the same number of Grade 7 students as Grade 8 students. The researcher then compared the selected students with school demographics to ensure a representative sample was included. The final step in selecting interview participants was to double check to be sure that all students had parental consent to be interviewed.

Instruments

The researcher used items from pre-existing surveys to compose the instrument for this study (Appendix C) which collected data for the first research question (RQ1). The first item in the survey collected student lunch (PIN) numbers. This four-digit number was used subsequently to identify students for interviews. Next, five questions were presented to obtain a measure of mathematics self-efficacy. These questions were the self-efficacy items that Huang et al. (2019) adapted from the Patterns of Adaptive Learning Scale (PALS; Midgely et al., 1998) and used to investigate the effect of math anxiety, self-efficacy, and growth mindset on the career interest of

Grade 7 students. These self-efficacy questions were 5-point Likert-style response items that asked students to rate their agreement with statements such as "I am certain I can master the skills taught in my math class this year" on a scale from "not at all true" to "very true." The five self-efficacy items were found to be acceptably reliable (α = .797). Mathematics growth mindset was measured with eight 6-point Likert-style questions that Huang et al. (2019) adapted from Dweck's (1999) growth mindset instrument. Four of these questions were framed with a growth mindset perspective, while the other four reflected a fixed mindset. The fixed mindset questions were reverse coded during quantitative analysis to ensure reliability and give an overall composite score of growth mindset. The eight growth mindset items were found to be reliable (α = .789). Permission to use these self-efficacy and growth mindset items for the current instrument is presented in Appendix F. Finally, mathematics identity was measured with two items: "I see myself as a math person" and "Others see me as a math person" (Bohrnstedt et al., 2020 & Cribbs et al., 2015). Permission to use these items is presented in Appendix G. The math identity scale, consisting of two items, was found to be reliable (α = .787). These questions, which were used in the High School Longitudinal Study 2009 (HSLS:09; Bohrnstedt et al., 2020), were followed with short answer "why?" questions. Student responses to these "why" items were used in the first round of qualitative data analysis and were explored more deeply as part of the student interviews. Table 2 presents the survey items that were used as well as the scoring values for each student response.

Table 2

Survey Items and Scoring for Measured Constructs

Measured Construct	Survey Items	Scoring
Self-Efficacy	• I am certain I can master the skills taught in my math class this year. • I am certain I can figure out how to do the most difficult work in my math class. • I can do almost all the work in my math class if I don't give up. • Even if the work is hard in my math class, I can learn it. • I can do even the hardest work in my math class if I try.	0 = Not at all true 1 = Slightly true 2 = Somewhat true 3 = True 4 = Very true
Fixed Mindset (reverse coded)	• You have a certain amount of math intelligence, and you can't really do much to change it. • Your math intelligence is something about you that you can't change very much. • No matter who you are, you can significantly change your math intelligence level. • To be honest, you can't really change how intelligent you are in math.	0 = Strongly Agree 1 = Agree 2 = Mostly Agree 3 = Mostly Disagree 4 = Disagree 5 = Strongly Disagree
Growth Mindset	• You can always substantially change how intelligent you are in math. • You can learn new things, but you can't really change your basic math intelligence. • No matter how much math intelligence you have, you can always change it quite a bit. • You can change even your basic math intelligence level considerably.	0 = Strongly Disagree 1 = Disagree 2 = Mostly Disagree 3 = Mostly Agree 4 = Agree 5 = Strongly Agree
Math Identity	• You see yourself as a math person. • Others see you as a math person.	0 = Strongly Disagree 1 = Disagree 2 = Agree 3 = Strongly Agree

Note. Responses to the two Math Identity items were summed to create a composite score ranging from 0 – 6 (Bohrnstedt et al., 2020).

The second research question (RQ2) was investigated using student data provided by the Charter School. A spreadsheet containing student demographic information was provided by the registrar. Socio-economic status (SES) was determined by whether students qualified for free or reduced lunch, and math achievement level was determined using Measure of Academic Progress (MAP) Growth assessment scores. The MAP Growth assessment is a norm-referenced universal screener developed by the Northwest Evaluation Association (NWEA) that is used internationally by schools to measure student achievement and track student growth (NWEA, 2021). Students at the Charter School take this assessment three times each school year: fall, winter, and spring. Teachers, counselors, and administrators examine the results of each administration for progress monitoring as well as to plan acceleration and remediation opportunities. NWEA has established norms for the MAP Growth assessment based on grade level and administration time. Students are ranked with a national percentile based on their achievement scores. The MAP Growth assessment uses five levels to rank student achievement in the nationally normed percentiles:

- 1^{st} – 20^{th} percentile is considered far below average,
- 21^{st} – 40^{th} percentile is considered below average,
- 41^{st} – 60^{th} percentile is considered average,
- 61^{st} – 80^{th} percentile is considered above average,
- 81^{st} percentile or higher is considered far above average.

For the purposes of this study, the researcher considered students scoring in the 1^{st} – 34^{th} percentile to be below average, 35^{th} – 67^{th} percentile to be average, and 68^{th} percentile and higher to be above average.

The third research question (RQ3) was explored using student interviews. The interview protocol is presented in Appendix D. By asking students specific questions about their perceptions of mathematical self-efficacy and growth mindset, the researcher sought to better understand how these constructs influenced students' perceptions of how they identified as "math people."

Validity and Reliability

The five self-efficacy items were taken from an adaptation of the Patterns of Adaptive Learning Scales (PALS; Midgley et al. 1998) first used by Griggs et al. (2013) and later by Huang et al. (2019). The Academic Efficacy subscale of PALS uses a 5-point Likert scale and has been validated using confirmatory factor analysis and has been administered to multiple samples. The Academic Efficacy subscale was deemed to have both construct validity as well as discriminant validity (Midgley et al., 1998). The reliability coefficient for the self-efficacy items for this study was $\alpha = .797$.

Growth mindset was measured using an adaptation of Dweck's 8- item Growth Mindset Scale (Dweck, 1999). Huang et al. (2019) adapted the items to read from a mathematical perspective. For example, the original item read "*Your intelligence is something you cannot change very much*" the adapted item read "*Your math intelligence is something you cannot change very much."* The Growth Mindset Scale is measured with a 6-part Likert scale. Four of the items are positively worded, to obtain a measure of growth mindset; and four of the items are negatively worded to obtain a measure of fixed mindset. For this study, as in Huang et al. (2019), the negatively worded items were reverse coded to obtain a measure of growth mindset. Dweck's (1999) Growth Mindset Scale has been used numerous times over the past two decades and has been proven to be both a valid and reliable instrument with numerous different sample populations (Midkiff, et al., 2017; Mindset Works, Inc., 2015). Midkiff et al. (2017) conducted an item response theory (IRT) examination of the Growth Mindset Scale and concluded that the four positively worded items were a better indicator of growth mindset than the negatively worded items were an indicator of a fixed mindset. However, the scale was deemed to be valid after analysis for known groups validity and discriminant validity. Cronbach's alpha for the growth mindset items used in this study was α = .789.

Mathematics identity was measured using two items, each with a 4-part Likert scale. These items were validated using both exploratory and confirmatory factor analyses as part of the NHLS:09 data analyses (Bohrnstedt et al., 2020). For this study, the reliability coefficient for the math identity items was α = .787.

Constructivist grounded theory relies on the practice of constant comparison to ensure validity of results. As themes began to emerge during qualitative analysis, the researcher continually referred back to the qualitative data and survey responses that had previously been collected. It is important to keep the words of participants intact throughout analysis (Mills et al., 2006) as the researcher uses personal experience to interpret findings and form a theory. For this study, In Vivo coding was used to maintain the participants' voice during the first cycle of qualitative data analysis. The researcher has over 20 years of classroom experience and incorporates many strategies to strengthen self-efficacy, growth mindset, and math identity into instruction. For this reason, inter-rater reliability was not used to calculate a Kappa coefficient of reliability, as no other researcher could view the data through the same lens. However, the researcher sought the opinion of a colleague, who served as a critical friend throughout the study, after the first cycle of coding to verify accuracy of codes and emergent themes. The colleague was in agreement with all codes the researcher had recorded. Methodological triangulation (Turner and Turner, 2009) of qualitative and quantitative data further ensured the reliability of the codes.

Data Collection

Quantitative

The researcher created a Google Form to be used as the survey instrument to collect quantitative data for RQ1. On the date of the survey administration, the researcher emailed the link to participating Grade 7 and Grade 8 students whose parents granted consent. Student email addresses were provided by the registrar. The researcher used the summary report in the Google Form for parental consent to maintain a roster of participating students. These data were exported to a spreadsheet owned by the researcher containing parents' names, students' names, and students' email addresses.

On the day of the survey, the researcher emailed a link to the Student Consent and Survey Google Form (Appendix C) to all students whose parents granted permission to participate. Homeroom teachers were provided with a roster of participating students and a script (Appendix E) to read as students logged in to their Chromebooks, checked their email, and began the survey. After the informed consent items, students were presented with a question asking whether they wished to proceed. Students who did not agree to participate in the survey exited the form before the survey items were presented. Teachers monitored the students during the survey and checked off student names on the provided roster when students submitted the form. Student emails were not collected. Students were only allowed to submit one response to the survey. The survey collected four-digit student PINs which were used to identify participants for subsequent interviews. The time required to complete the survey was approximately 15 minutes. Students received a small candy reward in appreciation for their participation.

Data for RQ2 was gathered upon completion of the student surveys. The school registrar provided the researcher with a spreadsheet containing student names, demographic information, and PINs. Demographic information included gender, ethnicity, and eligibility for free/reduced lunch (SES). The middle school principal provided the researcher with spring MAP Growth scores which students took in April 2022, and the researcher grouped the students into three achievement levels, below-average, average, and above average based on the students' norm-referenced percentile score. To ensure student privacy, the researcher created a password protected spreadsheet correlating student lunch numbers with these data. The researcher then merged these data sets: survey responses, demographic information, and MAP Growth scores together into a separate password protected spreadsheet with the PIN as the identifying marker for each student's information.

Qualitative

The second round of data was collected through individual semi-structured interviews. Purposeful and embedded sampling were used to select interview participants from the overall sample. Thirty students were interviewed: 15 from Grade 7 and 15 from Grade 8. Thirteen students possessed a weak math identity, 5 measured as having a typical math identity, and 12 were strong math identity. Individual interviews took place in the high school conference room over a five-day period of time during the students' Physical Education (PE) class. The researcher spoke with students with strong math identity on days 1 and 2, typical math identity on day 3, and weak math identity on days 4 and 5. All interviews were video recorded for clarity of tone as well as to allow the researcher an opportunity to study the physical demeanor and body language of participants as they answered questions. Each interview lasted approximately 15 minutes. The interview protocol is presented in Appendix D.

Data Analysis

Quantitative

The first research question, “What is the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students?” was investigated via data from the Google Form that students complete. Measures of mathematical self-efficacy, growth mindset, and math identity were calculated for each student. Responses to the five self-efficacy items math were added to obtain composite scores ranging from 0-20. Similarly, responses to the eight growth mindset items were added to obtain a composite score ranging from 0-40 (Castella & Byrne, 2015). The items that measured fixed mindset were reverse coded, so the total mindset score gave a measure of growth mindset (Castella & Byrne, 2015; Huang et al., 2019). Scores for the two math identity items were summed to create a composite score of 0-6 (Bohrnstedt et al., 2020).

SPSS was used to calculate descriptive data and reliability of the instruments used for the three variables under investigation. Self-efficacy was measured with a five item, 5-point Likert scale. Responses to these items were then summed and rated on a composite scale ranging from 0 – 20 (M = 13.38, SD = 3.73, α = .80). Growth mindset was measured using eight items on a 6-point Likert scale. These responses were summed to obtain a composite score ranging from 0 – 40 (M = 29.84, SD = 5.93, α = .79). Mathematics identity was calculated using two items with 4-part Likert responses (M = 3.07, SD = 1.58, α = .79) and had a range from 0 – 6.

To determine whether a student scored in the weak, typical, or strong range for self-efficacy and growth mindset, the researcher used the descriptive data. Students that scored one standard deviation below the mean, 0 – 9 on self-efficacy and 0 – 22 on growth mindset, were considered to be weak (below average). Students that scored one standard deviation above the mean, 17 - 20 on self-efficacy and 37 – 40 on growth mindset, were considered to be strong (above average). Students that had a composite score within one standard deviation of the mean were considered typical.

However, the range for math identity was much smaller, from 0 – 6. The math identity score was obtained when students selected one of four Likert-style responses for each item: 0 = *strongly disagree*, 1= *disagree*, 2 = *agree*, or 3 = *strongly agree*. With a standard deviation of $SD = 1.58$ and a mean value of $M = 3.07$ it did not make sense to use the same process to determine weak, typical, or strong math identity. As a result, the researcher opted to consider students with a math identity score of 4 – 6 as having a strong math identity. In order for students to obtain a math identity score of 4, they had to have answered "agree" to both questions: *I see me/others see me as a math person.* Students scoring a 0 – 1 on math identity were considered to have a weak math identity, as they had to have answered "strongly disagree" to at least one of the items. Students scoring a 2 – 3 were considered to have a typical math identity.

The composite scores of each construct that were calculated for each participant were used to compute Pearson correlation coefficients in SPSS. Next the researcher performed a multiple regression analysis of the data. The regression equation predicting the mathematical identity matrix ($\boldsymbol{Y_{MI}}$) is shown below. B_0 represents the *y*-intercept, β_{SE} represents the coefficient matrix of self-efficacy, the first predictor variable ($\boldsymbol{X_{SE}}$), and β_{GM} represents the coefficient matrix of growth mindset, the second predictor variable ($\boldsymbol{X_{GM}}$). The model error is represented by **ε**.

$$\boldsymbol{Y_{MI}} = \beta_0 + \beta_{SE}\boldsymbol{X_{SE}} + \beta_{GM}\boldsymbol{X_{GM}} + \varepsilon$$

β_{SE} measures how much math identity changes as self-efficacy changes by one unit while holding growth mindset constant. Likewise, β_{GM}, is a measure of how math identity changes as growth mindset changes by one unit while holding self-efficacy constant. Positive β values indicate that as self-efficacy or growth mindset increase, so does math identity. Negative β values indicate an inverse relationship, where stronger self-efficacy predicts weaker math identity or stronger growth mindset predicts weaker math identity. A p value of 0.05 was used to determine statistical significance of the β coefficients, as to whether one or the other significantly affects the outcome, $\boldsymbol{Y_{MI}}$.

The hypotheses for RQ1 are as follows:

H_0: There is no significant effect on math identity due to either self-efficacy or growth mindset; H_0: $\beta_{SE} = \beta_{GM} = 0$.

H_A: There is a significant effect on math identity due to either self-efficacy or growth mindset; H_A: Either $\beta_{SE} \neq 0$ or $\beta_{GM} \neq 0$.

The following assumptions for multiple linear regression were met.

- Linearity was determined using scatter plots with self-efficacy versus math identity and growth mindset versus math identity.
- Multicollinearity was determined by calculating the variance inflation factor (VIF) for each predictor variable. VIF < 10 was considered acceptable.
- Normality was determined by examining the histograms of the data points to ensure fit to the normal curve. Additionally, Q-Q plots were used to ensure the residuals follow the regression line. Scatter plots of the residuals will also be examined to determine whether outliers exist.
- Homoscedasticity was confirmed using scatter plots of the residuals versus the predicted values for each predictor variable.

Goodness of fit was determined with the correlation of multiple determination, $\boldsymbol{R^2}$. In multiple regression, $\boldsymbol{R^2}$ is the matrix that represents the sum of squares of the differences between estimated and predicted values. The closer $\boldsymbol{R^2}$ is to 1, the stronger the relation between the predictors and math identity.

To address the second research question (RQ2), "What are the differences in students' math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level?" the researcher used factorial multivariate analysis of variance (MANOVA) to analyze the student-level data. MANOVA is a statistical *F*-test used to compare possible interactions between two or more dependent variables (Mertler & Reinhart, 2017). Factorial MANOVA was used as there are four independent variables with distinct levels (gender, ethnicity, SES, and math achievement level) and three dependent variables (math self-efficacy, growth mindset, and math identity).

The equation representing the factorial MANOVA model Is $Y_{ijkl} = \mu + \alpha_I + \beta_j + \chi_k + \delta_l + (\alpha\beta)_{ij} + (\alpha\chi)_{ik} + (\alpha\delta)_{il} + (\beta\chi)_{jl} + (\chi\delta)_{kl} + (\alpha\beta\chi)_{ijk} + (\alpha\beta\delta)_{ijl} + (\alpha\chi\delta)_{ikl} + (\beta\chi\delta)_{jkl} + (\alpha\beta\chi\delta)_{ijkl} + \varepsilon_{ijklm}$ where μ is the overall mean; α_I, β_j, χ_k, δ_l are the main effects of gender, ethnicity, SES, and math achievement level; $(\alpha\beta)_{ij,}$ $(\alpha\chi)_{ik}$, $(\alpha\delta)_{il}$, $(\beta\chi)_{jl}$, $(\chi\delta)_{kl}$ are the two-way interactions; $(\alpha\beta\chi)_{ijk}$, $(\alpha\beta\delta)_{ijl,}$ $(\alpha\chi\delta)_{ikl}$, $(\beta\chi\delta)_{jkl}$ are the three-way interactions; and $(\alpha\beta\chi\delta)_{ijkl}$ is the four-way interaction.

The following assumptions for MANOVA were met.

- There were independent groups for all independent variables.
- A sufficient sample size with a minimum number of observations no less than the product of the number of dependent variables and the number of levels of the independent variables being tested, was achieved. In this case, a minimum of nine observations for each level tested.

- Linearity of the dependent variables was determined from prior RQ1 analysis of bivariate scatterplots to determine whether the scatterplots were elliptical and thus linear.
- Multi-variate normality among dependent variables was determined by Shapiro-Wilk's test to determine multivariate normality from prior RQ1 analysis.
- Homogeneity of the covariance matrices was determined using Box's M.
- Homogeneity of variances was determined with Levene's test.
- Collinearity was tested as part of RQ1 analysis with **R** < .9 considered acceptable.

The Box's M test was non-significant, $F(66, 2231) = 1.050$, $p = .368$, indicating heterogeneity of the covariance matrices so the researcher used the Wilks' Lambda statistic to interpret the MANOVA results. A *P*-value of 0.05 was used to test for statistical significance. The MANOVA was run to determine whether differences in the dependent (self-efficacy, growth mindset, and math identity) variable existed between gender, ethnicity, SES, and math achievement level. Individual ANOVAs were used post hoc to analyze differences between these independent variables on each construct (self-efficacy, growth mindset, and math identity).

The following hypotheses were tested as part of the analysis, where **μ** represents the vectors of the combined dependent variable.

H_{01}: There is no statistically significant difference in math self-efficacy, growth mindset, and math identity between males and females. H_{01}: $\boldsymbol{\mu}_{\mathbf{f}} = \boldsymbol{\mu}_{\mathbf{m}}$

H_{1}: There is a statistically significant difference in math self-efficacy, growth mindset, and math identity between males and females. H_{1}: $\boldsymbol{\mu}_{\mathbf{f}} \neq \boldsymbol{\mu}_{\mathbf{m}}$

H_{02}: There is no statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of White, or other (non-White) ethnic backgrounds.H_{02}: $\boldsymbol{\mu}_{\mathbf{white}} = \boldsymbol{\mu}_{\mathbf{notwhite}}$

H_2: There is a statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of White, or other (non-White) ethnic backgrounds. H_2: $\mu_{white} \neq \mu_{notwhite}$

H_{03}: There is no statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of low SES and students of typical SES (as determined by those that qualify for free or reduced lunch and those that do not).
H_{03}: $\mu_{F/R} = \mu_{notF/R}$

H_3: There is a statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of low SES and students of typical SES (as determined by those that qualify for free or reduced lunch and those that do not.)
H_3: $\mu_{F/R} \neq \mu_{notF/R}$

H_{04}: There is no statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of above average, average, or below average math achievement level. H_{04}: $\mu_{above} = \mu_{ave} = \mu_{below}$

H_4: There is a statistically significant difference in math self-efficacy, growth mindset, and math identity between or among students of above average, average, or below average math achievement level. H4: $\mu_{above} \neq \mu_{ave} \neq \mu_{below}$

The MANOVA was then followed post hoc with ANOVAs to determine whether differences existed between groups when the variables were considered independently from one another. A series of simple linear regressions were also conducted post hoc to determine whether predictive relationships existed between the dependent variables for the individual student factors of gender, ethnicity, SES, and math achievement level. Normality was determined by examination of the residual histograms and the linearity of the P-P plots of standardized residuals.

Qualitative

The third research question (RQ3): "How do student perceptions of mathematical self-efficacy, growth mindset, and math identity differ based on math identity level?" was investigated using first the student responses to the "Why?" survey questions and then through a series of individual participant interviews.

The first cycle of manual coding began with student responses to the "why" survey questions. The researcher used a spreadsheet to sort these responses into three groups, based on math identity level: weak, typical, and strong. The researcher then imported these data into the GoodNotes app on an iPad and began initial coding to analyze student responses. In Vivo codes were used through color and highlighting to pinpoint student comments that stood out (Saldaña, 2013). In Vivo coding, also known as verbatim coding, is appropriate for analysis of interviews with adolescents, whose voices may be marginalized as they tend to speak using current slang often using a vocabulary that evolves with popular culture and is not used by adults (Saldaña, 2013). Next, focused coding and highlighting were used in the second cycle to identify codes that occurred more frequently, thus developing categories and subcategories. Focused coding allowed for comparison across participant data (Saldaña, 2013). For example, comments from different students such as "I hate math," "I am not really fond of math," or "Math is my favorite subject" were all categorized under the theme "Like/enjoy" using focused coding. This process was facilitated by the ability to use the iPad and GoodNotes to annotate directly onto a .pdf document containing student responses. Once themes were identified, the researcher used magnitude coding (Saldaña, 2013) to calculate the frequency of responses for each theme by math identity level.

Interview data was coded in a similar fashion. The researcher recorded each interview on an iPad and transcribed the results into Microsoft Word once all interviews had been completed. Each student interview was saved as a separate document. To protect student anonymity, pseudonyms were used to identify interview participants instead of actual names. These results were exported to an Excel spreadsheet. Each row contained all responses from one student; each column contained all responses to a particular question. Having the questions in columns made it easier for the researcher to compare different student responses to the same question.

Additionally, three separate sheets were created within the Excel document according to the variable each group of questions investigated. Math identity questions were on one sheet, self-efficacy questions were on one sheet, and growth mindset questions were on another sheet. As before with survey responses, interview responses were sorted by math identity level. This allowed the researcher to look for commonalities among the perceptions of students with weak, typical, or strong math identities. The spreadsheet was imported into the GoodNotes App, and the researcher began the initial coding process of interview data using In Vivo methods (Saldaña, 2013).

During the first cycle of coding the researcher read down each column (question) seeking similar responses. Grounded theory researchers constantly compare responses as patterns begin to emerge from the data (Bernard & Ryan, 2010; Saldaña, 2013). When the researcher noticed several students responding in a similar way, color was used to highlight the responses. As the researcher studied the responses to each question, color and highlighting assisted in focused coding to determine the best themes for student responses. During the second cycle of coding, the researcher determined the frequency of codes in student responses.

The researcher noticed that students tended to answer differently and have different perceptions depending on the extent as to which they identified as a math person. This process allowed the researcher to compare qualitative data with quantitative data to determine whether patterns existed for students based on their math identity level. While analyzing the qualitative data, the researcher kept the results of the quantitative analysis in mind as themes and patterns began to emerge from the data.

The researcher used examples from student responses to justify these emergent themes. As this study follows a constructivist grounded theory approach, inter-coder reliability was not used when interpreting interview responses. Constructivist grounded theory relies on the perceptions and interpretations of the researcher in the context of the study (Birks et al., 2015; Charmaz, 2008) and the inclusion of another person interpreting the body of qualitative data contradicted the subjectivity of this approach (Thornberg et al., 2020). However, reliability was enhanced as the researcher sought the opinion of a colleague, the Curriculum Director at the Charter School who holds an EdD and is passionate about student success and qualitative research, as the In Vivo coding process began. The Curriculum Director's analysis of the initial codes was consistent with the researcher's analysis. Additionally, the researcher's background and experience of incorporating strategies that promote positive math self-efficacy and growth mindset into classroom instruction influenced the qualitative data analyses.

Mixed Methods

At the design level, this study was explanatory sequential, meaning that quantitative data was collected and analyzed first. These quantitative results were then used to select participants for semi-structured individual interviews as well as to guide analysis of the qualitative interview data.

Integration at the methods level was achieved through embedded sampling. Interview participants represented a sub-sample of the initial survey participants. Additional integration was achieved by connecting the descriptive data for participants in each phase of the study. The mean composite scores for self-efficacy and growth mindset of the survey participants were compared to the mean composite scores for self-efficacy and growth mindset of the interview participants. A graphic (Figure 19) was used to illustrate a side-by-side comparison of these data sorted by level of math identity (weak, typical, or strong). This analysis allowed the researcher to compare mean scores for self-efficacy and growth mindset of participants at each phase of the study.

At the reporting level, the researcher utilized data transformation by calculating the frequencies of themes that emerged from qualitative data. These themes were quantified and interpreted using graphs and data displays. Additionally, the researcher also used a joint display table to show how students of differing math identity levels perceived the three variables under investigation.

Table 3 presents the guiding questions, data sources, and analyses of the study.

Table 3

Data Sources and Analyses for Guiding Questions

Guiding Question	Instrument/Data Source(s)	Data Analysis
What is the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students?	1- Google Form Survey- a composite "score" was calculated for each construct for each student. 2- Demographic information provided by the registrar.	1- Multiple Regression to determine how self-efficacy and growth mindset influence math identity. 2- Simple linear regression to investigate whether variables are predictive of one another based on student demographic criteria.
What are the differences in students' math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level?	1- Demographic information provided by registrar. 2- MAP Growth scores provided by middle school principal. 3- Composite ratings for self-efficacy, growth mindset, and math identity from survey.	MANOVA Factors: gender, SES, ethnicity, & math achievement level. Response Vars- self-efficacy, growth mindset, math identity.
How do student perceptions of self-efficacy, growth mindset, and math identity differ based on their math identity level?	1- Answer to math identity "why" question from survey. 2- Interview questions.	1- In Vivo and focused coding of survey responses. 2- In Vivo and focused coding of interview transcripts. 3- Magnitude coding of themes based on math identity level.

Summary

This chapter has outlined the methodology that the current study used to investigate whether the constructs of mathematical self-efficacy, growth mindset, and mathematical identity correlate and whether student-level factors have an influence on these constructs. The study was conducted at a rural South Georgia middle school using an explanatory sequential design (Cresswell & Cresswell, 2018). First, quantitative data was collected via student surveys. These data were then merged with student demographic information and math achievement level data. Pearson correlations, multiple linear regression, factorial MANOVA, *post hoc* ANOVAs and *post hoc* simple linear regressions were used to explore whether relationships existed between the variables under consideration. For the qualitative data collection, the researcher used purposeful sampling to select a diverse group of participants. Qualitative data were collected through individual semi-structured student interviews. In Vivo and initial coding methods were used during the first coding cycle of data analysis. Focused coding and magnitude coding were used during the second cycle to seek themes and patterns present in the interview data. The researcher then used methodical triangulation to integrate these data into the grounded theory that is presented in Chapter IV.

Chapter IV: Results

Factors that influence the development of the mathematical identity of adolescents remain largely unexplained. There is evidence in the literature that self-efficacy and growth mindset contribute to how middle school students perceive themselves as “math people” (Berry et al., 2014; Bohrnstedt et al., 2020; Brenner et al., 2018; Huang et al., 2019; Miller & Wang, 2019; Usher, Ford, et al., 2019). This study explored the relationships between these variables among students at a rural South Georgia charter school. Additionally, the study explored whether differences among the variables existed due to the student level factors of gender, ethnicity, SES, and math achievement level.

The research questions this study aimed to understand are:

RQ1: What is the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students?

RQ2: What are the differences in students’ math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level?

RQ3: How do student perceptions of mathematical self-efficacy, growth mindset, and mathematical identity differ based on math identity level?

This chapter begins with a description of the participants included in the study. Quantitative and the initial round of qualitative data were collected through student surveys which all participants received. The researcher then purposefully selected students to participate in semi-structured individual interviews to further investigate how students’ perception of mathematical self-efficacy and growth mindset contribute to the development of their math identity. Next, the chapter presents the findings for each research question.

Research questions 1 and 2 were explored through quantitative analyses using data from student surveys. The researcher then used qualitative methods with data collected from the surveys and student interviews to investigate RQ3. Next, the chapter will present an integration of the findings and construct a theory based on evidence gathered from the data analyses. The chapter concludes with a brief summary of the findings.

Participants

A convenience sample of Grade 7 and Grade 8 students at the Charter School was used for this study. The recruitment process began with the middle school principal including survey information as part of her weekly informational email blast that goes out to all parents. After one week had passed, the researcher sent emails and text messages to parents that had not yet responded which included the link to the Parental Consent Form (Appendix B) as well as the link to an informational video. Additionally, paper copies of the parent/guardian consent form were sent home with students and collected by homeroom teachers. These recruitment procedures lasted two weeks.

Of the 145 students in Grades 7 and 8, 33 parents either did not respond or could not be contacted. Ten parents declined for their child to participate. The student survey was emailed to 102 students. Five students were absent and did not complete the survey. Three students declined to participate and exited the Google Form immediately. Ninety-four students completed the student survey. However, three of these students did not enter a valid lunch (PIN) number and could not be correlated with the correct demographic information. These students' results were not included in the data analysis. As a result, survey data was collected for 91 out of 102 students who received the student survey. This was a response rate of 89%. There were 47 students out of the total 68 students in grade 7 who participated in the survey. There were 44 students out of the total 67 students in grade 8 who participated in the survey. Table 4 shows the demographic information of the survey participants.

Table 4

Demographic Data for Survey Participants (N = 91)

	Male	Female	White	Not White	Not Low SES	Low SES	Below Average Ability	Average Ability	Above Average Ability
Grade 7 (*n* = 47)	23	24	36	11	19	28	9	22	16
Grade 8 (*n* = 44)	27	17	29	15	24	20	13	21	10
Total (*N* = 91)	50	41	70	21	43	48	22	43	26

Note. SES = socio-economic status.

Student interviews were conducted over a five-day period one week after the surveys were completed. The researcher created a spreadsheet and used color to highlight which students had composite scores that were above average, average, or below average for self-efficacy, growth mindset, and math identity. In all, 30 students were interviewed. Eighteen were males, 22 were White, and 16 were not considered low SES. These 30 students represented all levels of math identity: 13 students possessed a weak math identity, five students possessed a typical math identity, and 12 students possessed a strong math identity. Demographic data for interview participants are presented in Table 5.

Table 5

Demographic Data for Student Interviewees

	Male	Female	White	Not White	Not Low SES	Low SES	Below Average Ability	Average Ability	Above Average Ability
Frequency (*n* = 30)	18	12	22	8	16	14	11	11	8

Note. SES = socio-economic status, MI = math identity

Findings

Research Question 1

What is the relationship between mathematical self-efficacy, growth mindset, and mathematical identity of middle school students? First, SPSS was used to determine the internal reliability of the instruments used and to calculate descriptive data for the three variables under investigation. Self-efficacy was measured with a five item, 5-point Likert scale. Responses to these items were then summed and rated on a composite scale ranging from 0 – 20 (M = 13.38, SD = 3.73, α = .80). Growth mindset was measured using eight items on a 6-point Likert scale. These responses were summed to obtain a composite score ranging from 0 – 40 (M = 29.84, SD = 5.93, α = .79). Mathematics identity was calculated using two items with 4-part Likert responses (M = 3.07, SD = 1.58, α = .79) and had a range from 0 – 6.

Ranges for self-efficacy and growth mindset scores were determined by the descriptive statistics for each scale. Students that scored one standard deviation below the mean were considered below average (weak) and students that scored one standard deviation above the mean were considered above average (strong). Students that had a composite score within one standard deviation of the mean were considered typical. The math identity score was obtained when students selected one of four Likert-style responses for each item: strongly disagree,

disagree, agree, or strongly agree. Students scoring a 0 – 1 on math identity were considered to have a weak math identity. To have a score of 0 – 1, students must have answered "strongly disagree" to either one or both items. Students scoring a 2 – 3 were considered to have a typical math identity. Students with scores of 4 – 6 were considered to have a strong math identity. In order for students to rank with a math identity of 4, they had to have answered "agree" to both questions. Results of the survey are presented in Table 6, shows the number (percent) of students included in each category for each of variables tested.

Table 6

Survey Results (Frequency/Percentage) for Variables by Strength

	Weak		Typical		Strong	
	n	%	*n*	%	*n*	%
Self-Efficacy	13	14.3	68	74.7	10	11
Growth Mindset	15	16.3	61	67	15	16.4
Math Identity	14	15.4	37	40.7	40	44

Note. $N = 91$. Percentages may not add to 100 due to rounding.

Next, correlational analyses were conducted using SPSS to investigate relationships between the variables. Pearson correlations indicated statistically significant relationships between self-efficacy and mathematics identity ($r = .418$, $p < .001$) as well as between self-efficacy and growth mindset ($r = .423$, $p < .001$). These relationships indicated a moderate correlation. Next, a simultaneous multiple linear regression was conducted using SPSS to investigate whether self-efficacy and growth mindset were predictors of mathematics identity. A significant regression equation was found [$F(2, 88) = 9.34$, $p < .001$], with an adjusted $\boldsymbol{R}^2$ of 0.156 indicating that 15.6% of the variance in mathematics identity can be attributed to self-efficacy and growth mindset. The predicted math identity for participants was equal to .861 + .430(self-efficacy) – .031(growth mindset) when independent variables are measured in scale points. For every 1 scale point increase in self-efficacy, math identity increased by .430 units. Self-efficacy was a statistically significant predictor of math identity ($p < .001$). Growth mindset was not a statistically significant predictor of math identity ($p = .776$), as shown in Table 7. For every 1 scale point increase in growth mindset, math identity increases by -.031 units. The equation to represent this is $\boldsymbol{Y_{MI}} = .861 + .430\boldsymbol{X_{SE}} - .031\boldsymbol{X_{GM}} + \boldsymbol{\varepsilon}$ where $\boldsymbol{\varepsilon}$ explains the unexplained residual variance in math identity scores that was not accounted for by self-efficacy and growth mindset scores.

Table 7

Full Model Effects for Multiple Linear Regression

	Unstandardized Coefficients		Std. Coeff.			95% Confidence Interval for β	
	β	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	.861	.824		1.045	.299	-.777	2.499
Self-Efficacy	.183	.045	.430	4.029	<.001	.093	.273
Growth Mindset	-.008	.029	-.031	-.286	.776	-.065	.049

	Correlations			Collinearity Stats.	
	Zero-order	Partial	Part	Tolerance	VIF
Self-Efficacy	.418	.395	.390	.821	1.218
Growth Mindset	.151	-.030	-.028	.821	1.218

Note. Dependent Variable = Mathematics Identity

As shown in Table 7, the assumption of multi-collinearity was met as both self-efficacy and growth mindset had a tolerance value of .821 and a VIF of 1.218 (Mertler & Reinhart, 2017). The Kolmogorov-Smirnov and Shapiro-Wilk's test of normality were statistically significant results which indicated departure from normality. As a result, histograms, Q-Q plots, skewness, and kurtosis were examined for each of the three variables. The histograms indicated an approximately normal distribution and Q-Q plots appeared linear (see Figure 2). Skewness and kurtosis values were between -1 and 1 for all variables so the distributions were deemed normal (Mertler & Reinhart, 2017). Table 8 shows the normality data for the variables.

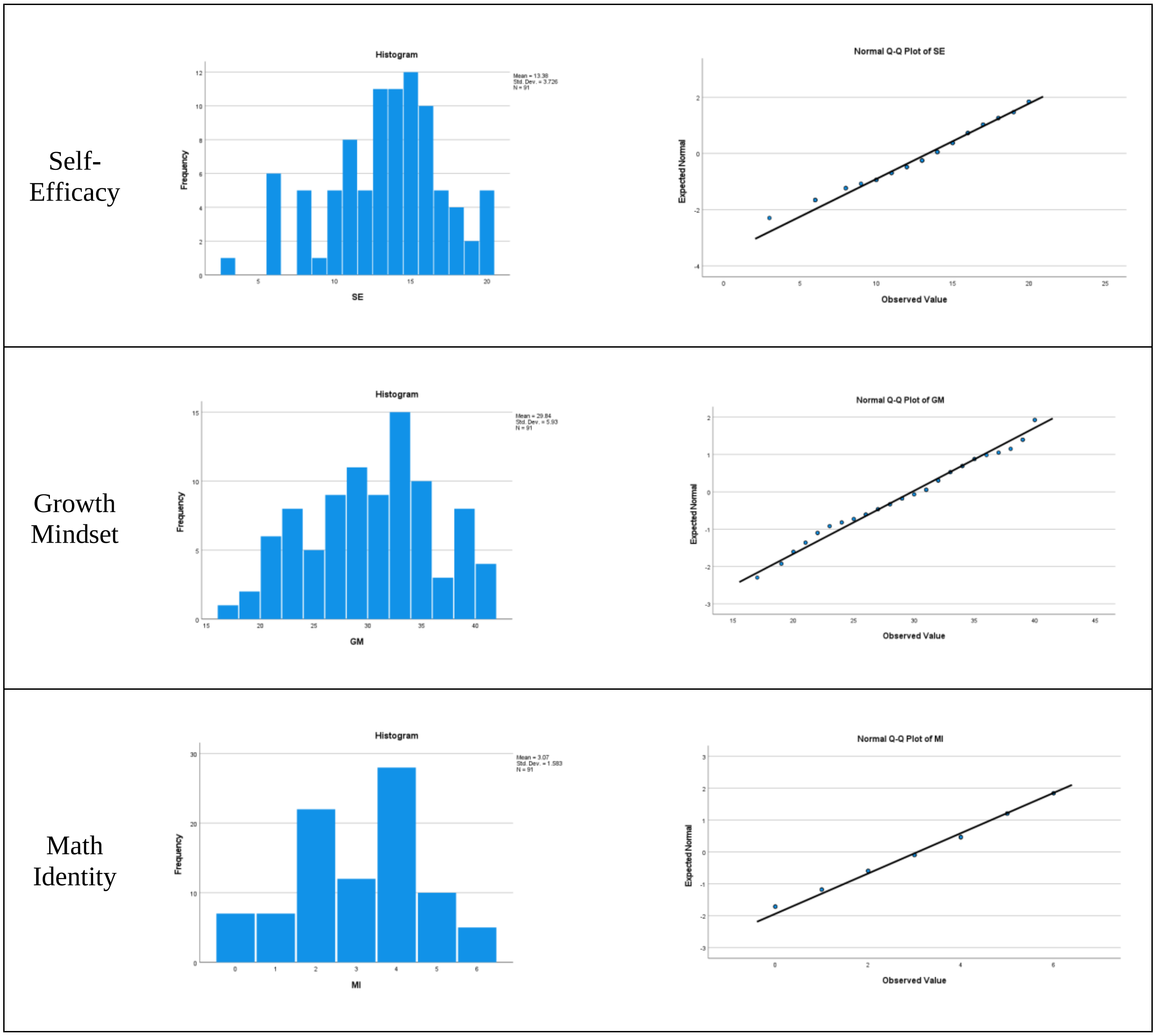

Figure 2. Histograms and Q-Q plots

Table 8

Normality Data

	Kolmogorov-Smirnov	Sig.	Shapiro-Wilk	Sig.	Skewness	Kurtosis
Self-Efficacy	.118	.003	.967	.021	-.451	-.036
Growth Mindset	.094	.044	.969	.030	-.121	-.798
Math Identity	.195	<.001	.937	<.001	-.197	-.634

The effect size, f^2, for the regression was calculated by dividing $\boldsymbol{R}^2$ by $1 - \boldsymbol{R}^2$ to give a value of .185. G-Power was used to then determine the statistical power of the analysis. The statistical power of this regression model is 0.98 as shown in Figure 3.

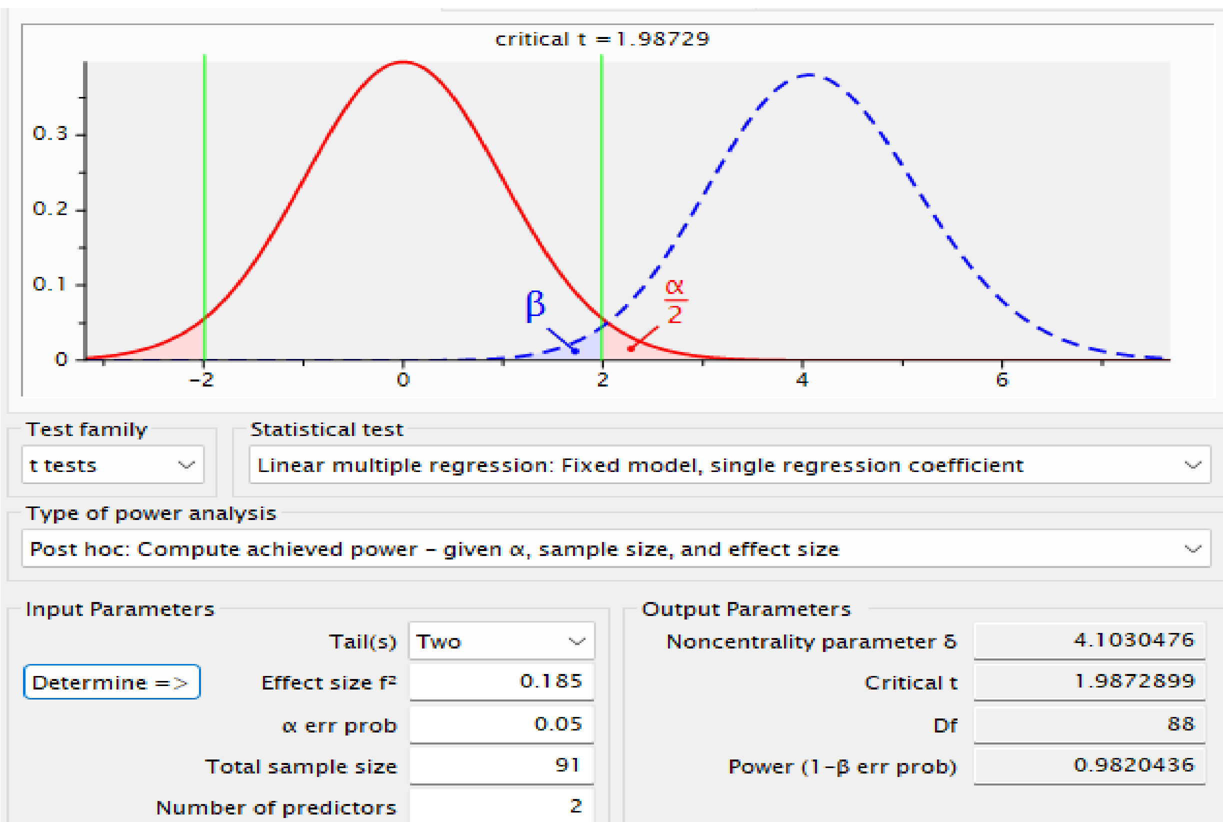

Figure 3. G-Power Analysis for RQ1 Multiple Regression

Research Question 2

What are the differences in students' math self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, or math achievement level? A multivariate analysis of variance (MANOVA) was conducted to determine whether significant differences existed between self-efficacy, growth mindset, and math identity based on gender, ethnicity, SES, and math achievement level. Linearity between the dependent variables was tested as part of the analysis for RQ1. Pearson correlation coefficients were calculated and indicated a significant moderate correlation between self-efficacy and math identity ($r = .418$, $p < .001$) and self-efficacy and growth mindset ($r = .423$, $p < .001$). Growth mindset and math identity were weakly correlated, and the relationship was not statistically significant ($r = .151$, $p = .076$). Next, descriptive data (Table 9, Table 10, Table 11) were run to investigate normality among the dependent variables. Multivariate normality was assumed as the skewness values were between -2 and +2 and kurtosis values were between -7 and +7 for all variables (Curran et al., 1996). Additionally, the residual matrices were elliptical as shown in Figure 4.

As seen in Table 9, the mean self-efficacy score for males was greater than the mean self-efficacy score for females. Additionally, the mean self-efficacy score for students who were White was greater than the mean self-efficacy score for students who were not White. There was little difference in the mean self-efficacy scores for students based on SES or between students of below average and average math achievement level. The mean self-efficacy score was greatest among students with above average ability. However, for students with below average math achievement level, the skewness value of -1.45 indicated that the distribution was left skewed. It is possible that some students exhibited much lower self-efficacy than their peers of average or above average ability. The maximum value for this group of students was 17. Additionally, the kurtosis for this subgroup of students had a value of 2.97, indicating a more peaked distribution of the data.

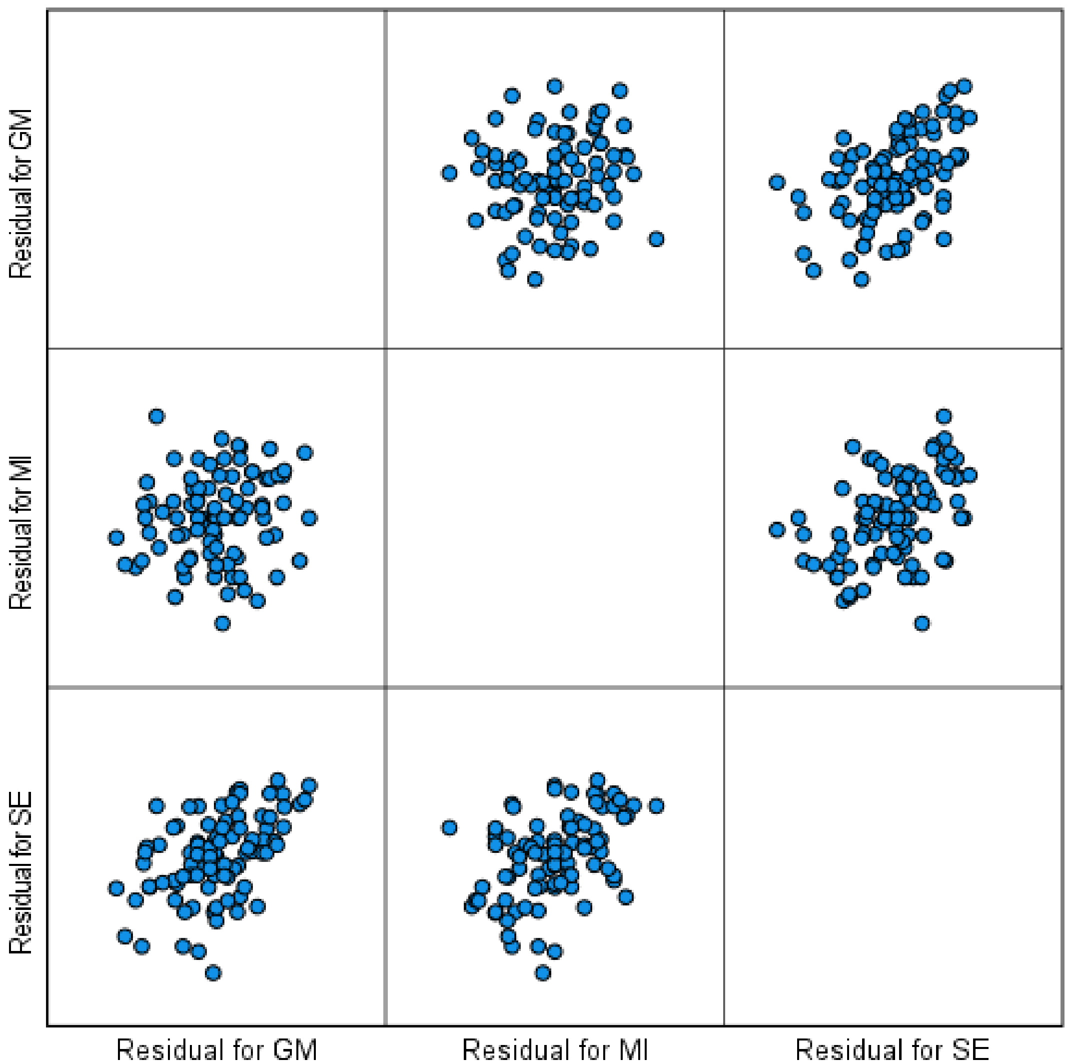

Figure 4. Residual Matrices for Dependent Variables

With regards to growth mindset (Table 10), the mean scores were greater for males than females, greater for White students than students who are not White, greater for students of typical SES than for students of low SES, and greater for students of average and above average ability than for students of below average ability. In other words, students belonging to marginalized subgroups tended to have more of a fixed mindset than their peers.

With regards to math identity, the means for White students and for students of typical SES were higher than for non-White students and students of low SES indicating that White students and students of typical SES held a stronger math identity. The mean math identity score for females was higher than the mean score for males. Students of average ability level had a stronger math identity than students of below average ability or students with above average ability. The means for students of below average math achievement (*M* = 2.95) and above average math achievement (*M* = 2.96) were almost identical, indicating the same level of math identity for these two subgroups of students (see Table 11).

Table 9

Descriptive Data for Self-Efficacy

	Gender		Ethnicity		SES		Math Achievement Level		
	Male	Female	White	Other	Typical	Low	Below	Ave.	Above
n	50	41	68	23	43	48	22	43	26
Mean	13.74	12.95	13.53	12.96	13.35	13.42	13.18	13.14	13.96
SD	3.81	3.63	3.61	4.12	3.60	3.88	3.33	3.85	3.90
95% *CI* Lower Bound	12.66	11.81	12.66	11.18	12.24	12.29	11.70	11.95	12.38
95% *CI* Upper Bound	14.82	14.10	14.40	14.74	14.46	14.54	14.66	14.32	15.54
Min	3	6	6	3	6	3	3	6	6
Max	20	20	20	20	20	20	17	20	20
Skewness	-.536	-.405	-.25	-.85	-.24	-.62	-1.45	-.27	-.35
Kurtosis	.353	-.367	-.34	.42	-.19	.16	2.97	-.59	-.17

Note. *SD* = standard deviation, *CI* = confidence interval, SES = socio-economic status.

Table 10

Descriptive Data for Growth Mindset

	Gender		Ethnicity		SES		Math Achievement Level		
	Male	Female	White	Other	Typical	Low	Below	Ave.	Above
n	50	41	68	23	43	48	22	43	26
Mean	30.48	28.78	30.44	27.57	30.74	28.79	27.73	30.26	30.50
SD	6.20	5.53	6.08	5.02	6.13	5.66	6.98	4.99	6.28
95% *CI* Lower Bound	28.72	27.04	28.97	25.40	28.86	27.15	24.63	28.72	27.97
95% *CI* Upper Bound	32.24	30.52	31.91	29.73	32.63	30.43	30.82	31.79	33.03
Min	19	17	17	21	17	19	17	19	19
Max	40	40	40	38	40	40	40	39	40
Skewness	-.178	-.06	-.27	.32	-.208	-.04	.39	-.50	.12
Kurtosis	-.96	-.47	-.64	-.95	-.711	-.84	-1.11	-.152	-.94

Note. *SD* = standard deviation, *CI* = confidence interval, SES = socio-economic status.

The Box's test was statistically not significant, indicating that the assumption of homogeneity of variance-covariance was fulfilled, $F(66, 2231) = 1.05$, $p = .368$. Therefore, the Wilks' Lambda statistic was used when interpreting the MANOVA results. Neither gender [$F(3,69) = 1.517$, $p = .218$, $\eta^2 = .062$], ethnicity [$F(3,69) =$, $p = .624$, $\eta^2 = .026$], SES [$F(3,69) = .721$, $p = .602$, $\eta^2 = .026$], nor math achievement level [$F(3,69) = .387$, $p = .543$, $\eta^2 = .017$] significantly predicted the combined dependent variable of self-efficacy, growth mindset, and math identity. Additionally, no significant factor interactions were observed. The results of the multivariate tests are presented in Table 12.

Table 11

Descriptive Data for Math Identity

	Gender		Ethnicity		SES		Math Achievement Level		
	Male	Female	White	Other	Typical	Low	Below	Ave.	Above
n	50	41	68	23	43	48	22	43	26
Mean	2.94	3.22	3.16	2.78	3.28	2.88	2.95	3.19	2.96
SD	1.71	1.42	1.53	1.73	1.53	1.62	1.50	1.59	1.69
95% *CI* Lower Bound	2.45	2.77	2.79	2.03	2.81	2.40	2.29	2.70	2.28
95% *CI* Upper Bound	3.43	3.67	3.53	3.53	3.75	3.35	3.62	3.68	3.64
Min	0	0	0	0	0	0	0	0	0
Max	6	6	6	6	6	6	6	6	6
Skewness	-.19	-.08	-.23	-.04	-.41	-.01	.09	-.47	.01
Kurtosis	-.79	-.55	-.50	-.84	-.11	-.83	-.45	-.36	-.75

Note. *SD* = standard deviation, *CI* = confidence interval, SES = socio-economic status.

Based on the MANOVA results, there was insufficient evidence to reject the null hypotheses for RQ2. In other words, self-efficacy, growth mindset, and math identity cannot be considered as one unified variable and must be investigated as separate constructs.

Post hoc ANOVAs. Next, three univariate analyses of variance (ANOVAs) were conducted post hoc to further investigate the relationships between the variables as well as any interaction effects that may have occurred. As there were three variables under investigation, a Bonferroni-type adjustment was made to the alpha level to avoid a potential inflated error rate (Mertler & Reinhart, 2017). The alpha level of .05 was divided by three and then rounded down to obtain an overall alpha value less than .05. As a result, the alpha level was adjusted to $\alpha = .016$ prior to conducting the univariate ANOVAs.

Table 12

MANOVA results

Effect	Wilks' *Λ*	*F*	*Hypothesis df*	*Error df*	Sig.	η^2	Obs. Power
Gender	.938	1.52	3	69	.218	.062	.384
Ethnicity	.974	.624	3	69	.602	.026	.174
SES	.970	.721	3	69	.543	.030	.196
Math Level	.967	.387	6	138	.886	.017	.159
Gender * Ethnicity	.940	1.463	3	69	.232	.060	.371
Gender * SES	.911	2.241	3	69	.091	.089	.544
Gender * Math Level	.929	.866	6	138	.522	.036	.334
Ethnicity * SES	.997	.076	3	69	.973	.003	.063
Ethnicity * Math Level	.977	.270	6	138	.950	.012	.121
SES * Math Level	.954	.550	6	138	.770	.023	.215
Gen * Eth * SES	.931	1.695	3	69	.176	.069	.425
Gen * Eth * Math Level	.973	.630	3	69	.598	.027	.175
Gen * SES * Math Level	.900	1.239	6	138	.290	.051	.475
Eth * SES * Math Level	1.00		0	70			
Gen*Eth*SES*Math Level	1.00		0	70			

Although the between-subjects effect of gender * ethnicity had a *p*-value of .042 for math identity, this finding was not significant due to the lowering of the *p*-value. If the *p*-value had been kept at .05 this finding would have been significant, but due to the increased risk of a type-2 error it cannot be assumed that gender * ethnicity is a significant predictor of math identity. Gender * ethnicity between-subjects effects for all variables are presented in Table 13. Comprehensive univariate ANOVA results are presented in Table 14, Table 15, and Table 16.

Table 13

*Gender * Ethnicity Between-Subjects Effects*

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*	η^2	Obs. Power
Self-efficacy	4.256	1	4.256	.275	.602	.004	.031
Growth Mindset	.475	1	.475	.013	.909	.000	.017
Math Identity	11.096	1	11.096	4.282	.042	.057	.351

Note. p = .016

Table 14

ANOVA: Self-Efficacy

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	η^2	Obs. Power
Gender	.001	1	.001	.000	.995	.000	.016
Ethnicity	1.431	1	1.431	.092	.762	.001	.021
SES	.006	1	.006	.000	.995	.000	.016
Math Level	.156	2	.078	.005	.995	.000	.016
Gender * Ethnicity	4.256	1	4.256	.275	.602	.004	.031
Gender * SES	22.659	1	22.659	1.464	.230	.020	.111
Gender * Math Level	46.421	2	23.211	1.500	.230	.041	.168
Ethnicity * SES	.343	1	.343	.022	.882	.000	.017
Ethnicity * Math Level	3.566	2	1.783	.15	.891	.003	.024
SES * Math Level	26.569	2	13.285	.859	.428	.024	.091
Gen * Eth * SES	18.175	1	18.175	1.175	.285	.016	.089
Gen * Eth * Math Level	1.916	1	1.916	.124	.726	.002	.022
Gen * SES * Math Level	10.147	2	5.073	.328	.722	.009	.040
Eth * SES * Math Level	.000	0	.	.	.	.000	.
Gen*Eth*SES*Math Level	.000	0	.	.	.	.000	.

Note. *df* = degrees of freedom, R^2 = .184 (Adjusted R^2 = -.034)

*p < .016

Table 15

ANOVA: Growth Mindset

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	η^2	Obs. Power
Gender	30.577	1	30.577	.849	.360	.012	.067
Ethnicity	61.218	1	61.218	1.701	.196	.023	.129
SES	9.723	2	9.712	.270	.605	.004	.030
Math Level	31.206	2	15.603	.433	.650	.012	.049
Gender * Ethnicity	.475	1	.475	.013	.909	.000	.017
Gender * SES	74.420	1	74.420	20.67	.155	.028	.159
Gender * Math Level	24.761	2	12.381	.344	.710	.010	.041
Ethnicity * SES	7.695	1	7.695	.214	.645	.003	.027
Ethnicity * Math Level	23.517	2	11.758	.327	.722	.009	.040
SES * Math Level	20.259	2	10.129	.281	.756	.008	.036
Gen * Eth * SES	51.422	1	51.422	1.428	.236	.020	.108
Gen * Eth * Math Level	35.917	1	35.917	.998	.321	.014	.077
Gen * SES * Math Level	136.749	2	68.374	1.899	.157	.051	.223
Eth * SES * Math Level	.000	0	.	.	.	.000	.
Gen*Eth*SES*Math Level	.000	0	.	.	.	.000	.

Note. *df* = degrees of freedom, $\boldsymbol{R}^2$ = .184 (Adjusted $\boldsymbol{R}^2$ = -.034)

*$p < .016$

Table 16

ANOVA: Math Identity

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	η^2	Obs. Power
Gender	8.170	1	8.170	3.153	.080	.043	.252
Ethnicity	.267	1	.267	.103	.749	.001	.021
SES	3.616	1	3.616	1.395	.241	.019	.106
Math Level	2.392	2	1.196	.462	.632	.013	.051
Gender * Ethnicity	11.096	1	11.096	4.282	.042	.057	.351
Gender * SES	2.993	1	2.993	1.155	.286	.016	.088
Gender * Math Level	1.370	2	.685	.264	.768	.007	.035
Ethnicity * SES	.054	1	.054	.021	.886	.000	.017
Ethnicity * Math Level	.040	2	.020	.008	.992	.000	.016
SES * Math Level	4.122	2	20.61	.795	.455	.022	.084
Gen * Eth * SES	2.900	1	2.900	1.119	.294	.016	.085
Gen * Eth * Math Level	.001	1	.001	.000	.986	.000	.016
Gen * SES * Math Level	3.744	2	1.872	.722	.489	.020	.076
Eth * SES * Math Level	.000	0	.	.	.	.000	.
Gen*Eth*SES*Math Level	.000	0	.	.	.	.000	.

(*continues)*

Table 16 *(continued)*

Note. df = degrees of freedom, $\boldsymbol{R}^2$ = .184 (Adjusted $\boldsymbol{R}^2$ = -.034)

$*p < .016$

Post hoc Regressions. Next, a series of simple linear regressions were run to more deeply investigate whether predictive relationships existed among the tested variables based on the nine demographic subgroups: male, female, White, not White, low SES, not low SES, below average math achievement, average math achievement, and above average math achievement. The researcher conducted 27 simple linear regressions: nine to test whether growth mindset predicted self-efficacy, nine to test whether self-efficacy predicted math identity, and nine to test whether growth mindset predicted math identity.

Growth mindset was found to significantly predict mathematical self-efficacy for males [$F(1, 48) = 13.042$, $p < .001$, $R^2 = .214$], females [$F(1, 39) = 5.719$, $p < .05$, $R^2 = .128$], students who are White [$F(1, 66) = 24.815$, $p < .001$, $R^2 = .273$], students who are low SES [$F(1, 46) = 7.252$, $p = .010$, $R^2 = .136$], students who are not low SES [$F(1, 41) = 14.526$, $p < .001$, $R^2 = .262$], students with average math achievement [$F(1, 41) = 10.373$, $p < .001$, $R^2 = .202$], and students with above average math achievement [$F(1, 24) = 10.648$, $p = .003$, $R^2 = .307$] (see Table 17).

In other words, growth mindset was a predictor of self-efficacy for all subgroups except students who are not White and students with below average math achievement. Growth mindset was a significant predictor of math identity for males [$F(1, 48) = 5.368$ $p = .025$, $R^2 = .101$], but not for any other subgroups (see Table 18).

Table 17

Growth Mindset (GM) as a Predictor of Self-Efficacy.

Predictor (GM)		Unstandardized Coefficients		Std. Coeff.				
	N	*B*	*SE*	*B*	*t*	Sig.	*F*	R^2
Male	50	.284	.079	.462	3.611	<.001	13.042	.214
Female	41	.235	.098	.358	2.391	.022	5.719	.128
White	68	.310	.062	.523	4.981	<.001	24.815	.273
Not White	23	.100	.178	.122	.565	.578	3.19	.015
Low SES	48	.253	.094	.369	2.693	.010	7.252	.136
Not Low SES	43	.300	.079	.511	3.812	<.001	14.526	.262
Below MAP	22	.131	.103	.274	1.276	.217	1.627	.075
Average MAP	43	.347	.108	.449	3.221	.003	10.373	.202
Above MAP	26	.345	.106	.554	3.263	.003	10.648	.307

N*ote*. SES = socio-economic status. MAP = math achievement level as measured by NWEA MAP Growth assessment.

Self-efficacy significantly predicted math identity for males [$F(1, 48) = 27.092$, $p < .001$, $R^2 = .361$], students that are White [$F(1, 66) = 17.440$, $p < .001$, $R^2 = .209$], students of low SES [$F(1, 46) = 11.200$, $p < .001$, $R^2 = .196$], students that are not low SES [$F(1, 41) = 7.644$, $p = .008$, $R^2 = .157$], students with average math achievement [$F(1, 41) = 5.261$, $p < .05$, $R^2 = .114$], and students with above average math achievement [$F(1, 24) = 22.956$, $p < .001$, $R^2 = .489$] (see Table 19). In other words, self-efficacy was a predictor of math identity for all subgroups except for students who are female, students who are not White, and students with below average math achievement.

Table 18

Growth Mindset (GM) as a Predictor of Math Identity

Predictor (GM)		Unstandardized Coefficients		Std. Coeff.				
	N	*B*	*SE*	*B*	*t*	Sig.	*F*	R^2
Male	50	.087	.038	.317	2.317	.025	5.368	.101
Female	41	-.021	.041	-.083	-.518	.607	.269	.007
White	68	.027	.031	.108	.880	.382	.774	.012
Not White	23	.076	.073	.219	1.208	.316	1.057	.048
Low SES	48	.014	.042	.048	.327	.745	.107	.745
Not Low SES	43	.056	.038	.226	1.484	.146	2.201	.051
Below MAP	22	-.011	.048	-.051	-.230	.820	.053	.003
Average MAP	43	.043	.049	.135	.871	.389	.759	.018
Above MAP	26	3090	.052	.335	1.741	.095	3.030	.112

N*ote*. SES = socio-economic status. MAP = math achievement level as measured by NWEA MAP Growth assessment.

Table 19

Self-Efficacy (SE) as a Predictor of Math Identity.

Predictor (SE)		Unstandardized Coefficients		Std. Coeff.				
	N	*B*	*SE*	*B*	*t*	Sig.	*F*	R^2
Male	50	.269	.052	.601	5.205	<.001	27.092	.361
Female	41	.067	.062	.172	1.088	.283	1.184	.029
White	68	.194	.047	.457	4.176	<.001	17.440	.209
Not White	23	.131	.087	.311	1.500	.148	2.251	.097
Low SES	48	.185	.055	.443	3.347	.002	11.200	.196
Not Low SES	43	.169	.061	.396	2.765	.008	7.644	.157
Below MAP	22	.095	.098	.212	.970	.344	.941	.045
Average MAP	43	.139	.061	.337	2.294	.027	5.261	.114
Above MAP	26	.302	.063	.699	4.791	<.001	22.956	.489

N*ote*. SES = socio-economic status. MAP = math achievement level as measured by NWEA MAP Growth assessment.

Research Question 3

How do student perceptions of mathematical self-efficacy, growth mindset, and math identity differ based on math identity level?

Survey results. Initial analysis used the “why” questions from the student survey: “I see myself as a math person. Why?” and “Others see me as a math person. Why?” Students selected one of four Likert-style responses for each item: strongly disagree, disagree, agree, or strongly agree and then wrote a brief explanation as to why they selected that response. To begin the qualitative analysis of characteristics that students perceive in “math people,” the researcher exported these survey data to a spreadsheet and sorted the responses by math identity score from weakest to strongest. The responses were sorted into three groups: weak math identity with scores from 0-1, typical math identity with scores from 2-3, and strong math identity with scores from 4-6. Next, the researcher imported these data into GoodNotes, an app that allows users to import and annotate on top of documents, creating a new .pdf. The researcher then used In Vivo and focused coding to analyze student responses. Colors were used to highlight student responses that were similar, and themes emerged. The most prevalent themes were that math people “like” or “enjoy” doing mathematics and that math people are students who were “good at” math. The theme “perceived content proficiency” was used to include all student responses that involved being “good at” math. For example, students that tended to do well in math perceived themselves as being “good at” math, while students that tended to struggle perceived themselves as being “bad at” math. Similarly, the theme “enjoy” was used for both students that take pleasure in mathematics practices as well as for students that do not like or enjoy doing math. “Effort” was indicative of how easy or hard success in mathematics was perceived to be. The theme “help” was used both for students that were often approached to assist their peers as well as for students who sought out their peers for assistance. Table 20 presents examples of student responses from each major theme.

Table 20

Themes and Example Student Responses from Survey

Theme	Example student responses
Perceived content proficiency	"I'm not the best at math"
	"I'm bad at it"
	"It's not my strong suit"
	"I struggle with it"
	"I usually don't get questions right"
	"I understand it"
	"I'm somewhat good at it"
	"Math has always been my weak subject"
	"It's the class I'm best at"
	"I have good math scores"
	"I'm smart in math"
	"I always pass"
	"I understand it; it just clicks for me"
	"People call me the smart kid in our math class"
Enjoy	"I hate math"
	"I don't like math"
	"It is not my favorite thing to do"
	"I've never been that interested in it"
	"I do not personally enjoy it"
	"I've loved math all my life"
	"I like the subject"
	"I like solving math problems"
	"It is my favorite subject"
	"I love math"

(continues)

Table 20 *(continued)*

Effort	"It is hard sometimes to do"
	"It doesn't come as quickly to me"
	"It is very difficult if you don't understand the first time"
	"I don't pick up on it as quickly as my classmates"
	"I just study hard"
	"It comes easy to me"

	"Caught on to it naturally" "Math is very easy" "I don't have a hard time doing math "
Help	"I'm never able to help people" "I am more of the person who will ask for help" "I can help people with their math work" "When I help my classmates" "I'm always willing to help people" "I'm tutoring a girl in math" "People sometimes ask me for help"
Other interests	"I like reading more" "People just see me as a country boy" "Everyone sees me as a social studies or ELA person" "I want to be a zoologist" "I'm more of an ELA person"
Class participation	"I always speak up in math class" "I'm always raising my hand to answer a question" "I participate in class"

Several of the themes had quotes that were actually opposites. For example, a student with a weak math identity said, "I hate math" but a student with a strong math identity said, "I've loved math all my life." Both statements were coded under the theme "Enjoy" even though they describe opposing emotions. Both statements speak to the level of student enjoyment of the subject. Other themes that had opposite quotes included perceived content proficiency, effort, and help. A breakdown of frequency of opposing quotes is found in Table 21.

Table 21

Frequency of Opposing Quotes Used to Determine Themes by Math Identity Level

	Perceived Content Proficiency		Enjoy		Effort		Help	
	Bad at	Good at	Don't like	Like	Hard	Easy	Need help	Can help
Weak MI	8	0	6	0	1	0	0	0
Typical MI	10	12	5	6	2	3	2	3
Strong MI	0	34	0	13	0	13	0	15

Note. N = 91, but totals may not add to 91 due to multiple student responses. MI = math identity

Next, the researcher used magnitude coding (Saldaña et al., 2013) to quantify the frequency of the themes. The number of students that used certain words/themes in their responses as to how they or others perceive them as math people gave the researcher an opportunity to understand how the majority of participants perceived qualities possessed by math people.

Of the 91 responses, 47% of students mentioned being good at math and 32% of students mentioned enjoying doing math. Other themes that were observed included the amount of effort required to be successful (19%), helping others (18%), having interests other than mathematics (12%), and class participation (6%). While all levels of math identity associated enjoying math and perceived content proficiency with being a math person, only students with a stronger math identity associated helping others and class participation with being a math person. Additionally, students with a strong math identity were more likely to associate content proficiency with being a math person than were students of weak or typical math identities. Students with weak and typical math identities mentioned having other interests while students with stronger math identities did not. Figure 5 illustrates the frequency of the themes based on math identity level.

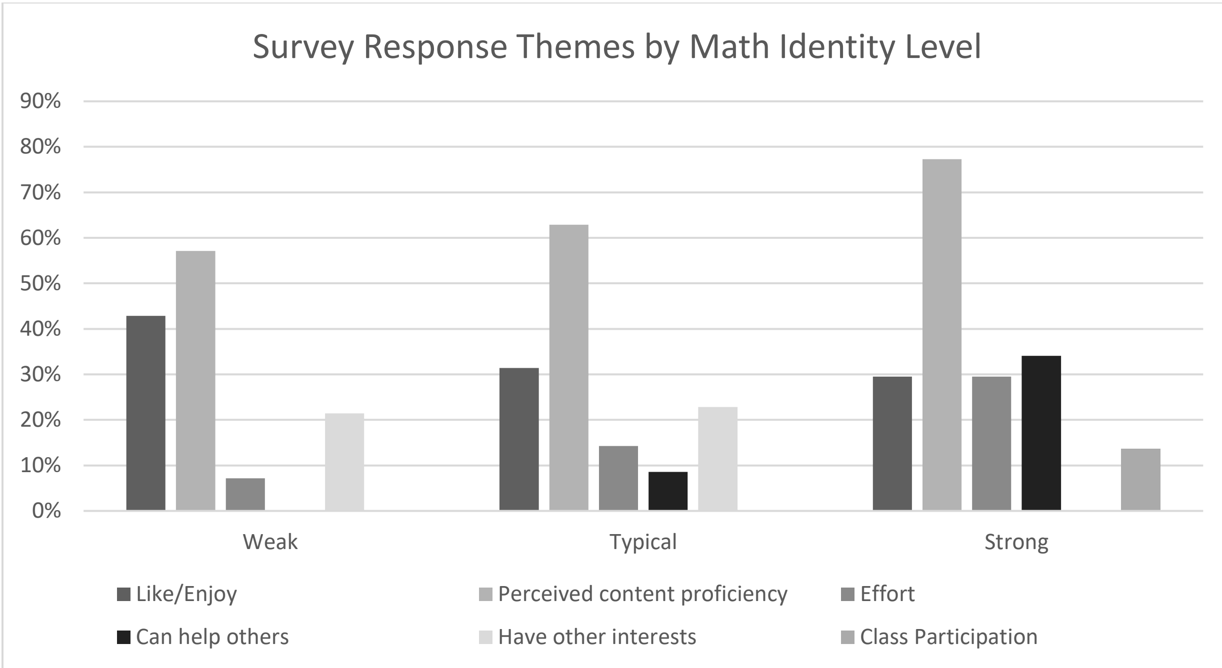

Figure 5. Survey Response Themes by Math Identity Level

Interview Results. The researcher used embedded sampling and quantitative data collected from the survey responses and the school registrar to select 30 students to participate in semi-structured individual interviews. Twelve students held a weak math identity, five had a typical math identity, and 13 had a strong math identity. The subsequent figures illustrate the percentage of students whose responses were coded as particular themes for each math identity level.

Math Identity Items. Similar to the survey responses, students tended to view having content proficiency, such as “good at” and “knowing how” to do math, with being a math person. Additionally, students of all math identity levels tended to view enjoying math as a necessity for being a math person. However, students with weak math identity believed that math people are able to do mental math more easily. Students with weak and strong math identities mentioned speed, with the perception that math people can do math more quickly. Students with a strong math identity were the only ones that associated being able to help others with being a math person. The percentage of students with these response themes are illustrated in Figure 6.

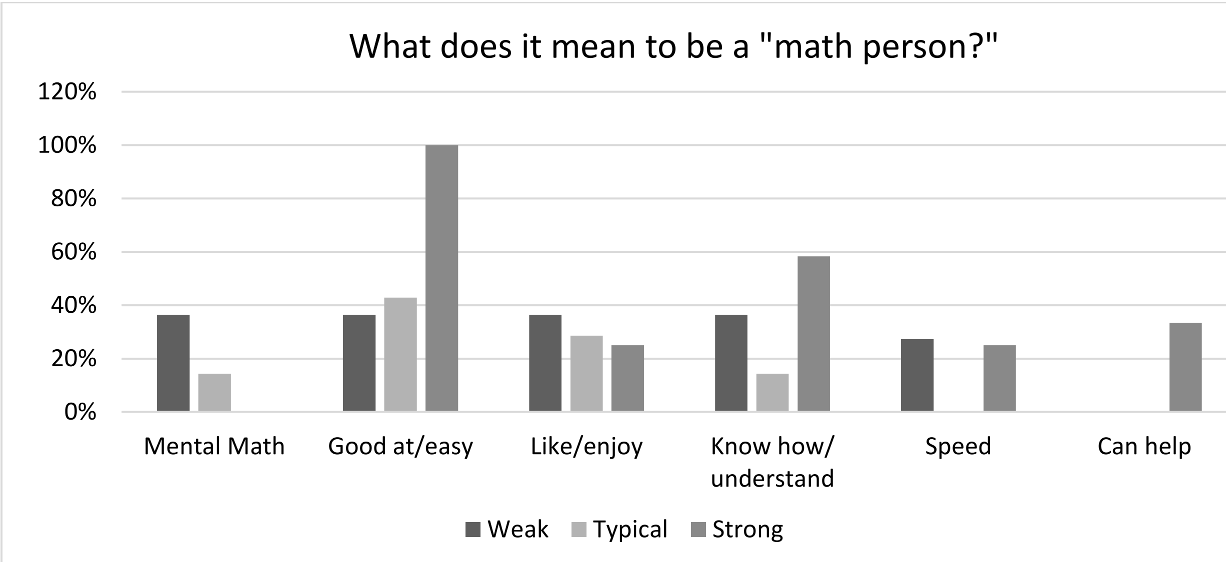

Figure 6. What does being a math person mean to you?

When asked to recall a time when they felt like a math person, students at all levels of math identity tended to remember specific content topics such as "transformations, translations, stuff like that," "when we did integers," "when I'm solving equations," or "on the Milestones test" rather than classroom activities or instructional practices. Students with weak and typical math identities associated grades or scores "when I get a straight 100" or "when I'm doing good on IXL" with feeling like a math person. Most students with a strong math identity associated understanding and "it's easy to me" with feeling like a math person but did not mention grades or assessment scores. Some students recalled certain grade levels, "in 4th grade" or "in Kindergarten before there were letters in math" or a certain teacher "I felt like a math person in Ms. Stephanie's class" or "Coach Glenn made it so you could understand it" (see Figure 7).

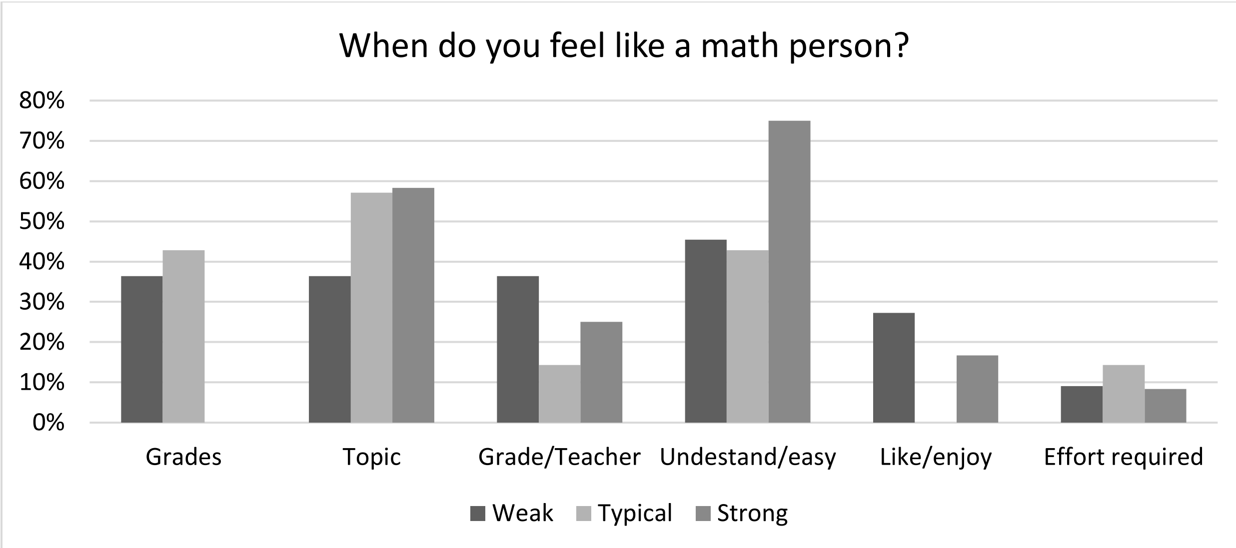

Figure 7. Describe a time when you felt like a math person.

When answering the question as to why others do/do not perceive you as a math person, students with weak math identities tended to mention grades. Students with typical and strong math identities believed their peers thought they were “good at” math or were able to solve problems more quickly. Students with weak math identities spoke of needing help in class, while students with strong math identities mentioned being asked for help (see Figure 8).

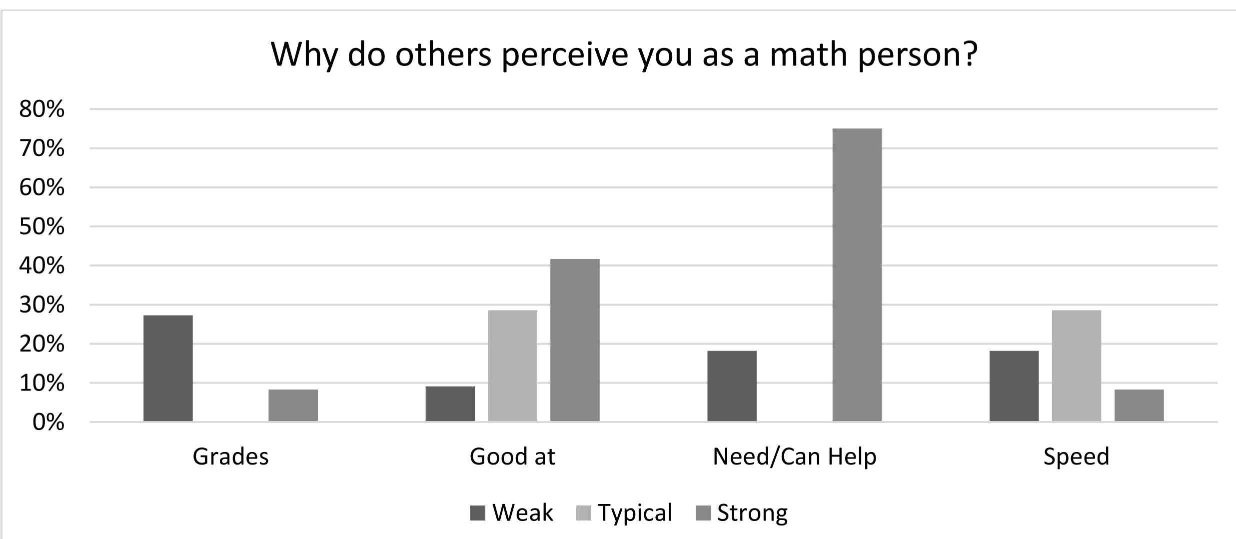

Figure 8. Why do you think others do/do not see you as a math person?

Self-efficacy Items. Self-efficacy was investigated by asking students to consider when they did/did not feel confident in math class. Some students recalled certain activities they did well on such as IXL or a test. Several students also mentioned certain content topics such as “proportions” or “when we were doing square roots.” Almost half of all students interviewed stated that they felt confident when they knew how to do the material. A few students with weak math identities could not remember a time feeling confident in math class (see Figure 9).

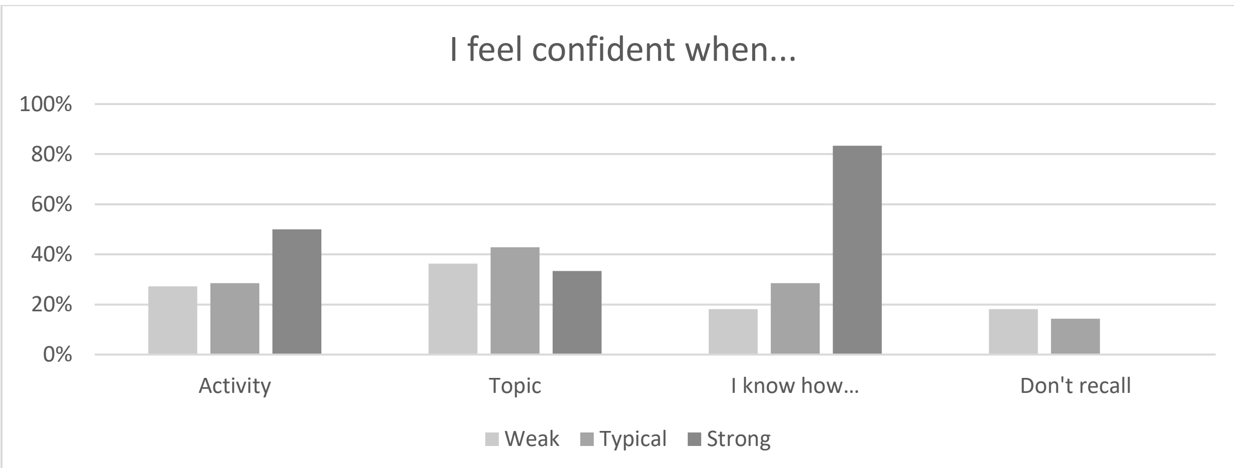

Figure 9. Describe a time when you felt confident in math.

Although several students mentioned certain content topics, those with weak math identities tended to feel insecure when they received poor grades “when I did bad on a math test” or did not understand “not knowing the questions” or “when I thought I knew but I was wrong.” A few students, mostly those with typical or strong math identities, could not remember a time when they felt insecure (see Figure 10).

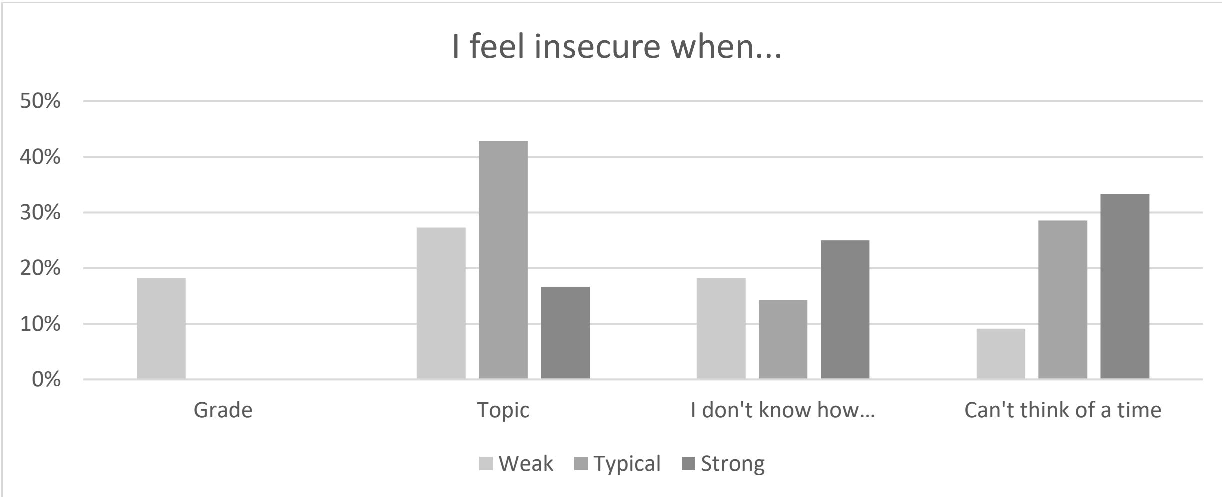

Figure 10. Describe a time when you felt insecure in math.

After speaking to several students, the researcher noticed how some were including group work in their explanations of when they felt confident in math class. Therefore, a follow-up question was added to the self-efficacy portion of the interview: “Tell me about group work. Do you feel like it helps you in math class?” Not all students were presented with this question, although it came up in several interviews before the researcher began to include it as part of the protocol. Students with lower levels of math identity tended to prefer group work, stating “Group work is better. Because having a person there and talking to them about it helps a lot.” and “I just feel more comfortable. I’m not the only person getting it wrong or getting it right.”

Albert, a male student with a strong math identity, said that group work tends to make him less efficacious:

> A group of 4 and 3 people get a different answer than me. I feel like I might be wrong. We might decide to use their answer instead since it was 3 to 1. I’m more confident on individual work. I don’t second guess myself as much.

Students tended to feel safer when they worked in groups of similar ability. Emma, a female student with a strong math identity, took the time to explain her thoughts (words in italics are those of the researcher):

> I feel like with group work, a lot of classrooms end up being half and half so the ones that are kind of dull with math and the ones that are sharp and right on it end up getting together. I feel like the ones that are sharp and right on it don't so much as help they kind of just go on and work out the problem and show it to them, which doesn't really help us learn but it does help get the work done. But at the same time individual work if you don't really understand you are kind of just sitting there stuck and don't know what to do. So, it's kind of (makes motions with hands like a toss-up). *So, what is your preference? If you had to pick?* Truthfully, I would pick group work because I struggle a lot. *So, what type of grouping is best way to group kids? What have you experienced that worked well for you?* Two middle kids coming together and hopefully being able to solve a problem. Not a middle and low or a middle and high because then the higher one is going to take over and the middle and low probably won't get very far with the problem.

Percentages of student responses are shown in Figure 11.

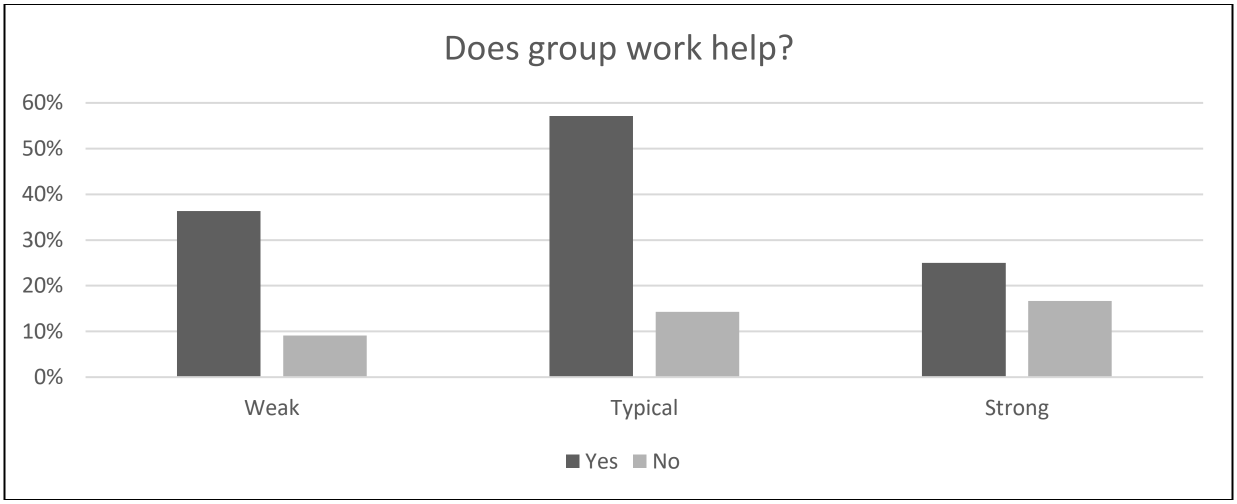

Figure 11. Student Opinions of Group Work by Math Identity Level

As a follow-up to the group work question, the researcher inquired whether students ever wished to be in a different class. The classes are homogeneously grouped and travel together for all academic subjects. While some students stated that they liked their current classmates, a few wished they were in other classes. Some for social reasons: "none of my friends are in my class," "Yes, some people talk about weird stuff. I don't know why I say that, but weird stuff," and several for behavioral reasons: "there is a group of boys that are together this year and I feel like it has also affected our learning," "We have bad students in our class. They will throw stuff at you, talk about you, peer pressure. They will say things like if you get something wrong." Karly, a female student with a weak math identity who happened to be in an inclusion class, stated

> Yes, because when my class is all struggling, when you have two kids that don't understand the same thing, then you are not going to accomplish anything, I feel like someone can't go and help the other person except for Ms. Stephanie, but I feel like there are other kids in other classes that you could ask them to explain it to you and they know it.

However, a similar number of the students interviewed stated that they liked their current class, explaining that they were comfortable with the students in the class and felt safe there (see Figure 12).

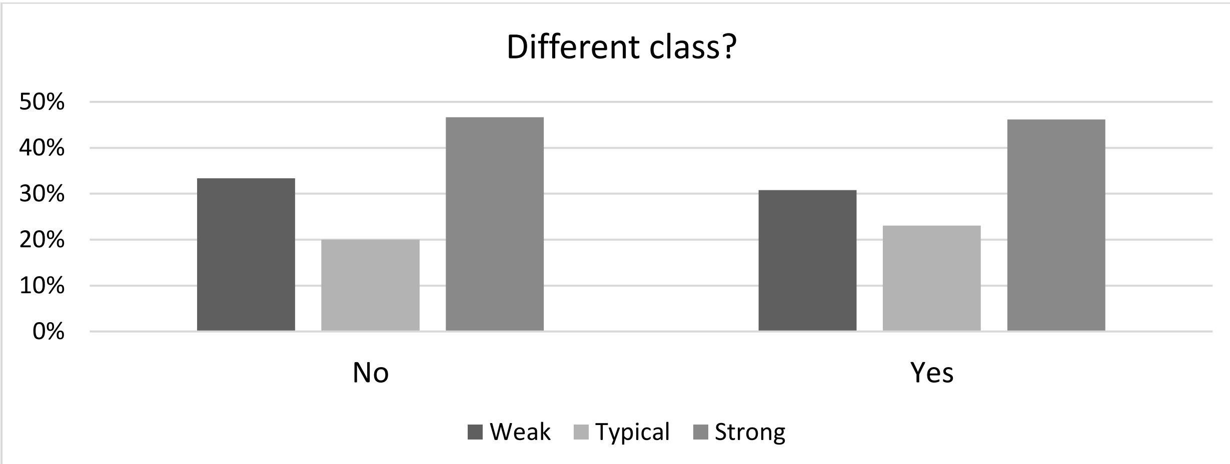

Figure 12. Students that wished they were in a different class.

Growth Mindset Items. Growth mindset was investigated with a series of questions to determine whether the student embraced a growth mindset or a fixed mindset, as well as to explore how the student felt about making mistakes. When asked whether they believed that you are either "born a math person" or "not born a math person" 56% of students stated "yes, some people are born math people." However, almost all of those that initially disagreed put conditions on their answer such as "you can work hard and learn more" or "you have to get introduced at first, but you might become a math person with practice." Students that agreed made comments such as "some people are talented," "some people just enjoy it naturally," "some people are just born with the genes," and "some people are just gifted in math…like some kids that are 8 years old and are solving college math." Taylor, a female with a strong math identity, gave a personal example:

> Honestly, I kind of DO think because everybody's brains work differently and stuff. Like, some people's brains understand things like math more. For example, I have trouble with

math sometimes, but reading and writing I'm really good at. My sister is the opposite, she is really good with math, but she has trouble with reading.

When asked whether they believed that a person could train their brain to be smarter, students of all math identity levels of students agreed that you could with practice, hard work, and effort (see Figure 13).

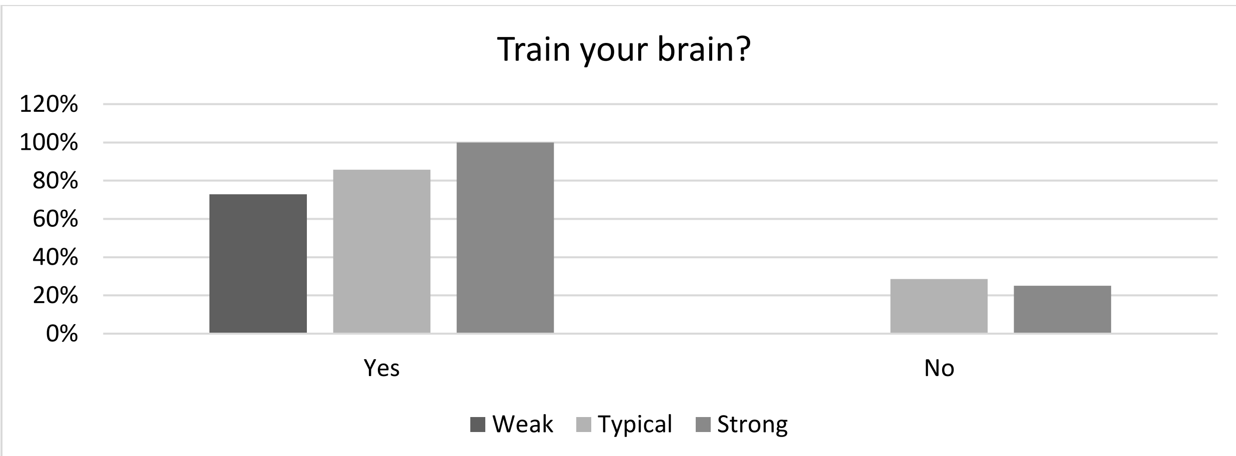

Figure 13. Can you train your brain?

When asked about mistakes, 87% of students viewed mistakes as learning opportunities as opposed to failures (Figure 14). Although some students felt "upset," "sad," "embarrassed," or "dumb" when they made a mistake, most viewed mistakes as a chance to learn and to try again (Figure 15). Students with typical and strong math identities mentioned that messages from adults upon making mistakes tended to be encouraging, while more students with weak math identities spoke of adults being "disappointed" (see Figure 16).

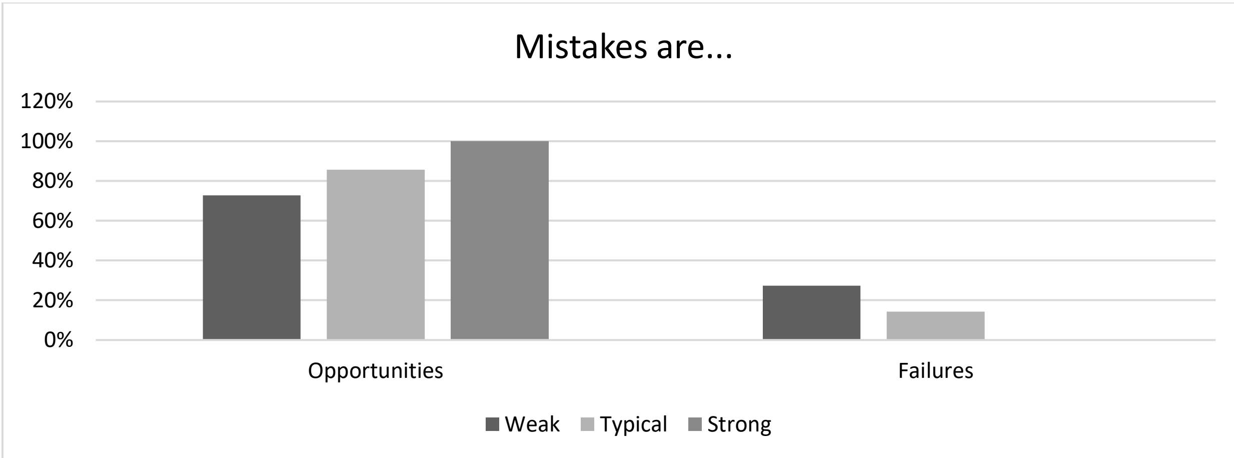

Figure 14. Do you view mistakes as failures or as opportunities?

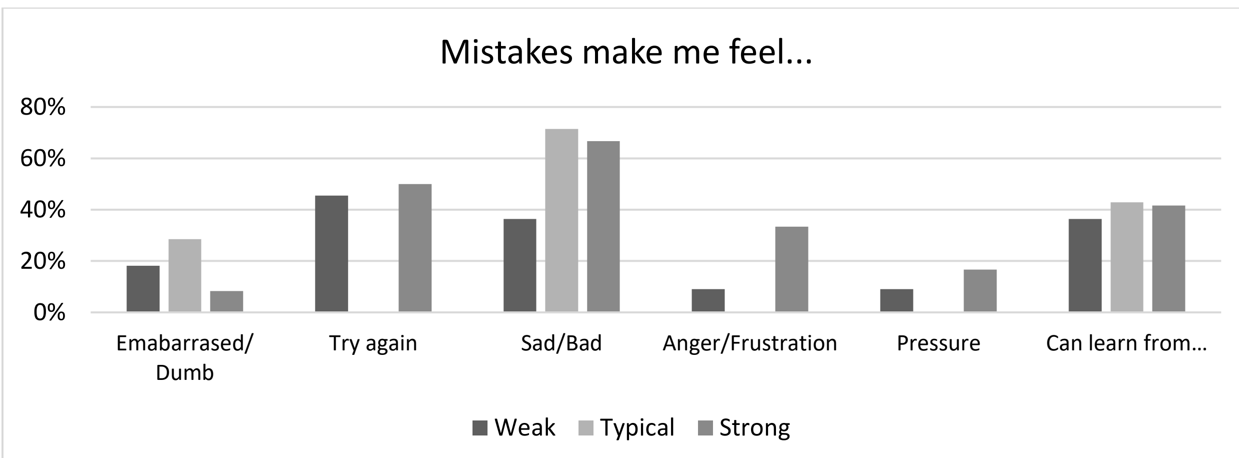

Figure 15. What emotions do you feel when you make a mistake?

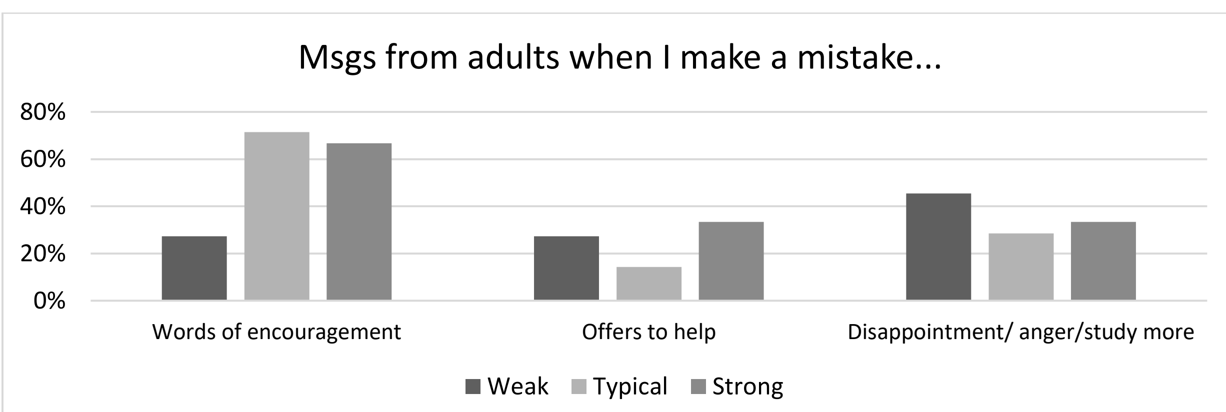

Figure 16. What do your grown-ups say when you make a mistake?

Beth, a female with a strong math identity, went back to explain more on her view of failure at the end of the interview:

> What does failure mean? It is an event I can look back on and I can go back and think I don't need to do that anymore. I can change what I did or what can I do differently the next time I do this?

Next, the researcher asked students when they felt smart. Only three students mentioned making a certain grade. About one third of students said they feel smart when they know the content or "can understand it and do good." Eleven students mentioned specific content lessons or topics that they were comfortable with, and six students said they feel smart when they understand something that their classmates do not. There was not a noticeable difference in responses based on math identity level (see Figure 17).

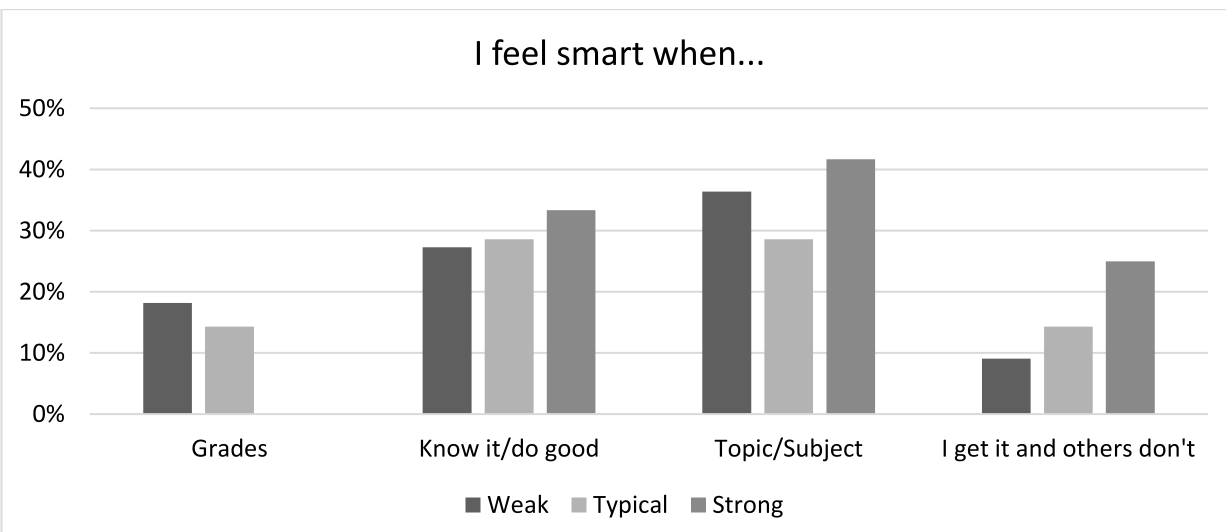

Figure 17. When do you feel smart?

The final question of the interview asked students whether they believed that grades or the ability to explain to a peer was a better indicator of understanding. Only four of the 30 students interviewed felt like grades were a better indicator of understanding and they had lower ranked math identities (see Figure 18). Several students mentioned the unreliability of grades which may be "just a number" or that some students may cheat or just memorize material and not have true understanding. Maurice, a male with a strong math identity stated:

> When they can explain. Because a grade, you don't know how they got that grade. They could've cheated, they could've done anything. They could've just memorized the formulas. They like can answer questions, but not be able to explain it. But if you can explain it then you know what you're doing and can answer questions.

Albert responded similarly, stating:

> When they can explain to a peer. Because the grade can come from someone else. The grades don't reflect as much on a person as their ability to explain it. So, let's say someone has awful grades but they completely understand the subject. They could just be like, oh they don't want to do their work, or people will think they don't understand, they are just not intelligent because they have bad grades. But if they were to come up to you and they explain in depth what it is then it would be a lot different that if someone had a good grade and couldn't explain. Because if it comes from someone could have a good grade and not be able to explain it then someone else did the work for them.

Several students also mentioned the value of shared discourse and how peers may learn from each other. Allie, a female with a typical math identity stated:

> I feel like when they can explain something to the class. Like, making a good grade can, but I feel like when you can show the class, like when people don't get it, I feel like that when somebody gets a question right and then you don't you feel like they are smarter than you but when they can explain to the class I feel like that helps everybody more than

> if they made a good grade on their test. When you talk about it and stuff that helps everybody learn.

Robert, a student with a weak math identity, said that both grades and being able to explain are good indicators of understanding: "I think, can it be both? Good grade, like you succeeded, and you KNOW it. In the other you are helping another student learn what you know and better understand what the teacher said." Students also noted the importance of using their own (student) language for understanding as opposed to teacher language. Brooklyn, a female student with a strong math identity, explained:

> The teacher sometimes won't get what the students are thinking and someone around their age is practically thinking the same thing. And if they don't understand it, they can go to someone else that is decently smart or was paying attention and can actually figure out what the teacher was saying.

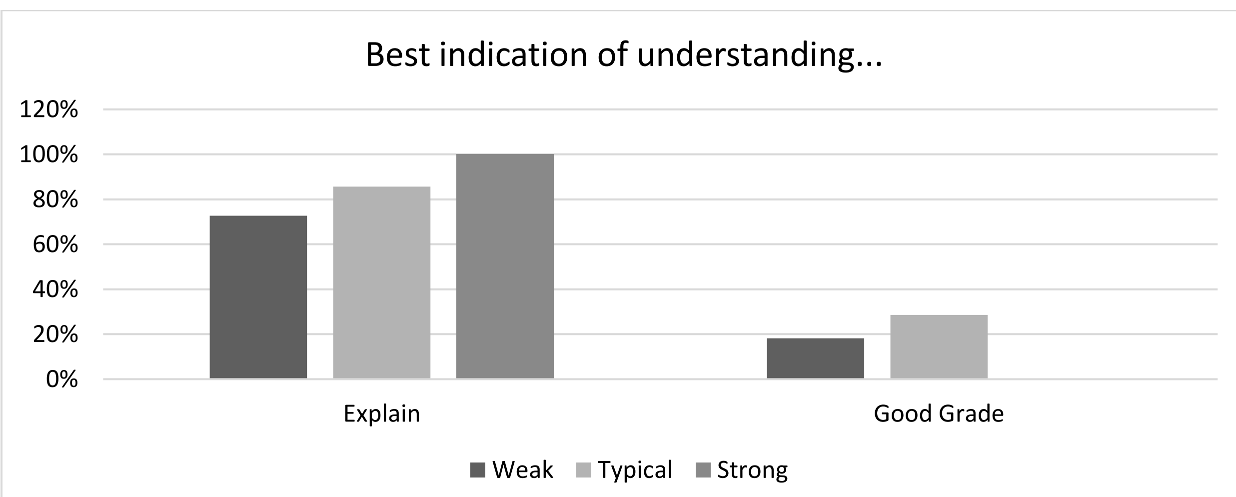

Figure 18. Are explanations or grades a better indicator of understanding?

Conclusions. Taken together, these interview data led the researcher to draw the following conclusions:

- In order to be perceived as or to perceive oneself as a math person, one must not only exhibit content proficiency, but must also enjoy the process of doing mathematics.
- The ability to help peers contributes to the perception of a stronger math identity.
- Students associated the amount of effort required to understand math content with their ability to do the math.
- Students were more efficacious when they were able to readily understand the content.
- Students were more likely to recall certain content topics when they felt efficacious as opposed to classroom activities or instructional practices.
- Students preferred and felt safer when working in groups of similar ability.
- Students of all math identity levels possess a growth mindset, tending to view mathematics ability as something that can be improved with practice and mistakes as learning opportunities.
- Students of all math identity levels believe the ability to explain a concept is a stronger indicator of understanding than a grade on an assignment.

Integration and Summary of Results

Research question 1 investigated the relationships between the three variables under consideration. Pearson correlations indicated a moderate correlation between self-efficacy and math identity ($r = .418$, $p < .001$) as well as between self-efficacy and growth mindset ($r = .423$, $p < .001$). A simultaneous multiple linear regression was conducted to determine whether self-efficacy and growth mindset predicted math identity. Self-efficacy was found to be a significant moderate predictor of math identity (p < .001), but growth mindset did not significantly predict math identity. The regression equation found was $\boldsymbol{Y_{MI}} = .861 + .430\boldsymbol{X_{SE}} + -.031\boldsymbol{X_{GM}} + \boldsymbol{\varepsilon}$.

Research question 2 investigated whether the student factors of gender, ethnicity, SES, or math achievement level significantly predicted the combined dependent variable of self-efficacy, growth mindset, and math identity. A MANOVA was conducted and found insufficient evidence to reject the null hypotheses. The combined dependent variable of self-efficacy, growth mindset, and math identity could not be predicted by these student-level factors as no significant relationships existed. ANOVAs were conducted post hoc to determine whether these factors had an effect on each individual variable; once again, no significant effects were observed.

Next a set of simple linear regressions were conducted to determine if one variable was a significant predictor of another at the student level. Growth mindset was found to be a predictor of self-efficacy for the following subgroups: males, females, students who are White, students with low SES, students without low SES, students with average math achievement and students with above average math achievement. Self-efficacy was found to be a predictor of math identity for the following subgroups: males, students who are White, students with low SES, students without low SES, students with average math achievement and students with above average math achievement. Growth mindset was a significant predictor of math identity for males.

Research question 3 inquired about student perceptions of these three variables. The researcher interviewed 30 students and found that the qualitative data supported the quantitative data. Students who felt more efficacious tended to have stronger math identities, like Albert and Beth. These data supported the moderate significant correlation between self-efficacy and math identity. The majority of students interviewed possessed a growth mindset regardless of their math identity level, such as Karly and Robert who both had weak math identities, but firmly believed that mistakes are part of the learning process, and Allie, who possessed a typical math identity but believed that "you are not born a math person, it is something that you learn as you grow." These qualitative findings in which students at all levels of math identity possessed a growth mindset supported the quantitative findings that there was not a significant relationship between growth mindset and math identity.

Figure 19 illustrates the comparison of mean composite scores for self-efficacy and growth mindset from survey data (N = 91) to the interview participants (n = 30). These means were calculated by sorting the composite scores for self-efficacy and growth mindset by math identity level for the total sample as well as for the embedded sample of interviewees. The mean was then calculated for each construct (self-efficacy and growth mindset) for each subgroup's math identity level. Additionally, although the students interviewed represented a stratified sample of students at the Charter School, there were no notable differences in interview responses based on demographic factors. These data supported the findings of the MANOVA that tested RQ2, in that no significant subgroup differences were found.

The researcher observed during qualitative data analysis that students of all math identity levels associated being a math person not only with content proficiency but also an enjoyment of doing mathematics. Students with a weaker math identity were more likely to associate speed and mental math achievement with being a math person, while students with stronger math identities did not mention these qualities. Students of all identity levels tended to be more self-efficacious when they understood a topic, and many recalled certain topics that they were confident about or struggled with.

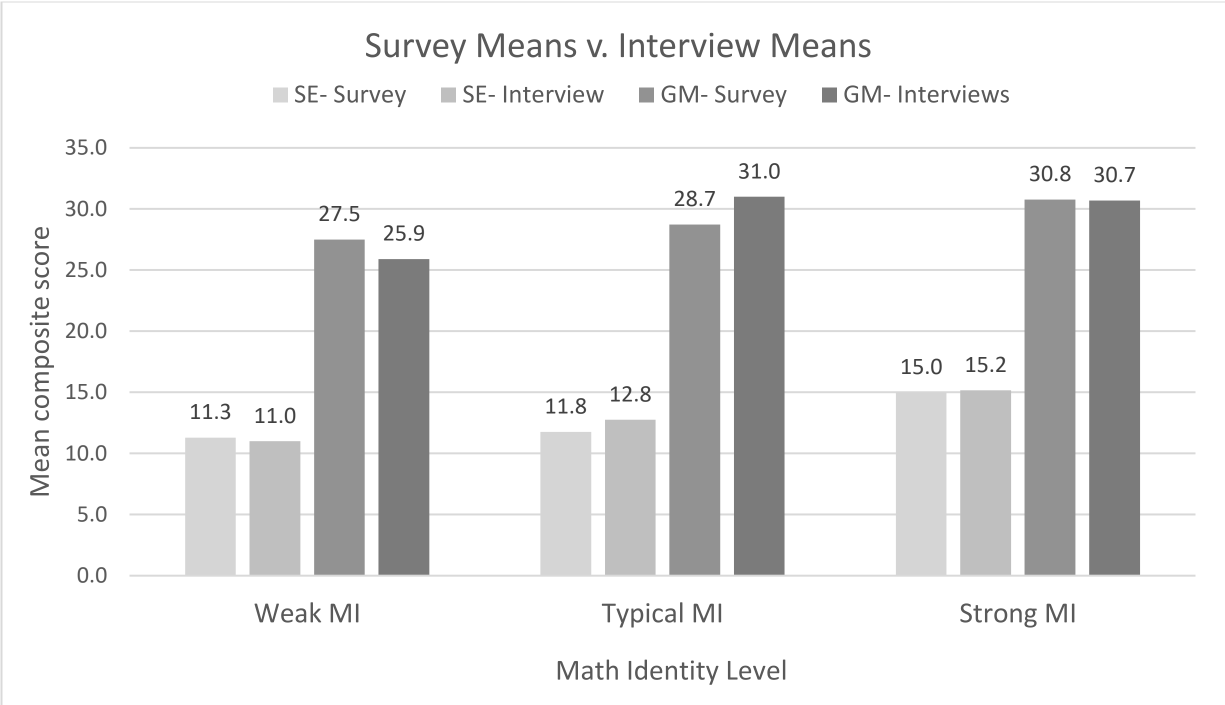

Figure 19. Mean composite scores for survey and interview participants.

Additionally, many students felt more confident working in groups, particularly those of weak or typical math identity. Students of all math identity levels tended to exhibit a growth mindset, stating that one is not "born" a math person and viewing mistakes as opportunities to learn. Table 22 presents examples of quotes for all variables investigated based on math identity level.

As a result of mixed methodology analysis, the researcher concluded that growth mindset was not a salient factor in the formation of math identities for the participants. However, growth mindset can influence self-efficacy, which in turn may contribute to the strengthening of math identity. Math identity of the participants in this study was fostered through perceived content mastery and an enjoyment of the subject.

Table 22

Example Quotes for Constructs by Math Identity Level

Math Identity (MI)	
How one perceives oneself as a "doer of math."	
Weak MI	"Someone that likes math. Someone that enjoys doing it and is good at it." "People who do math really fast, swiftly without a calculator and sometimes do difficult problems in their head."
Typical MI	"Being good at it? I think it means that you are good at math and probably like doing it."
Strong MI	"I feel like a math person is someone that loves math. They would really be vocal about how they love math, it's their favorite things, they do it every day and it's really easy to them." "A person that is very good at math that can easily explain it to other people without confusing them."
Self-Efficacy	
Task specific confidence and expectation of success.	
Weak MI	"When I know what I'm doing and know what I'm dealing with. I'm doing good with it, and I feel more confident in myself, in what I'm doing and if I succeed then I feel like I have this boost of confidence."
Typical MI	"Group work is better. Because having a person there and talking to them about it helps a lot."
Strong MI	"A group of 4 and 3 people get a different answer than me I feel like I might be wrong. We might decide to use their answer instead since it was 3-1. More confident individual work. I don't second guess myself as much."
Growth Mindset	
The implicit belief that intelligence is malleable, and mistakes represent opportunities to learn.	
Weak MI	"I think that people have to get introduced to it at first and then they might become math people with practice and better understand it than other people." "Opportunities to learn, bc you are learning your mistakes, I guess. You are growing your brain to learn."
Typical MI	"You get smarter over time, so I don't know how you could be born a math person." "If you just make a mistake, you can fix it. You can always fix your mistake."
Strong MI	"I feel like they have to study and learn to get to where they are at in life. They aren't just born being smart. They have to study to get to where they are right now." "Opportunities. Because if you don't make mistakes, then you won't learn something new. But when you make a mistake then you actually learn something bc you learn what you did wrong."

Chapter V: Conclusions

Summary of the Study

What makes someone a "math person?" How do middle school students establish their mathematical identities? Do the constructs of self-efficacy and growth mindset play into the development of mathematical identities? If so, does this differ for different populations of students? Studies have shown that mastery experiences and social persuasion are prominent factors in establishing self-efficacy (Butz & Usher, 2015; Usher, 2009; Usher, Ford, et al., 2019). Additionally, there is evidence to suggest that self-efficacy and growth mindset have a correlation (Huang et al., 2019; Komarraju & Nadler, 2013). Researchers have also found that less efficacious students tend to subscribe to a fixed mindset (Kotok, 2017). Existing research on the formation of one's math identity suggests that expectancy beliefs, interest and recognition have a direct effect (Cribbs et al., 2015; Miller & Wang, 2019; Verdin et al., 2018). Competence had an indirect effect on math identity although the effect of competence was strongest through recognition and vicariously received messages (Cribbs et al., 2015). More recently, a longitudinal analysis of NAEP data has shown that self-efficacy in Grade 9 was predictive of math identity in Grade 11, and Grade 12 math identity had a direct effect on math achievement (Bohrnstedt et al., 2020).

However, limited understanding remains as to the effect that mathematical self-efficacy and growth mindset have on the development of mathematical identity in middle school students, especially in rural populations (Radovic et al., 2018; Usher, Ford, et al., 2019). This study contributes to the existing literature by exploring the relationships between mathematical self-efficacy, growth mindset, and math identity for students in Grades 7 and 8 at a rural South Georgia charter school. The study analyzed the effects of demographic data on the combined variable of growth mindset, self-efficacy, and math identity. Additionally, this study used qualitative analysis and math identity levels to examine student perceptions of self-efficacy, growth mindset, and what makes someone a math person.

Discussion of the Findings

Initial quantitative analyses found significant moderate correlations between self-efficacy and growth mindset ($r = .423$, $p < .001$) as well as between self-efficacy and math identity ($r = .418$, $p < .001$). These findings support previous research (Komarraju & Nadler, 2013; Kotok, 2017) that students with a higher self-efficacy tend to hold a stronger growth mindset believing that intelligence is malleable and can be improved with effort while students with weaker self-efficacy hold a more fixed theory of intelligence. Additionally, the relationship between self-efficacy and math identity aligned with existing evidence that a bidirectional relationship exists between self-efficacy and math identity from Grade 9 to Grade 11 (Bohrnstedt et al., 2020). The relationship between growth mindset and math identity was not significant ($r = .151$, $p = .076$). Figure 20 illustrates the relationships between the variables under investigation.

Next, a simultaneous multiple regression was performed to determine whether self-efficacy and growth mindset were predictive of math identity. A significant equation was observed [F (2, 88) = 9.34, $p < .001$] with an adjusted R^2 of 0.156 indicating that 15.6% of the variance in mathematics identity can be attributed to self-efficacy and growth mindset. The regression equation can be written as $Y_{MI} = .861 + .430X_{SE} - .031X_{GM} + \varepsilon$. However, the coefficient of growth mindset was very close to zero and was slightly negative implying an extremely weak and inverse relationship between growth mindset and math identity.

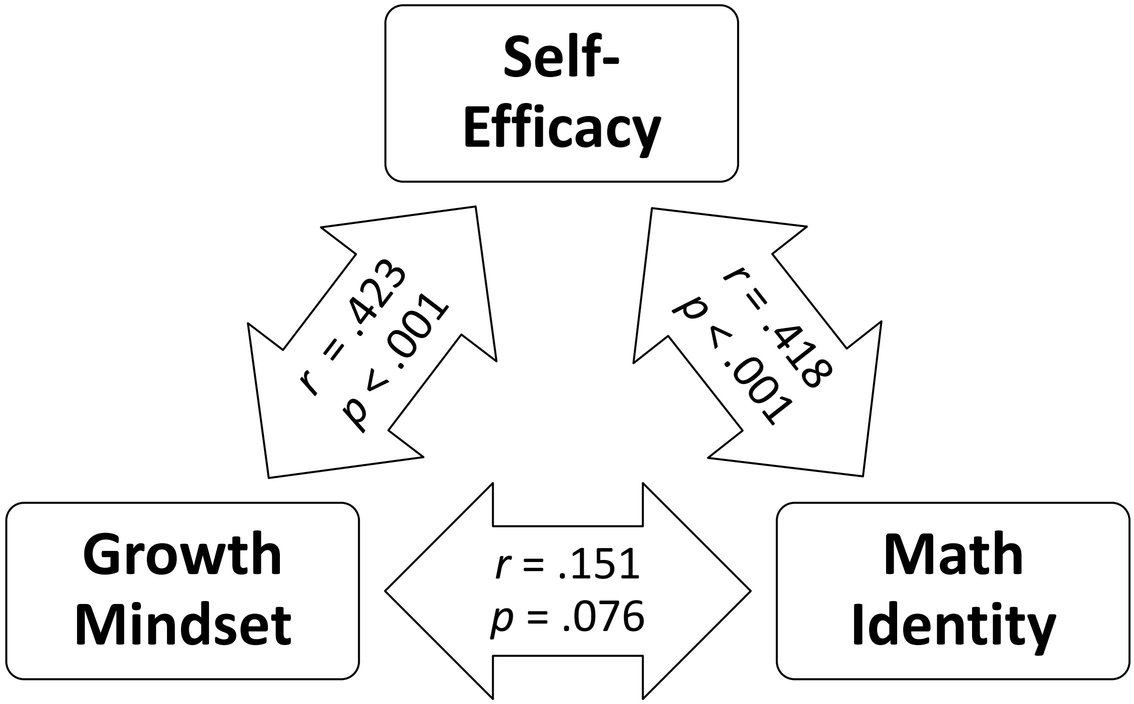

Figure 20. Relationships between variables.

In an attempt to ascertain whether the three constructs could be combined into one dependent variable, a MANOVA was conducted to determine whether student-level factors of gender, ethnicity, SES, or math achievement level were significant. When no significant relationships were found (see Figure 21)., Post hoc ANOVAs were then conducted with an adjusted $\alpha = .016$ to investigate whether significant between-subjects effects existed for the constructs when considered separately. No significant relationships were observed.

The researcher then investigated whether any relationships existed between the variables for each of the subgroups. A series of simple linear regressions were run for self-efficacy and growth mindset, self-efficacy and math identity, and growth mindset and math identity, for each of nine individual subgroups: male and female, students who were White and students who were not White, students of low SES and students of typical SES, and students of below, average, and above average math achievement. Males were the only group for which growth mindset was a significant predictor of math identity.

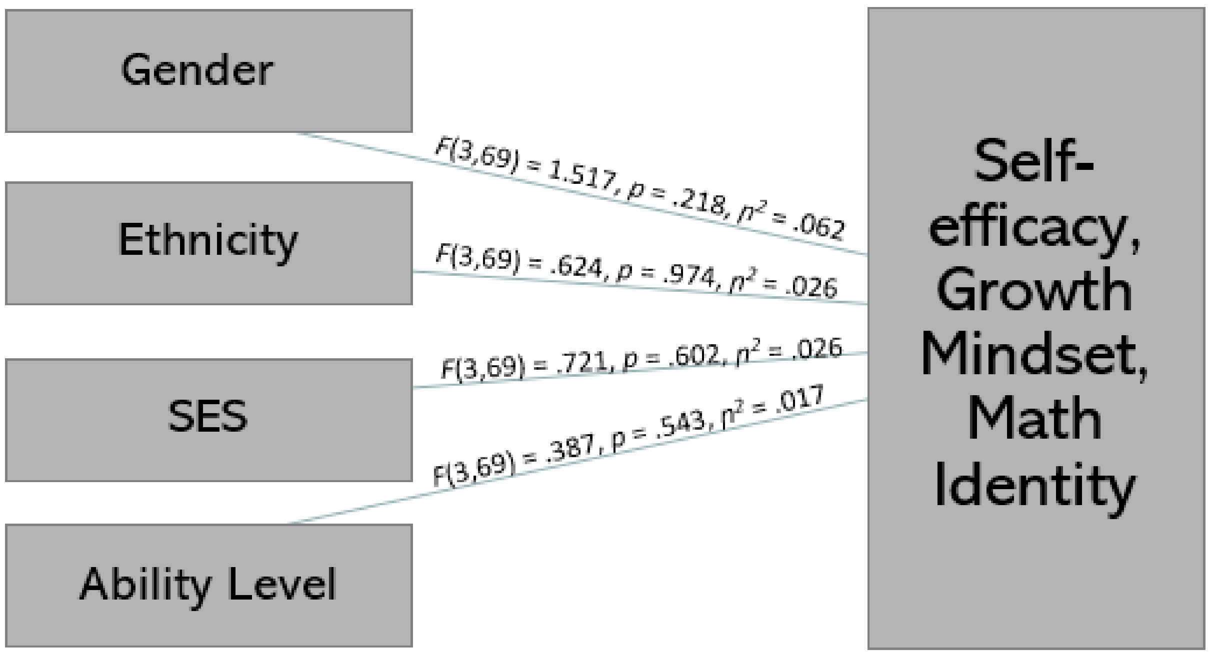

Figure 21. MANOVA results.

As for the relationship between growth mindset and self-efficacy, significant prediction equations were found for all subgroups except students that were not White and students of below average ability level. These data contrast findings by Huang et al. (2019) and Komarraju and Nadler (2013) who reported a correlation between growth mindset and self-efficacy for males but not for females. An additional finding by Huang et al. (2019) was that growth mindset predicted self-efficacy for both males and females when controlling for math achievement level. Although the current study did not control for math achievement level, growth mindset was found to be a predictor of self-efficacy for students of average and above average math achievement.

With regards to self-efficacy and math identity, significant prediction equations were found for males, students who are White, students of all SES, and students of average and above average ability level. There was not a predictive effect for females, students who are not white, or students of below average ability. This finding partially aligns with research by Bohrnstedt et al. (2020) who found a reciprocal relationship for self-efficacy and math identity from Grade 9 to Grade 11.

Taken together, the subgroup data from the simple regressions seem to support prior research (Butz & Usher, 2015; Usher, 2009) that males and students who are White may have different factors that play into the formation of their self-efficacy and identity than do females and students of color. Researchers have reported that self-concept (identity) is formed from past experiences (Marsh et al., 2019). The primary factor in self-efficacy for males was mastery experiences (Usher, 2009) while females and minorities tend to receive more affirmation from vicarious sources like peers and social situations (Usher, 2009; Butz & Usher, 2015). Moreover, task value has been shown to be a primary factor of math identity for students who are Black while outcome expectancies are a more salient factor of math identity for students who are White (Miller & Wang, 2019).

The importance of recognition cannot be overstated. Of all the other variables tested, Cribbs et al. (2015) reported that recognition had the strongest effect on math identity. It is possible that for females and students of color, the perception of how others “see” them is so important that they strive to meet those expectations. They feel have to fit in socially or fit a mold of how to be “seen.” Good, Rattan, and Dweck (2012) found that perceived gender stereotypes and a perceived fixed mindset environment was a significant predictor of whether females felt like they belonged college calculus classes, but the same perceptions did not have the same effect for males. Strayhorn (2015) reported that a sense of belonging and being valued was a vital component to program satisfaction and success for Black males enrolled in college STEM programs. Furthermore, Berry et al. (2011) found extrinsic recognition to be one of four vital components of the math identity of middles school Black males enrolled in a summer math program.

Analysis of the qualitative data found that content proficiency alone is insufficient for one to be perceived as a math person; interest and enjoyment must also be present. These findings concur with Cribbs et al. (2015) who found that college students with an interest in mathematics held a stronger math identity. Similar findings were also reported by Verdin et al. (2018), although participants for the Verdin study were under-graduate college students enrolled in engineering courses. Intrinsic interest value in mathematics has a positive effect on efficacy as well as performance for adolescents (Yurt, 2015). Furthermore, students with an interest in mathematics and a stronger math identity are more likely to pursue higher level math courses in high school (Guo et al., 2015).

The theme of “help” was prominent in the interview responses. Students with a weak math identity often needed to ask for help, while students with a stronger math identity were reinforced by being able to help their peers. These findings underscore the importance of peer perceptions and vicarious messages that are prominent in existing efficacy research (Berry et al., 2011; Cribbs et al., 2015; Miller & Wang, 2019). The formation of the adolescent identity relies heavily on the perceptions of others as students seek a sense of belonging to find their place in different groups (Sinclair et al., 2019), much like Wegner’s (1998) communities of practice.

With regards to grouping structures, most students stated that they were content with their class assignment, although several mentioned behavior issues. The question of how to group students has been around for decades in education and there are valid arguments for both homogeneous and heterogeneous grouping. In fact, grouping arrangements, which can be controlled by administrators and teachers, are considered one of the structures that may unintentionally affect the identity development of adolescents (Verhoeven et al., 2019). Ability grouping sends a fixed mindset message to students and can be harmful to the identity formation of all, particularly for students in the top group (Boaler, 2016). Participants for this study were grouped homogeneously by ability level and traveled with the same classmates for all academic classes.

With regards to mistakes, students were asked how they viewed mistakes as part of the questions intended to determine whether they possessed a growth or fixed mindset. Although an overwhelming majority of students viewed mistakes as learning opportunities, the question "How do you feel when you make a mistake?" brought out some differences depending on the strength of a student's math identity. More than 60% of students with typical and strong math identities stated that mistakes made them feel sad or bad. One third of the students with strong math identities stated that they felt anger or frustration when they made a mistake. Avineri et al. (2011) offered a possible explanation for these responses in that advanced students may feel that mistakes threaten their "smartness." Although the findings of this study did not indicate that students with a strong math identity tend to hold a fixed mindset, there is evidence in the literature to support the notion that many gifted students are simply good at following procedures which mimic the teacher's steps and as a result are uncomfortable when a task requires them to think creatively, struggle productively, and try, try again (Avineri et al., 2012; Boaler, 2016; Liljedahl, 2021). They tend to have a fixed mindset and feel that mistakes threaten their "smartness" (Avineri, 2012).

Researchers have found that students assigned to a perceived higher status group may view themselves as valuable contributors, strengthening their identity (Legette & Kurtz-Costes, 2021a; Verhoeven et al., 2019), while students assigned to lower groups may perceive themselves as less valuable. Contrariwise, the Big-Fish-Little-Pond Effect (BFLPE) is a theory stating that students tend to compare themselves with the ability of group to which they are assigned (Marsh & Seaton, 2015). Higher ability students will have weaker math identities when they are part of a higher achieving group and lower ability students will have stronger identities when placed with a lower achieving group. It would seem that both of these theories point to a need for de-tracking and instead structuring classes by heterogeneous grouping. In fact, one student's comment of wishing to be in another class because her entire class was struggling supports the need for heterogeneous grouping. Jo Boaler (2016, p. 111) speaks of "Growth Mindset Grouping" in which students are de-tracked into heterogeneous groups and taught mathematics through the use of complex open-ended tasks that encourage students to collaborate and be responsible for each other. Moreover, ability grouping has been found to have an effect size of .12, barely above the typical developmental effect you would expect over the course of a year (Almarode et al., 2019). An effect size of .40 is considered to be medium and includes the effect of the teacher. Effect sizes larger than .40 are considered to be high, representing more than a year's growth in school.

With regards to group work, there is much research to support the importance of collaborative learning at the middle school level (National Middle School Association, 2003). Almost every student that was asked stated they preferred working in a group for their math practice. Many appreciated the safety it provided, if you made a mistake the whole class would not know; many liked the fact that if they didn't understand, chances were someone in the group did and could help. Most of the students spoke of being able to discuss the mathematics with their peers, and on a subsequent interview question almost 100% of students spoke of the importance of being able to clearly explain a concept as a criterion for understanding. These findings support the findings of Verdin et al. (2018), who reported that communicating and transmitting knowledge to peers was a component of being a math person.

Autonomy is another criterion for identity development. Boaler and Greeno (2000) reported that students did not want to be passive receivers of knowledge. Students felt more agency when allowed to discuss, discover, and make meaning of ideas and concepts as opposed to typical "sit-and-get" instruction. The process of discussion and classroom discourse allowed students to strengthen their sense of agency and therefore perceive themselves as doers of mathematics. The effect size of classroom discussion is .82 (Almarode et al., 2019). Effective discussions have the potential to not only allow students to explain what they have learned, but also can strengthen their math identities through recognition as valued members of the mathematics community.

In summary, the qualitative findings of this study parallel the framework theorized by Cribbs et al. (2015) who posited that interest, recognition, and competence would all be salient factors in the formation of math identity. Although this study focused on the constructs of self-efficacy and growth mindset as predictors of math identity, qualitative analysis points to perceived competence, interest, and recognition as salient factors. Competence and recognition play into self-efficacy through mastery experience and vicarious messages. Although Bandura (1994) noted that more efficacious students tend to be more intrinsically interested in topics, interest is a quality that is unique to each individual student.

Significance of the Methodology

This study used a mixed methods explanatory sequential design (Creswell & Creswell, 2018). Mixed methods explanatory sequential design was appropriate because the initial data collection was quantitative via student surveys and the integration of demographic data. Next, qualitative data was collected through student interviews to better understand student perceptions of math identity, self-efficacy, and growth mindset. The use of interviews alongside surveys helped avoid method bias (Podsakoff et al., 2012) and allowed the researcher an opportunity to probe more deeply into the thinking of the respondents. Although math identity was measured with only two quantitative items with no neutral choice option, subsequent qualitative data collection provided further insights into the perceptions of interview participants.

Furthermore, triangulation of the quantitative and qualitative data strengthened the findings. A comparison of mean composite scores for self-efficacy and growth mindset between the survey participants and the interview participants revealed little difference between means for all levels of math identity. Interview participants with a weak math identity scored slightly lower than survey participants on self-efficacy (-0.3) and growth mindset (-0.4). Interview participants with a typical math identity scored higher on self-efficacy (+1.0) and growth mindset (+2.3) than the survey participants. For students with a strong math identity, the group means were almost identical. The self-efficacy mean was (+0.2) higher for interview participants and the growth mindset mean was (-0.1) lower for interview participants. Analysis of these data from the embedded sample reinforced the findings from the total sample, that growth mindset is not a salient factor in the development of mathematics identity.

Contributions of the Theoretical Framework

The theoretical framework contributed to the study by forcing the researcher to approach the data collection process with an open mind. Grounded theory is inductive research, and in its truest form begins with no preconceived thoughts or ideas about the theory behind the behavior that is being studied (Birks et al., 2019; Tie et al., 2019). However, the researcher has over 20 years of classroom experience and often incorporates research-based strategies into instruction that foster self-efficacy, growth mindset, and mathematics identity. It would have been impossible for the researcher to interpret the qualitative data from a completely objective viewpoint. Therefore, constructivist grounded theory was appropriate as it considers the perspective of the researcher and uses prior knowledge and preconceptions to help answer *how* and *why* questions (Charmaz, 2008). Prior knowledge and experience with self-efficacy and growth mindset instructional strategies and research allowed the researcher to pose more effective follow-up questions during qualitative data collection.

Constant comparison of data during iterative collection cycles are a key component of grounded theory research (Kolb, 2012). This study began with quantitative data collection, which included the first cycle of qualitative data. The researcher used responses to the *Why?* survey questions to refine the initial interview protocol. The process of interviewing students of similar math identity levels on the same day allowed the researcher to compare students' answers in real-time and ask more probing follow-up questions. During the coding process, constructivist grounded theory was used with In Vivo coding during the initial cycle, followed by focused coding during the intermediate cycle (Tie et al, 2019). Finally, theoretical coding was used to integrate the qualitative data with the quantitative data to form the theory that answered the research questions posed in this study.

As the majority of participants possess a growth mindset and believe that mistakes are opportunities for learning, growth mindset is not a salient factor in the formation of math identity. However, growth mindset can foster self-efficacy, which in turn fosters math identity. Additionally, interest matters. Students with a strong math identity not only enjoy math but are also interested in mathematics and are perceived to be proficient in the doing of mathematics.

Delimitations, Limitations, and Recommendations for Future Research

The results of this study are delimited to students in Grade7 and Grade 8 during the 2021-2022 school year at the Charter School. Additionally, the results of this study are delimited by the researcher's choice to include only two mathematics identity items on the survey instrument. It is possible that the inclusion of more items to measure mathematics identity would have given a clearer picture of student perceptions. The researcher attempted to balance this shortcoming through qualitative data collection using questions such as: "*What does 'being a math person' mean to you? Why did you say that you are/are not a math person? Why do you believe that other people perceived you to be/not be a math person?"* to understand what qualities students attribute to being a "math person." The qualitative data collected in this study supported the survey data that was collected during the first round of data collection.

This study is limited to populations with demographics similar to that of the Charter School. Although the ratios for males to females and for low SES to typical SES were close to 1:1, the ratio of White to not White was approximately 3:1. The Charter School is a small rural school with a total enrollment K-12 of about 800. Additionally, the school that served as the site for this study is a state Charter School. Parents must elect for their children to attend and sign a contract. Students must continue to meet expectations stated in the school's discipline and academic policies to remain enrolled. As a result, these findings are not generalizable to populations dissimilar to that of the Charter School. Future researchers may wish to conduct a similar study with a more diverse group of participants. It is likely that results would be different if the study were conducted at a public school in a more urban area.

Another limitation of the study was the homogeneous grouping of students. These students had been with the same peer group for several years and social bonds and hierarchies were well established. It was clear during the interview process that the students knew each other well as several commented on disruptive behaviors that made learning difficult. It is possible that the homogeneous groupings contributed to social desirability bias, the tendency of participants to respond in a manner they believe to be expected and acceptable in their group instead of selecting responses that are more reflective of their true perceptions or feelings (Grimm, 2010; Nederhof, 1985).

A further limitation of the study existed in that the participants will have the researcher as their Algebra 1 teacher in the future. Although care was taken to avoid contact with participants prior to data collection, some participants had older siblings that were in the researcher's class or may have seen the researcher on campus during the school year. Most survey participants were aware that the researcher would be their teacher in the future and all participants were informed as part of the interview protocol. Although the researcher assured interview participants that they were safe, no one would know what they said, and their answers would not affect any future interactions once the researcher was their instructor, it is possible the interview responses were biased and not a true representation of their perceptions.

The structure of the MAP Growth test is a potential limitation for the reliability of the measure of math achievement level. Although well established as a valid and reliable assessment of student ability (NWEA, 2021), it is possible that students do not try their best on the test because it is not a “gradebook” assessment. It is the experience of this researcher that when students know an assessment “doesn’t count” they may not try, resulting in skewed results with an inaccurate measurement of true ability. The test is adaptive. Although based on common core standards, each next question depends on whether the answer to the previous question was correct. As students continue to answer correctly, they are presented with increasingly challenging items. As a result, the test may take twice as long for a higher ability student than for a student with a lower ability. Students may just “click through” the assessment in order to be finished sooner. Future researchers may wish to use a different assessment to measure math achievement such as the State of Texas Academic Assessments and Readiness (STAAR) test or even state assessment scores such as the Georgia Milestones End of Grade (EOC) assessments.

Furthermore, the data collected in this study was a snapshot of student progress, achievement, and perceptions at one singular time point. This study was conducted during the final month of the school year, so it is possible that student answers would have been different if the study took place at a different point in time. The timing of data collection meant that students had time to reflect on the year and were better able to answer the interview questions about identity and growth mindset. However, it is possible that their answers to the self-efficacy items would have been different if the study had taken place in August instead of in May. Future researchers may also want to conduct a longitudinal study to investigate how student perceptions and ratings on these constructs change over time. It would be interesting to explore the same data throughout the adolescent years of Grades 6 – 12. Bohrnstedt et al. (2020) reported that math self-efficacy in Grade 9 was predictive of math identity in Grade 11 Additionally, mathematics identity has been found to be predictive of mathematics achievement in Grade 12 (Bohrnstedt et al., 2020). Therefore, it would be worthwhile to investigate whether mathematical efficacy, growth mindset, or math identity are predictive of SAT scores or choices of college major.

A further limitation of this study is due to the design. The study was not an experimental design, so the results are correlational. Future researchers may wish to consider a quasi-experimental design or randomized controlled trial using a growth mindset intervention taught in the context of mathematics to explore the causal effects on self-efficacy, growth mindset, and math identity on math assessment scores. Growth mindset interventions have been shown to increase student motivation (Blackwell et al., 2007; Romero et al., 2014; Yeager et al., 2019) and self-efficacy (Samuel & Warner, 2019) and it is possible that such techniques would be beneficial to adolescents in strengthening their math identities. Boaler (2016) has much research on *Mathematical Mindsets* and how such instruction can be beneficial to students of all ability levels.

With regards to the instruments used in this study, future researchers may wish to use other instruments to measure growth mindset or self-efficacy such as the Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009). Additionally, future researchers may wish to include the construct of grit in their investigation. There is evidence that grit is positively correlated with self-efficacy (Usher, Caihong, et al., 2019) as well as with growth mindset (Park et al., 2020). Furthermore, using different rating scales to measure each construct may reduce the risk of method bias. The use of a semantic differential scale or graphic rating scale in addition to a Likert scale may provide more reliable responses (Podsakoff et al., 2012).

Future researchers may also wish to investigate mathematics identity with a more thorough instrument. Although the items used in this study fit well with current identity research, in that the perceptions of others are as important as one's own perceptions (Bohrnstedt et al., 2020), there were only two items included and both items had a forced choice design. Forced choice items, which do not include a neutral response option such as *neither agree nor disagree* or *don't know*, have been shown to reduce social desirability bias (Nederhof, 1985). Future researchers should consider the use of social desirability scales and implement techniques to reduce this bias. However, the use of an instrument that includes more items and has been tested for validity and reliability such as the 20-item scale created by Kaspersen and Ytterhaug (2020) may offer a more comprehensive analysis of the origins of students' mathematics identity.

Furthermore, this study did not utilize inter-rater coders when analyzing the qualitative data. Future researchers should consider using more than one person to interview and code the qualitative data, and make sure this person is not associated with the participants. The reliability of the qualitative findings would be increased with the use of more than one coder and could be justified by calculating Cohen's Kappa (Gisev et al., 2013), a measure of the percent agreement of codes between raters. The closer to 1.0 the Kappa value is, the more in agreement the coders are, giving a more reliable analysis of the data.

Additionally, the MANOVA results indicated that the composite variable formed by self-efficacy, growth mindset, and math identity are separate constructs. Therefore, they should be considered separately in future research. However, researchers have proven that demographic variables do have an influence on efficacy and identity (Berry, et al., 2011; Bohrnstedt et al., 2020; Usher, Ford, et al., 2019) so future researchers may wish to conduct a ANCOVA or MANOVA and include demographic variables as covariates in the analysis. Researchers may also want to investigate whether contextual-level variables such as school climate or teacher expectations affect students' self-efficacy and math identity.

Implications of the Study

This study was inspired by the researcher's desire to better understand how adolescents develop their math identities. It was the hope of the researcher that by better understanding how math identities are formed, strategies can be incorporated into instructional practices to help strengthen those identities. To that end, this study has contributed several important findings.

With respect to growth mindset, the finding that growth mindset did not significantly correlate with or predict math identity was a bit surprising. However, upon closer examination of the data and discussion with students during interviews, it became evident that most students possessed a growth mindset. Further evidence of this finding was the mean growth mindset score on the student survey, 29.84 out of a possible 40 points, and the finding that the majority of students tended to view mistakes as learning opportunities. However, math class needs to be a safe place to make mistakes. Teachers can help encourage a growth mindset by praising effort and process instead of outcomes (Boaler, 2016). Furthermore, there is evidence that teaching strategies incorporating classroom interactions that allow students to actively engage in mathematical discourse with their peers, make mathematical connections to students' everyday experiences, and encourage conceptual learning as opposed to rote memorization have a positive effect on the formation of math identity (Cribbs et al., 2020). It is also possible that instructional strategies such as those found in *Mathematical Mindsets* (Boaler, 2016) and *Building Thinking Classrooms in Mathematics* (Liljedahl, 2021) can help strengthen the development of students' math identities as they become doers of math.

With respect to self-efficacy, the finding that self-efficacy correlated with growth mindset corroborated previous findings (Huang et al., 2019; Kotok, 2017). Additionally, growth mindset predicted self-efficacy for all subgroups except students that were not White and students of below-average ability. These findings suggest the importance of interventions to foster or reinforce the concept of growth mindset. It would also be beneficial for school structures to focus on learning and mastery goals, as opposed to performance goals. Much of the school structure in the United States focuses on performance goals such as final grades or test scores. Additionally, participants in this study recognized that the ability to explain a concept was stronger evidence of understanding than a good grade.

With respect to math identity, this study found that self-efficacy was moderately correlated with and predicted math identity for males, students who are White, and students of average and above-average ability. It would be beneficial for schools to incorporate strategies that offer students an opportunity to experience autonomy, establish agency, and discuss the content that they are learning with their peers. Such strategies would be likely to strengthen their mathematical self-efficacy, which in turn could foster their identities as “math people.”

It is also important to consider traditionally marginalized groups when planning interventions and designing new instructional strategies. This study found no effect for non-White students and students of below-average ability with self-efficacy to math identity and growth mindset to self-efficacy. Additionally, there was no effect on math identity from self-efficacy for females. One must wonder why? If math identity is based on content proficiency, peer recognition, and interest, what can be done to improve proficiency and to spark interest among traditionally marginalized student groups? Miller and Wang (2019) reported a greater increase of math identity for Black students due to teacher’s positive impact on mathematics task value. Boaler and Greeno (2000) reported that students need autonomy and a vision of how mathematics fits into the future they have imagined for themselves. Tomlinson (2018) stated that complex instruction, the creation and implementation of “groupworthy tasks,” offers opportunities for advanced students to be challenged as well as for struggling students to experience success. The practice of visibly random grouping (Liljedahl, 2022) allows students to share thoughts and ideas with others in the classroom that they may not have worked with before, giving all students an opportunity to have their thinking recognized by their peers. Recognizing smaller successes and praising the process during a collaborative task helps students to build mastery experience (Boaler, 2016; Liljedahl, 2022).

Task value has a stronger effect on math identity than efficacy for students who are Black (Miller & Wang, 2019; Usher & Pajares, 2009). When making educational choices, females tend to value social identity more than interest, while males most value interest (Sinclair et al., 2019). Time and again, interest has been found to be a salient factor as to whether someone identifies as a math person (Cribbs, 2015; Huang et al., 2019; Kotok, 2017; Miller & Want, 2019; Sinclair et al., 2019, Verdin et al., 2018). In fact, when comparing gender-typed educational choices among Grade 9 students in Sweden, Sinclair et al. (2019) found that subject-specific interests were so strongly correlated to subject-specific identities that it was not meaningful to treat the two groups of predictors as distinct.

Conclusion

This mixed methods study investigated the relationships between the constructs of self-efficacy, growth mindset, and math identity among middle school students at a rural charter school. Significant correlations between growth mindset and self-efficacy as well as between self-efficacy and math identity were observed. Additionally, several predictive relationships were found between these variables for certain population subgroups. There was not a significant relationship between demographic factors and the dependent variable of growth mindset, self-efficacy, and math identity. However, students of all math identity levels tended to hold a growth mindset and recognized the importance of discourse in the learning process. The participants associated content proficiency, being able to help peers, and interest or enjoyment of the content with being a math person.

In conclusion, consider this question from a different perspective: “Do you believe some people are just born math people?” Although this question was included in the interview with the intent to tease out whether participants held a fixed or incremental mindset, after analyzing data from the current study alongside existing literature, perhaps this question was better suited to investigate math identity. Can all students learn math with a bit of effort? Yes, although it will come easier to some than others. Are all students naturally interested in mathematics? No. Even though strategies are available to schools and educators which have been shown to foster math identity; even though teachers can offer support to help students be successful; even though parents and social communities may be supportive; interest and enjoyment matter. As math educators, we would be wise to incorporate strategies and methods that expose our students to the beauty of mathematics and allow them the opportunity to make their own discoveries with the hope that they will become as fascinated as we are. But even so, they may just prefer something else more.

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APPENDICES

Appendix A

Permission to Conduct the Study

Grounded in Tradition • Reaching to the Future

BACONTON
Community Charter School

Lynn Pinson
Administrator

Kelly Rucker
Elementary Principal

Missy Huber
Middle School Principal

Dr. Mary Sullivan
High School Principal

January 24, 2022

Dear Columbus State IRB:

On behalf of Baconton Community Charter School, I am writing to grant permission for Carrie Pierce, a doctoral candidate at Columbus State University, to conduct her research "Relationships Between and Student Perceptions of Self-efficacy, Growth Mindset, and Mathematics Identity of Adolescents in a Rural South Georgia Charter School."

I understand Ms. Pierce will recruit approximately 150 of our middle school students to participate in an online survey as well as conduct interviews with smaller focus groups at Baconton Community Charter School over a six-to-eight week period.

We are happy to participate in this study and contribute to this important research.

Sincerely,

Lynn Pinson
School Administrator

Appendix B

Parent/Guardian Informed Consent

Parent/Guardian Informed Consent

You are being asked to participate in a research project conducted by Carrie Pierce, a student in the Ed.D. Curriculum and Instruction Program in the Department of Teacher Education, Counseling, and Leadership at Columbus State University. This process will be overseen by Dr. Deborah Gober.

* Required

1. Email *

Purpose	The purpose of this study is to examine the effects of mathematical self-efficacy and growth mindset on the development of mathematical identity.
Procedures	Students whose parents have granted consent to participate in the study will be emailed a Google Form survey. The survey will be completed during homeroom and will last no more than 20 minutes. The researcher will then use these survey results along with demographic information provided by the school (Winter MAP Growth scores, gender, ethnicity, and socio-economic status) to analyze trends/patterns in subgroups of students. Next, the researcher will select approximately 25 students for interviews. These interviews will last approximately 20 minutes and will be video recorded on the researcher's iPad. The researcher may then elect to conduct further interviews after the initial round of data analysis. The researcher is the only person who will have access to survey results, subgroup information, and interview data. All data collected will be deleted upon completion of this study and will not be used in future research projects. The total anticipated time for participant involvement in this study from survey to interviews will be no more than 3 months.

Possible Risks or Discomforts	This project poses no physical risks to students. Psychological risk or discomfort to students is minimal. Students will not be required to respond to questions that make them uncomfortable and may elect to withdraw from the study at any time. Interviews will take place in a neutral location on campus. The researcher will lead interview discussions and an objective teacher will be present to take notes.
Potential Benefits	This study offers no benefits to students. However, school administration may use the generalized findings of the study as a guide to incorporate strategies that may help foster student self-efficacy in math, build a growth mindset, and strengthen students' mathematical identities. There is evidence in the literature that strengthening these three constructs may improve math achievement.
Cost and Compensation	Students will receive a small candy compensation (M&M's or Skittles) for participation in the study.
Confidentiality	The researcher will maintain password protected spreadsheets on a personal computer in her home office with all survey and student information. No other parties will have access to this information except for the researcher. A list of student names and lunch numbers will be kept in a separate password protected spreadsheet. Student survey responses and demographic information will be identified by lunch number. Upon receipt of the data for math ability level, the researcher will merge student names with lunch numbers. After this is done, the researcher will remove student names from this data set. From this point forward, all student information will be identified by lunch number, not by name. Interviews will be recorded on the researcher's personal iPad. The iPad is password protected and is accessible only to the researcher. Transcripts of the interview sessions will be stored on the researcher's personal computer. All student data will be deleted within one year of completion of the study.

Withdrawal	Participation in this research study is voluntary. Your child may withdraw from the study at any time, and his/her withdrawal will not involve penalty or loss of benefits.
Additional Information	For additional information about this research project, you may contact the Principal Investigator, Carrie Pierce, at 229-787-9999 or cpierce@bccsblazers.org. If you have questions about your rights as a research participant, you may contact Columbus State University Institutional Review Board at irb@columbusstate.edu.
Parent/Guardian Consent	I have read this informed consent form. If I had any questions, they have been answered. By signing below, I give consent to my child's participation in this research project.

2. Parent/Guardian Name *

____

3. Date *

____

Example: January 7, 2019

Student Name and Consent to Participate.

4. I consent for my child to participate in the Google Form survey. *

Mark only one oval.

- YES
- NO

5. Child's name *

____

6. Date *

____

Example: January 7, 2019

7. I consent for my child to participate in additional interviews if selected. *

Mark only one oval.

- YES
- NO

8. Child's name *

____

9. **Date** *

Example: January 7, 2019

Appendix C

Participant Consent and Survey Items

Section 1 of 15

Student Informed Consent & Survey

You are being asked to participate in a research project conducted by Carrie Pierce, a student in the Ed.D. Curriculum and Instruction Program in the Department of Teacher Education, Counseling, and Leadership at Columbus State University. This process will be overseen by Dr. Deborah Gober.

After section 1 Continue to next section

Section 2 of 15

Purpose

The reason for this study is to figure out how self-efficacy in math and growth mindset affect how someone sees themselves as a math student.

Section 3 of 15

Procedures

I'm emailing you because your parents have agreed it is okay for you to participate. This survey should take less than 20 minutes.

Ms. Pierce will use these results and some of your personal information, like gender, race, income, and MAP test scores, to look for patterns or trends.

Ms. Pierce will then choose students to participate in interviews. The short interviews, about 20 minutes, will be recorded. After looking at the interview evidence, Ms. Pierce may want to interview some students again or choose other students to interview.

No one else will be able to see the survey or interview data. The evidence will be deleted when the study is finished. Student data collection will take less than three months.

Section 4 of 15

Possible Risks or Discomforts

This project poses no physical and minimal psychological risks to students. You will not have to answer any questions that make you uncomfortable and you may stop participating at any time.
Interviews will take place in the high school conference room.

Section 5 of 15

Potential Benefits

This study offers no direct benefits for students.

Section 6 of 15

Cost and Compensation

You will receive a small candy compensation (M&M's or Skittles) for participating.

Section 7 of 15

Confidentiality

Ms. Pierce will keep all data on her personal computer and iPad which are password protected. Survey results and personal information will be coded with lunch numbers, not with your name. All data collected will be deleted within one year after the study is complete.

Section 8 of 15

Withdrawal

Your participation is completely voluntary. You may choose to exit the study at any time.

Section 9 of 15

Additional Information

If you have further questions, please contact Ms. Carrie Pierce at cpierce@bccsblazers.org.

Section 10 of 15

Assent

I have read this informed consent form. If I had any questions, they have been answered. By continuing, I agree to participate in this research project.

Please select one of the choices below. *

- Yes, I will participate
- No, I will not participate.

Section 11 of 15

Survey

Description (optional)

What grade are you in? *

- 7
- 8

What is your 4-digit lunch number? *

Short answer text

Section 12 of 15

Part 1

Please answer the following questions honestly. There are no right or wrong answers. Just choose the answer that describes how you feel. Think about next year as you answer these questions.

I can do almost all the work in my math class if I don't give up.

- Not at all true
- Slightly true
- Somewhat true
- True
- Very true

Even if the work is hard in my math class, I can learn it.

- Not at all true
- Slightly true
- Somewhat true
- True
- Very true

I am certain I can master the skills taught in my math class next year.

- Not at all true
- Slightly true
- Somewhat true
- True
- Very true

I am certain I can figure out how to do the most difficult work in my math class.

- Not at all true
- Slightly true
- Somewhat true
- True
- Very true

I can do even the hardest work in my math class if I try.

- Not at all true
- Slightly true
- Somewhat true
- True
- Very true

Section 13 of 15

Part 2

Using the scale below, please indicate the extent to which you agree or disagree with each of the following statements by selecting the option that corresponds to your opinion. There are no right or wrong answers. I am interested in your ideas.

You have a certain amount of math intelligence, and you can't really do much to change it.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

Your math intelligence is something about you that you can't change very much.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

No matter who you are, you can significantly change your math intelligence level.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

To be honest, you can't really change how intelligent you are in math.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

You can always substantially change how intelligent you are in math.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

You can learn new things, but you can't really change your basic math intelligence.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

No matter how much math intelligence you have, you can always change it quite a bit.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

You can change even your basic math intelligence level considerably.

- Strongly Disagree
- Disagree
- Mostly Disagree
- Mostly Agree
- Agree
- Strongly Agree

Section 14 of 15

Part 3

How much do you agree or disagree with the following statements?

I see myself as a math person.

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

Why? *

Long answer text

Others see me as a math person.

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

Why? *

Long answer text

Section 15 of 15

Next Steps...

Description (optional)

I may have additional questions for you after I have collected all surveys and reviewed the data. Please indicate if you are willing to participate in additional interviews if selected. *

- I agree to answer additional questions if selected.
- I do not wish to participate further.

Appendix D

Interview Protocol

Introductory Protocol:

Thank you so much for agreeing to speak with me and share your thoughts and ideas! I really appreciate your willingness to help me with my research study. I'll be videoing our session today on my iPad so that I can review your answers and enter them correctly. No one will have access to these videos but me and I will delete them when the study is over. Please be assured that anything you tell me during this interview is completely confidential and will only be used for my research purposes. Our conversation will last 15-20 minutes.

I have a form which I need for you to sign before we begin. It states that (1) All answers are confidential, (2) Your participation is completely voluntary. You do not have to answer any questions that make you uncomfortable and you may choose to end the interview at any time. (3) No harm will come to you as a result of participating in this interview.

Introduction

You were selected for this interview based on your survey responses relating to math identity. My research explores the factors that influence whether middle school students view themselves as "math people." There is evidence to support the idea that self-efficacy, the belief that one can be successful at a certain task, and growth mindset, the idea that all brains are capable of growing and learning, play a part in developing the math identities of students your age. I am interested in speaking to you today to learn how these concepts have shaped your perception of your personal math identity.

Math Identity Questions

1- What does "being a math person" mean?
2- Describe a time when you felt/did not feel like a math person?
3- You said that you believe others do/do not perceive you as a math person. What makes you think so?
4- Where do you feel like you "rank" in your class? Why?
5- Do you ever wish you were in a different class? With different people? Why?

Self-Efficacy Questions

1- Describe a time when you felt confident doing math. Do you remember the activity? The setting?
2- Describe a time when you felt insecure doing math. Do you remember the activity? The setting?

Growth Mindset Questions

1- Do you believe that some people are born “math people?”
    a) Why?
2- Do you think that you can “train your brain” to become smarter? Why?
3- Describe how it feels to make a mistake.
4- Do you tend to view mistakes as opportunities to learn or as failures? Explain.
5- What types of things do your teachers/parents say when you make mistakes?
6- Sometimes kids feel smart in school, sometimes not. When do you feel smart?
7- Which do you think is a better indicator of whether a student understands a concept: when they make a good grade or when they can explain the concept to a classmate? Can you explain why you feel this way?

Closing

Thank you again for agreeing to speak with me! I have really enjoyed talking to you and appreciate your honest answers. Your answers will help me understand how students your age develop the math identities that they carry into high school. I look forward to teaching you and getting to know you better in the future.

Appendix E

Teacher Script

Teachers, please read the **BOLD** print aloud to your students.

SAY: **Please log into your Gmail on your Chromebook. You will see an email from Carrie Pierce (cpierce@bccsblazers.org). Open the email and wait on the rest of your classmates. Do not click on the link to the Google Form until I instruct you to begin.**

Allow students a moment to open and read the email.

SAY: **You have received this email because your parents have given consent for your participation in this research study. The Google Form in this email serves as the informed consent for you to participate in the study. The Google Form also includes the survey items.**

Take a moment to read each section of the informed consent. When you reach the end of the consent portion of the Google Form, you will be presented with a question which will allow you to exit the form if you do not wish to participate. Once you begin the survey, you have the option to answer the items. You do not have to respond to any items that make you uncomfortable.

Remember, there are not right or wrong responses. Ms. Pierce simply wants to know what you think based on your experience. Please take your time and think carefully before responding to each item.

Please raise your hand when you reach the "Your form has been submitted" screen so that I can check you off on my roster.

Pause to be sure all students are ready to begin.

SAY: **You may open the Form and begin.**

Teachers, please check off names as students complete the form on the roster provided.

Please hang on to these rosters. I will come by to collect them from you.

Thank you so much for helping me with my research!

Carrie Pierce

Appendix F

Permission to Use Self-Efficacy and Growth Mindset Items

COLUMBUS STATE UNIVERSITY

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu>

instruments to measure math self-efficacy and growth mindset

2 messages

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu> Sat, Jul 3, 2021 at 5:04 PM

To: xiaoxia.huang@wku.edu, jzhang64@uh.edu, laura.hudson2@warren.kyschools.us

Good afternoon,

While working on my doctoral thesis investigating the relationships between math self-efficacy, growth mindset, and math identity of middle school student, I ran across an article that you had authored on the moderating effect of gender on STEM career interest.

I noticed that you adapted 5 self-efficacy items from PALS as well as using a growth mindset survey from Dweck for your instruments. I am hoping that you will share these surveys with me. With your permission, I would like to include them in my research study.

Thank you and I look forward to hearing from you,

Carrie Pierce

Huang, Xiaoxia <xiaoxia.huang@wku.edu> Tue, Jul 6, 2021 at 2:58 PM

To: "Carrie Pierce [Student]" <pierce_carrie@columbusstate.edu>, "jzhang64@uh.edu" <jzhang64@uh.edu>, Laura Hudson <laura.hudson2@warren.kyschools.us>

Hi Carrie,

Thank you for your inquiry. I have attached the self-efficacy instrument and the growth mindset instrument used in our study. I wish you the best for your doctoral thesis.

Sincerely,

Silvie

Xiaoxia "Silvie" Huang, Ph.D.
Associate Professor in Instructional Design
Gary A. Ransdell Hall #1028
School of Teacher Education
College of Education and Behavioral Sciences

Western Kentucky University

From: Carrie Pierce [Student] <pierce_carrie@columbusstate.edu>
Sent: Saturday, July 3, 2021 4:05 PM
To: Huang, Xiaoxia <xiaoxia.huang@wku.edu>; jzhang64@uh.edu; Laura Hudson <laura.hudson2@warren.kyschools.us>
Subject: instruments to measure math self-efficacy and growth mindset

** This message originated from outside WKU. Always use caution following links. **

[Quoted text hidden]

Mindset and SE.docx
18K

Appendix G

Permission to Use Math Identity Items

COLUMBUS STATE UNIVERSITY

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu>

Request to use survey questions for my research
3 messages

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu> — **Mon, Oct 18, 2021 at 11:51 AM**
To: GBohrnstedt@air.org

Good morning!

I am in the process of reviewing literature for my dissertation and found your recent article based on NAEP data entitled "Mathematics Identity, Self-Efficacy, and Interest and Their Relationships to Mathematics Achievement: A Longitudinal Analysis"

My study will investigate the relationships between math self-efficacy, growth mindset, and mathematical identity of 7th & 8th grade students at a rural South Georgia charter school.

I am interested in using the items that measure math identity and self-efficacy as part of my quantitative data collection. I understand that these questions were included in the 2009 NAEP, but want to be sure that I have your permission to use them.

I found and printed a copy of the supplementary materials that accompanied the article. Any other resources that may be helpful to my research would be greatly appreciated!

Thank you for considering my request. I look forward to hearing from you.

Sincerely,

Carrie Pierce

Bohrnstedt, George <GBohrnstedt@air.org> — Mon, Oct 18, 2021 at 2:39 PM
To: "Carrie Pierce [Student]" <pierce_carrie@columbusstate.edu>

Carrie: The items came from the High School Longitudinal Study:2009 (HSLS:09) and not from NAEP. Since the HSLS is in the public domain (See https://nces.ed.gov/surveys/hsls09/questionnaires.asp) **I think you can use the questions freely. Of course, you would want to acknowledge that the items came from the HSLS:09 when writing up your results and not me.. The documentation and codebooks can be found at** https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011328.

Hope this helps and good look with your research project.

George W. Bohrnstedt

[Quoted text hidden]

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu> — Mon, Oct 18, 2021 at 3:15 PM
To: "Bohrnstedt, George" <GBohrnstedt@air.org>

Thank you so much!
[Quoted text hidden]

Appendix H

IRB Approval

COLUMBUS STATE UNIVERSITY

Carrie Pierce [Student] <pierce_carrie@columbusstate.edu>

Expedited Approval Protocol 22-052

CSU IRB <irb@columbusstate.edu> Wed, Apr 20, 2022 at 1:18 PM
To: "Carrie Pierce [Student]" <pierce_carrie@columbusstate.edu>, Deborah Gober <gober_deborah@columbusstate.edu>
Cc: CSU IRB <irb@columbusstate.edu>, Institutional Review Board <institutional_review@columbusstate.edu>

Institutional Review Board
Columbus State University

Date: 4/20/2022
Protocol Number: 22-052
Protocol Title: Relationships between and student perceptions of mathematical self-efficacy, growth mindset, and mathematics identity of adolescents in a rural South Georgia charter school.
Principal Investigator: Carrie Pierce
Co-Principal Investigator: Deborah Gober

Dear Carrie Pierce:

Representatives of the Columbus State University Institutional Review Board have reviewed your research proposal identified above. It has been determined that the research project poses minimal risk to subjects and qualifies for expedited review under 45 CFR 46.110. Approval is granted for the research project.

Please note any changes to the protocol must be submitted, using a Project Modification form, to the IRB before implementing the change(s). Any adverse events, unexpected problems, and/or incidents that involve risks to participants and/or others must be reported to the Institutional Review Board at irb@columbusstate.edu or (706) 507-8634.

If you have further questions, please feel free to contact the IRB.

Sincerely,
Sammy Kanso, Graduate Student
Institutional Review Board
Columbus State University

***** Please note that the IRB is closed during holidays, breaks, or other times when the IRB faculty or staff are not available. Visit the IRB Scheduled Meetings page on the IRB website for a list of upcoming closures. *****