3-2020

Student Perceptions Of Mathematical Mindset Influences

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STUDENT PERCEPTIONS OF MATHEMATICAL MINDSET INFLUENCES

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BA (Westfield State University) 2011
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DISSERTATION

Presented to the Affiliated Faculty of

The College of Graduate and Professional Studies at the University of New England

Submitted in Partial Fulfillment of Requirements
For the degree of Doctor of Education

Portland & Biddeford, Maine

March 2020

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March 2020
Educational Leadership

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ABSTRACT

This mixed methods study examined the factors and experiences junior level (e.g., 11th grade) public high school students enrolled in a college-prep mathematics course perceived as influencing the development of their mindset associated with mathematics. Current research defines mindset as the set of attitudes and beliefs held by an individual (Dweck, 2008b) and a determining factor in student success (Mosley, 2017). With educators at the study site noticing an increase of fixed mathematical mindsets among students and a lack of student perspective contained within current literature, further investigation and understanding was needed. This study addressed research questions related to student beliefs about their individual mathematical mindset as well as the factors and experiences they believed were most influential to the development of their mathematical mindset. Data was collected through the use of a mindset scale and individual interviews. The mindset scale was used to classify student participants' mindsets. Individual interviews were conducted to encourage conversation and sharing of personal stories and experiences to distinguish recurring themes. In this study, through the collection and analysis of student participants' data, three major themes were identified:

1. teacher influence on a student's mathematical mindset
2. influence of a student's prior mathematical experiences on their mathematical mindset, and
3. family influence on a student's mathematical mindset.

Findings and dissection of these themes concluded that there is a need for additional professional development related to mathematical mindsets for all educators who interact with students in relation to the subject. There is also a need to develop and implement family resources for helping students through mindset-focused strategies. The goal of this research was to provide further information, investigation, and understanding of high school students' perceptions about the factors and experiences that contribute to their mathematical mindset in an effort to continue the conversation on mindset development and its ability to impact a student's mathematics successes and education.

Key Words: Growth Mindset, Fixed Mindset, Student Perceptions, Mathematics Education, High School, Mindset Development

University of New England

Doctor of Education
Educational Leadership

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March 30, 2020
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ACKNOWLEDGMENTS

There are many individuals who deserve recognition and thanks for their support and encouragement throughout this journey, for without them this degree may never have come to fruition. To my advisors Dr. Heather Wilmot, Dr. Daren Ackerman, and Dr. Matthew Beyranevand, thank-you does not seem to suffice. Dr. Wilmot, I truly appreciate all the phone calls and e-mails you fielded, your ability to keep me grounded, and constant guidance throughout this journey. Dr. Ackerman, your personalized feedback, support, and unparalleled knowledge about theory and literature will not be forgotten and is something I will always cherish. Dr. Beyranevand, I feel blessed to now have gotten to work with you both professionally and academically. Your expertise on mindsets, check-ins, and excitement for my progress will forever leave me grateful for your hand in this journey.

A major thank-you is owed to my peers and amazing research team, Sid, Rosie, Dana, and Sharese, I would have been lost without each of you. Thank you for the constant laughter and words of encouragement provided from the very first day of our journey together. It was an absolute joy getting to know each one of you as well as learning from and experiencing your talents and professionalism. Finally, while I desperately wish a sixth member of our team, Tiffany, was here to celebrate with us, we will never forget her nor her work. I know she stayed watching over each of us as we completed this journey.

To my family—I don’t even know where to begin. Craig, my incredible husband. I’m not sure what I did to deserve your love, support, and patience, but I am forever grateful. Thank you for always listening to my read-throughs, taking on extra so I could write, being my shoulder to cry on, and believing in me when I lost confidence in myself. Emanuele, the most incredible kid

a parent could ask for, you sacrificed a lot for me over these past 3 years. You never complained about me not being able to join you in going somewhere or participating in some activity. You were one of my biggest cheerleaders. I cannot wait to make up for all the missed time. Please know, this was all for you. You can and will do anything you put your mind to. To my parents Carole and Doug Burns, I am the luckiest daughter in the world. Your support, encouragement, and help were immeasurable. I am and will be forever thankful for the two of you. Greg and Brandon, my jokesters of brothers, while I may have been annoyed by your endless teasing at the time, I am so thankful you kept me laughing and for your constant check-ins on Manny and Craig. Lastly, I owe a thank-you to my in-laws, Frank and Susan Vitale who always offered to help in so many ways. I love each and every one of you and look forward to substantial carefree time together.

I would be remiss not to give a special shout out to my colleagues who always offered their support and a cheerful word, the student participants who willingly shared a piece of their life and experience with me, and my favorite Starbucks baristas who kept me well caffeinated throughout many late night sessions. Additionally, to my friends who patiently and willingly accepted my "I can't" replies, I am so thankful for you and your understanding. I am excited for many more yes replies and future times spent together! Lastly to Brittany, Lauren, and Laura, your ability to know when I needed to step away from the computer and your desire to celebrate even my smallest accomplishments along this journey leave me speechless. I am beyond grateful for your friendships.

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CHAPTER 1

INTRODUCTION

Mathematics students in the United States continue to underperform, underscore, and fall farther behind when compared to other developed and industrialized nations (Desilver, 2017). As a country, the United States emphasizes the importance of education as evidenced by recent national education initiatives such as the new common core, yet current practices in mathematics education have done little to close the increasing gap. Fixed mindsets among students may contribute to the widening gap as their static view of intelligence provides justification for poor performance (Murphy & Thomas, 2008).

Mindsets are a determining factor of student success (Dweck, 2000; Mosley, 2017). The mindset a student possesses affects the student's academic path, effort, motivation, resilience, and perseverance (Carroll et al., 2009). Growth mindset, the individual belief that traits can be developed and enhanced through effort, practice, and perseverance (Dweck, 2000), is associated with numerous educational benefits, including more optimistic views, outperformance of peers, and increased resiliency (Waithaka, Furniss, & Gitimu, 2017, p. 6). In contrast, fixed mindset, the individual belief that traits are static and cannot be developed or improved (Dweck, 2000), is linked to a lack of grit, learned helplessness, and poor achievement (Duckworth, 2017; Hochanadel & Finamore, 2015, p. 48). The U.S. Department of Education (2016) recognizes the implications of mindset on student progress. Educational researchers continue to explore and uncover the need to understand and consider mindset in student learning and performance (Froedge, 2017) and researchers are beginning to recognize the importance of including student perspectives to enact meaningful educational change (Cook-Sather, 2002; Noguera, 1999). The blatantly different outcomes and recognized implications associated with varying mindsets emphasize the need to fully understand the factors and experiences that contribute to the development of mathematical mindsets and demonstrate a need for the inclusion of student perspectives. Educators at the study site, a suburban public high school located in northeastern Massachusetts, have noticed an increase in the number of students possessing fixed mathematical mindsets and the connection to negative outcomes, including poor performance (K. Doulamis, personal communication, December 15, 2018). Without a thorough understanding of what is contributing to this trend it is likely to continue. It is imperative that educators begin to understand the factors and experiences students perceive as contributing to their mindset if educators hope to effectively incorporate resilience and growth mindset–related lessons into the classroom. Through this understanding and inclusion of altered instructional strategies educators can continue to further students' current success and arm students with educational and psychological tools to overcome current and future challenges.

Statement of the Problem

Educators at the study site have noticed a rapid shift in the mindset of students and the educational track they align to. Fixed mindsets have become prevalent among students in mathematics courses and as a result, students are quick to display behaviors of helplessness and avoidance (K. Doulamis, personal communication, December 15, 2018). For students who possess a fixed mindset, low self-esteem, difficulty communicating challenges, and the necessity of verbal validation become paramount (Murphy & Thomas, 2008, pp. 271–273).

The prevalence of a fixed mindset in the mathematics classroom is not a new phenomenon. Approximately half of all students possess a fixed mindset, accepting and settling with the negatives that accompany it (Boaler, 2013, p. 143). Not only is this mindset and its static view of intelligence accepted (Murphy & Thomas, 2008, p. 273), but it has become socially acceptable for students to perform poorly in the subject (Wai, 2012). Surveys report mathematics is the only subject with a prevalent response of "I'm bad at it," when categorized by high school students as their least favorite course and asked for further explanation (Authentic Education, 2013, p. 2). There is a lack in current literature and research to define the depth to which social acceptability of performing poorly in mathematics permeates the larger society.

The mathematics department at the study site has worked tirelessly to combat the social acceptance of poor performance and fixed mindsets by offering professional development to its educators. Professional development seminars have examined Dr. Matthew Beyranevand's (2017) mindset-based book *Teach Math Like This, Not Like That*, investigated the Global Math Project's (2018) activity "Exploding Dots," and in addition attended seminars intended to equip teachers with growth mindset instructional strategies. While teachers believe the effort is worth the work, they possess only part of the equation for helping students adapt from a fixed to a growth mindset. Classroom lessons and language can discourage, just as easily as lessons and language can encourage students to positively reflect on their capabilities, progress, and resilience. In addition, research by Soni and Kumari (2015) concluded that peers and relatives influence students' educational aspirations more so than educators (p. 159), but students' thoughts and ideas on the topic remain unheard. While substantial research exists examining mathematical mindsets, researchers have failed to examine and include the perceptions of those affected most: the students.

Purpose of Study

The practical goal and purpose of the study was to understand high school students' perceptions about factors and experiences that contribute to their mathematical mindset and may encourage the formation of one type of mathematical mindset over another. To accomplish the goal and purpose, the researcher worked with a sample group of junior level (11th grade) public high school students currently enrolled in a college-prep level math course. Students completed the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015) to determine their current mathematical mindset. A random sample of students participated in a single semistructured interview. Interview questions were based on mindset theory. The researcher sought to advance understanding about mindset and its effects on mathematics education by examining student-perceived mathematical mindset influences. Through a more comprehensive understanding of mathematical mindset development, necessary information and changes can be shared and implemented to improve students' current mathematical mindsets, promote positive views of mathematics, improve self-efficacy and self-esteem, and enhance success in mathematics.

Research Questions

Previous research and literature illustrate the educational benefits of a growth mindset, yet many students, despite transformed teaching methods, continue to view their knowledge and abilities as fixed. This researcher posed the following questions:

1. What factors and experiences impact the mindset associated with mathematics for junior level (e.g. 11th grade) public high school students enrolled in a college-prep level mathematics course?
    a. How do junior level public high school students enrolled in a college-prep mathematics course describe the beliefs and attitudes that they feel contribute to their mindset associated with mathematics?

b. What factors and experiences do junior level (11th grade) public high school students enrolled in a college-prep level mathematics course believe influence their mindset associated with mathematics?

Conceptual Framework

The researcher sought answers to the research questions by focusing on student responses to a mindset scale and to interview questions about perceived mathematical mindset influences. Student responses were examined through the theoretical lens of Mindset Theory (Dweck, 2000). Entity and incremental theories are two implicit mindset theories developed by Dweck (2008b) to describe why students may or may not put effort into developing skills, understanding concepts, and overcoming challenges. These two theories define and explain growth (e.g., incremental theory) and fixed (e.g., entity theory) mindsets.

Entity theory, or fixed mindset, creates a barrier lessening students' chances of success whereas incremental theory, or growth mindset, is associated with optimistic views of mathematics, increased resilience, and higher levels of success (Boaler, 2013, p. 143). The vastly different educational outcomes associated with the varying theories and Dweck's (2000) assertion that mindsets are malleable emphasizes the importance of understanding mindset development in relation to mathematics. This study that examined the factors and experiences students perceived as contributing to their mathematical mindset was considered to be "complete" with the incorporation of both of these theories.

Assumptions and Limitations

The results of this study depend on the responses of the participants, therefore, the researcher assumed that all participating junior level (11th grade) public high school students enrolled in a college-prep mathematics course answered questions openly and honestly.

Additionally, the researcher acknowledges that the study took place within her current organization. To obtain bias-free results the researcher allowed the collected data to drive the analysis and outcomes and used the bracketing strategy to ensure this occurred. As an educator and doctoral student, the researcher took extra care to ensure these two roles did not conflict in a way that could compromise the study.

Limitations of the study are related to the size and population of the participants. The study is limited to the perceptions of participants (junior level public high school students enrolled in a college-prep mathematics course) in one suburban public high school. Additionally, the demographics and socioeconomic status of the participant group may limit the applicability of results to other demographics or socioeconomic status.

Significance

Multiple layers of significance exist if one intends to understand the factors and experiences junior level public high school students enrolled in a college-prep mathematics course believe contribute to their mindset associated with mathematics and their educational attainment and success. Mathematics education is well emphasized in the United States, but when comparing these students to those around the world, American students fall behind other developed and industrialized nations (Desilver, 2017). Examining the testing data used to formulate the international rankings, the National Assessment of Educational Progress (NAEP), last given in 2015, showed a drop resulting in the lowest scores for the United States since 2007 (Desilver, 2017). If the United States wishes to advance their academic standing in the future, it is paramount to investigate the factors and experiences that inhibit the ability of students to further progress in their education. A student's mindset and its development is one such factor.

Fixed mindsets in high school mathematics create a number of potential hazards. Students with fixed mindsets are less likely to take risks, less likely to advance (both in content and career), and more invested in the image of appearing successful than actually achieving success (Dryden, 2012). Similar to Dryden (2012), Mosley (2017) promoted growth mindsets by listing the positive effects of this mindset. He explained that students with growth mindsets continue to outperform, persevere longer, and achieve more success when compared to their counterparts (Mosley, 2017, para. 5). The two mindsets lead to a view of education and ability in starkly different light, and these beliefs affect individuals' progress and lead to vast differences in learning. Researchers must understand the factors and experiences that influence the development of attitudes and mindsets associated with mathematics.

Research continues to point toward potential influences outside the classroom. Parent involvement has been linked to student success in school (Center on Education Policy, 2012, p. 1) and students achieve more success when parents are actively invested in their education, even though the parent may be unable to assist (Center on Education Policy, 2012, p. 1). An additional study named peer pressure and societal acceptance of poor mathematical performance as contributing factors to students' views of mathematics (Wai, 2012). While some student responses hint towards these connections, no information or studies were located that investigate if students perceive these factors and experiences as contributing to the development and creation of their mathematical mindsets.

Background

Mathematics is a required component of education for all American students whether they receive their education publicly, privately, or at home (Chazan, 2000). The nation has numerous educational laws, acts, and initiatives, however "no single government agency controls public education in grades K through 12. Rather, authority for most educational decisions lies with education agencies in the 50 individual states, which in turn share decision making with the individual school districts" (Dossey, McCrone, & Halvorsen, 2016, p. v). To help align the numerous mathematics curricula offered across the country, in 2010 the Common Core State Standards for Mathematics (CCSSM) was released. Dossey, McCrone, & Halvorsen (2016) report that 43 states and the District of Columbia have partially or fully adopted CCSSM as their mathematics frameworks (p. 11). Massachusetts, the state where the site for this study is located, accepted the new standards while adding additional frameworks to maintain the rigor and educational system the state is known for (Reis, 2017). Governor Charlie Baker, as quoted by Reis (2017), expressed "Massachusetts' ability to continually adapt and update our educational standards is an important part of why our students and public schools lead the nation in many categories." While the state of Massachusetts had much to celebrate when adopting the revised standards, Reis (2017) explained, "the standards are not a curriculum, and they do not specify which materials teachers should use. In Massachusetts, curriculum, materials and methods are determined at the local level" (para 8).

The study site, a large suburban public high school located in the northeastern part of the state, complies with the state standards and has adopted and created materials that support a curriculum tied to the state standards. While the school offers a rigorous curriculum developed to enhance student understanding and mathematical success, fixed mindsets have become prevalent among students in mathematics courses resulting in behaviors of helplessness and avoidance (K. Doulamis, personal communication, December 15, 2018). Understanding mindset through the inclusion of the student perspective is necessary to advance students' mathematical success and develop curriculum and instructional methods and materials to encourage the development of growth mindsets in the future.

Definitions

The definition of terms has two purposes. The first purpose is to minimize external influences on words that are used in this study. The second purpose is to establish a connection between the listed terms and the study of student perceptions of factors and experiences contributing to mathematical mindset development. The terms have been defined below for a beneficial understanding of their relation to the research.

College Prep. A label applied to courses that are designed and developed to prepare students with a foundational knowledge base to meet academic demands of college courses (Merriam-Webster, 2019).

Course Content. The subjects, topics, and/or ideas taught to students in a specific class.

Curriculum. The courses offered by an educational institution (Merriam-Webster, 2019) or the content and learning standards covered in a course.

Fixed Mindset. The belief that intelligence is static or that an individual is born with a specific amount of intelligence and there is little to be done to change it (Murphy & Thomas, 2008, p. 271). The term *fixed mindset* is used interchangeably with the terminology *entity self-beliefs*.

Growth Mindset. The belief that intelligence is malleable, and that hard work and persistence can increase intelligence (Dweck, 2000; Murphy & Thomas, 2008, p. 271). The term *growth mindset* is used interchangeably with the terminology *incremental self-beliefs.*

Junior Level. For the purpose of this study, junior level is defined as a student in their third year of high school or a student who has earned a minimum of 120 credits, but no more than 175 credits. The term *junior level* is synonymous with *11th grade*.

Mindset. The set of attitudes and beliefs held by an individual (Dweck, 2008b, p. 14).

Public School. A free tax-supported school run by the local government (Merriam-Webster, 2019).

Special Education Services. The support provided to students who need additional tools to access the curriculum in public education; supports provided at no cost to the student or student's caregiver (Massachusetts Department of Elementary and Secondary Education, 2019).

Specialized Supports. The tools implemented to help all students access the curriculum. Examples of support include, but are not limited to, guided notes, graphic organizers, and supportive technology (Massachusetts Department of Elementary and Secondary Education, 2018).

Student. For the purpose of this study, a student is defined as an adolescent enrolled in a public high school who attends classes to progress through the educational system and meet its associated requirements. The term *student* is used interchangeably with *learner*, *participant*, or *child*.

Teacher. For the purpose of this study, a teacher is defined as a state certified professional who instructs students to help them acquire specific knowledge within a classroom setting (Merriam-Webster, 2019). The term *teacher* is used interchangeably with *educator.*

Conclusion

If the nation wishes to further mathematics education, the inclusion of high school students' perceptions of factors and experiences contributing to their mathematical mindset development must be investigated. It is known that students with a growth mindset continue to outperform, persevere longer, and achieve more success when compared to their fixed-mindset peers (Mosley, 2017). Further understanding the factors that students believe most substantially contribute to the development of their mathematical mindset can lead to numerous benefits including, but not limited to, improved mathematical success for students. Additionally, fortified with this information, researchers, educators, and parents will have the ability to inform and alter instructional strategies and interactions to attempt to increase the number of students possessing mathematical growth mindsets.

Chapter 1 provides an overview of the benefits and drawbacks associated with mindset in mathematics education. In addition, this study sought to identify the importance and need for understanding students' beliefs about factors and experiences that contribute to the development of their mindset associated with mathematics, specifically examining the various impacts different mindsets have on the student and their ability to progress and achieve success. Chapter 2 presents an extensive literature review examining the historical context of the problem, the current state of mathematics education and both growth and fixed mindsets. The study continues in Chapter 3 to examine methodology and processes for data collection and analysis. Findings and detailed results are reported in Chapter 4. The study concludes with Chapter 5 providing a summary of the findings, recommendations for action, recommendations for further study, and conclusions. A list of references is furnished at the end of the study.

CHAPTER 2

LITERATURE REVIEW

This mixed-methods study examined the perspectives of junior level (11th grade) public high school students enrolled in a college-prep level mathematics course at a suburban northeastern Massachusetts high school. The primary purpose of this study was to identify and define factors and experiences junior level public high school students believe greatly contribute to their mathematical mindset. Chapter 2 provides context for this study. Students are major stakeholders in education and "have unique perspectives on learning, teaching, and schooling; their insight warrants not only the attention but also the responses of adults" (Cook-Sather, 2006, p. 359).

Webster and Watson (2002) stated, "a review of prior, relevant literature is an essential feature [for] advancing knowledge" (p. xiii). Chapter 2 presents this review while synthesizing and dissecting various themes found throughout literature and previous research studies that provide a foundation for understanding mindsets and the various factors and experiences that students may perceive as influences.

The research and literature related to the study exposed associated themes and subthemes. Chapter 2 addresses these themes beginning by investigating the current state of mathematics education in the United States and continues by exploring concerns with the United States' current mathematics education global rankings. A main component of the study, mathematical mindsets, are explored, defined, and synthesized in relation to student perspectives and student self-efficacy. Additionally, the importance of parental or caregiver involvement and teacher influence are examined. Literature relating to various components of teaching mathematics and the importance of relationships in the classroom is analyzed to enhance the exploration and understanding of teacher impact. Chapter 2 continues by exploring various factors that influence mindsets and examining the value of student perspectives. The chapter concludes with the conceptual frameworks and a summary of important themes found in the literature.

United States Mathematics Education

Mathematics at all levels is a difficult subject to teach yet is a critical component of education that helps students develop and sharpen problem-solving skills (Beyranevand, 2017, p. xi). Mathematics courses are a compulsory piece of education and this requirement associates mathematics with a specific dynamic of teaching and learning that students are predisposed to before entering the classroom. This affects students' views about both the subject and the educator (Chazan, 2000, pp. xii–xiii).

Contrary to the notion that places mathematics instruction into a one-size fits all mold, Chazan (2000) explained that individual teachers' beliefs and the teaching methods they choose create variability across classrooms (p. 3). For example, when introducing a lesson on factoring quadratic equations one teacher may choose to have students use guess and check, or trial and error methodology, another might use a more visual box method approach, and a third might introduce the concept using a previously created and proven process. All three instructional methods meet the curriculum and learning standards in relation to the content, but each offers students a very different approach and understanding. This variability presents mathematics educators and students with unique challenges to overcome as expectations and prior knowledge may not align (Chazan, 2000, pp. 3–6, 15). A student who has been exposed to only the box method for factoring a quadratic will need to learn and adjust to the instructional methods of an educator who uses a specific process-based methodology. In addition to varying instructional strategies, student attitudes, mindsets, and self-efficacy about mathematics affect how an individual processes, perceives, and works in the classroom (Boaler, 2013; Dweck, 2000; Dweck, 2008a).

International Achievement Gap

Mathematics curriculum has been slow to evolve (Klein, 2003). Changes that have previously occurred, such as the incorporation of National Council for Teachers of Mathematics (NCTM) standards and the adoption of the National Common Core standards, have been met with resistance (Klein, 2003). Hiebert (2013), as cited in Larson (2017), explained that this resistance to change is a result of mathematics being a cultural activity (para. 4). Hiebert (2013) further defined this statement by explaining “a cultural activity means that the instructional strategies and practices teachers embrace are not likely newly invented by each teacher, but rather are learned and adopted through experience and observation” (as cited in Larson, 2017, para. 7). Larson (2017) projected these sentiments on to all adults as each has his or her own preconceived notions related to what they expect to see in a math classroom and how problem solving should be taught. These individual expectations have led to a lack of national agreement on mathematics learning and instruction, thus limiting its ability to change. The resulting stagnant stance on mathematics education has allowed generations of American students to fall behind when compared globally (Whitney, 2016, para. 5). Recent research conducted by the Pew Research Center placed the United States in 38th place out of 71 countries when examining mathematics education, a shockingly low place on the list considering the country’s 6th place ranking in 1990 (Bendix, 2018). Desilver (2017) used figure A to illuminate the United States’ subpar and middle of the pack rankings when compared globally.

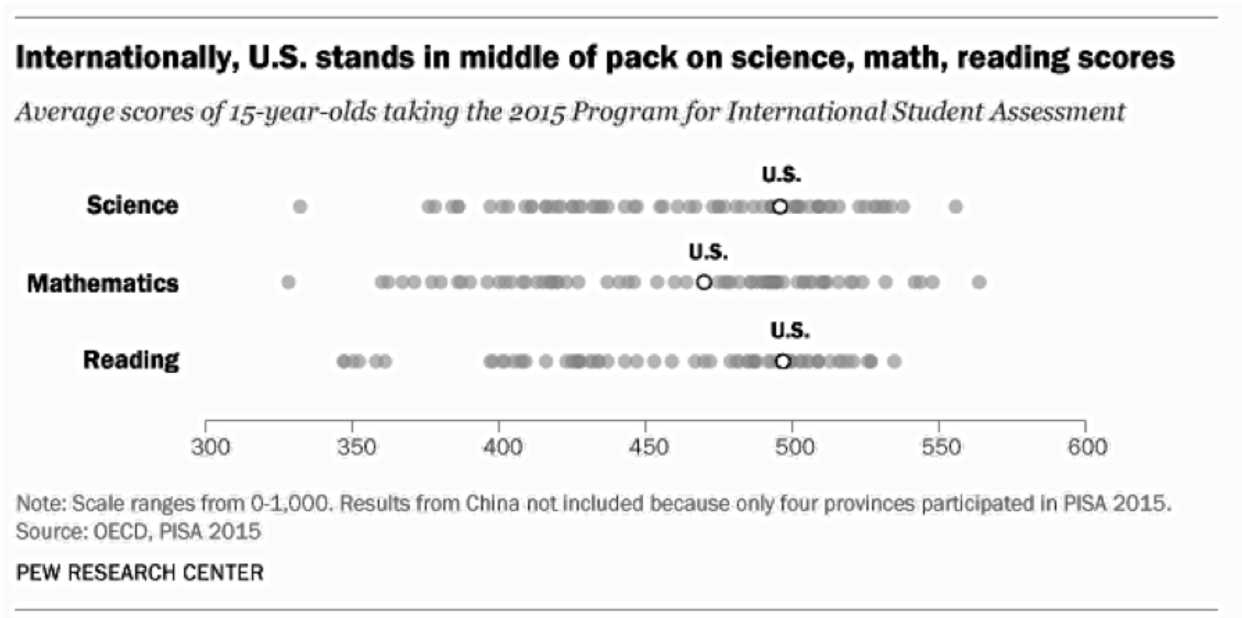

Figure 1. U.S. Stands in Middle of Pack for Global Education Ranking from "U.S Students' Academic Achievement Still Lags that of Their Peers in Many Other Countries" by Drew Desilver, 2007 (http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students- internationally-math-science/) copyright 2020 by Pew Research Center

This figure visually highlights and displays the startling reality that the United States, one of the world's largest and wealthiest nations, continues to lag behind many other developed and industrialized nations in mathematics education (Desilver, 2017, para. 1). American students are not receiving an education that prepares them to compete globally, limiting their ability to enter high-paying career fields or hold leadership positions in the technology industry (Desilver, 2017; Whitney, 2016).

Conflicting views exist from researchers about causes of the achievement gap. One view attributes socioeconomic status as a contributing factor (Montt, 2011, p. 63), while others link teacher quality, opportunities to learn, allocation of resources, and/or the intensity of schooling to the root of the problem (Desilver, 2017; Klein, 2003; Montt, 2011). Furthermore, researchers and well-known educators Haimovitz and Dweck (2017) and Clough (2008) contend the key to lessening and eliminating this gap lies in the beliefs and mindsets of students.

The United States needs "thoughtful change in education" and instruction (ed.gov, 2012) if it wishes to advance its current international rankings, break away from its middle ground standings, and create competitive, well equipped, and informed students. As a nation, it is imperative that students are offered an education that makes them globally marketable as anything less creates a disadvantage requiring substantially more effort, work, and sense of inquiry to catch, not surpass, peers provided with a globally driven education (Desilver, 2017; Whitney, 2016). Science, Technology, Engineering, and Mathematics (STEM) courses equip students with skills necessary to understand and adapt to the changes and advancement in technology for success in today's economy. Commonly, student beliefs about STEM content and their ability in these fields are pessimistic and negative (Chen, 2013, p. 4). Changing these perspectives to the opposing view would equip students with the necessary attitude to overcome challenges and excel, allowing them to become more marketable in a global economy (Boaler, 2013; Chen, 2013; Whitney, 2016).

Mathematics Deficits in College and the Workforce

Society requires individuals to have a minimum level of mathematical competency often required for employment (Soni & Kumari, 2015, p. 159). Mathematical literacy, the ability to problem solve, reason, and analyze information is the new language of the workforce and one-third of American students are not able to apply or use it (Henry-Nickie, 2018, para. 1). Low standards have created a lack of preparation in mathematics education (Santelises, as cited in Butrymowicz, 2017, para. 24). Summarizing a 2012 report by Complete College America, Butrymowicz (2017) stated, "nearly half of entering students at two-year schools and a fifth at four-year schools were placed in remedial [mathematics] classes" (para. 8). The requirement and inclusion of these courses for more than 500,000 college students declares that high school diplomas do not guarantee students are mathematically prepared for college (Butrymowicz, 2017, para. 2). The demand to equip students with a mathematics education that achieves competency, provides skills needed for employment or further education, and promotes a mindset of learning remains high (Butrymowicz, 2017; Henry-Nickie, 2018).

The need for individuals with exceptional math skills has dramatically increased and is expected to continue to increase at a rapid rate (Henry-Nickie, 2018; Soni & Kumari, 2015); however, mathematics remains one of the least popular majors in college (Chen, 2013, p. 3), and less than half of students who originally begin the coursework will remain in the major (Chen, 2013, p. 3). A link between mathematical attrition and student motivation, confidence, and beliefs about their capacity to learn exists (Chen, 2013, p. 4). Chen (2013) and Henry-Nickie (2018) shares similar thoughts that through re-creation of curriculum and understanding mindset in students, it is possible for students entering the mathematics field in college to become better equipped with the necessary beliefs and skills to maintain their enrollment and thrive in the major.

Students exiting high school and college need math skills to be successful in all occupations. Math skills, such as numeracy and numerical problem solving "are not only fundamentally important to everyday job function, but also are a strong indicator of broader cognitive abilities" (Silverstein, 2016, para 2). Businesses want employees who promote the success of the company. Silverstein (2016) found that cognitive aptitude or cognitive ability is a predictor of job success. Students with low levels of mathematical ability become less marketable as additional training, supervision, and support may be needed, leading to increased company costs and decreased profits and available resources. A poor mathematical ability can result in missed opportunities and unemployment. Unemployment is not the only obstacle those with math deficits face. Mallows, Carpentieri, and Litster (2016) explained that occupation levels often relate to mathematical ability (p. 14). Lower mathematical ability can be a factor in preventing promotion or growth within a profession. An individual's opportunities become limited when math skills are lacking (Silverstein, 2016).

Mathematical Mindsets

Mindset, the set of attitudes and beliefs held by an individual (Dweck, 2008b, p. 14), is a determining factor in whether or not a student will experience success (Mosley, 2017, para. 5). Studies conducted by Boaler (2013), Dweck (2000) and Mosley (2017) found evidence that suggested the way educators use and interpret information relating to intelligence may directly affect the mathematical achievement of students regardless of ability. For example, numerous studies corroborate that leveling or grouping students by their mathematical ability can harm achievement and efforts of students by altering teacher expectations and through the affirmation of student beliefs (Boaler, 2013; Darling-Hammond, 2010; Montt, 2011). Strauss (2013) further confirmed grouping low level students into the same class as a detriment to education by calling the practice a self-fulfilling prophecy. Students are aware of the class level they are in and what it says about them. This provides no motivation for improvement, but rather gives students the opportunity to remain stagnant without challenge or growth (Strauss, 2013). Student self-beliefs are affirmed within leveled classrooms and their successes become limited.

Carol Dweck (2008b) developed two implicit theories, entity theory and incremental theory, that further explain why students may or may not put effort into developing skills, understanding concepts, and overcoming challenges. The entity theory, or fixed mindset, is individual beliefs that traits such as math skills are static innate traits that cannot be developed further (Dweck, 2008b, p. 3). Contrary to entity theory, incremental theory, or growth mindset, is associated with individual beliefs that traits can be developed and enhanced through effort and perseverance (Dweck, 2008b, p. 3). Both theories influence how a student learns and the successes they may or may not experience.

Entity Theory/Fixed Mindset

Fixed mindsets are categorized by an individual's belief that their abilities and intelligence are static, unchangeable, or a trait they were born with (Dweck, 2000; Gregory & Kaufeldt, 2015). This view of intelligence can prevent skill development and leads to a lack of grit, learned helplessness, and poor achievement (Hochanadel & Finamore, 2015, p. 48). While many negatives are associated with entity theory, mindsets are not permanent (Dweck, 2008b). This malleable nature of mindsets emphasizes the importance of discovering student-perceived factors and experiences that influence mathematical mindset development in an attempt to promote a mindset that increases student achievement and success rather than limits it.

Incremental Theory/Growth Mindset

Growth mindsets are possessed when a student feels their intellectual ability can change and develop (Dweck, 2000). This mindset is associated with the perception that improved performance and achievement comes from hard work, effort, and perseverance (Dweck, 2000, p. 3). Growth mindsets develop and strengthen through a focus on process over product (Dweck, 2000, p. 16). Dweck (2000) detailed that a focus on process emphasizes the effort behind obtaining the solution and rewards the student with praise for the work a student puts in toward achieving a solution rather than with a numerical or letter grade (pp. 17–18). Praise on process provides substantially more valuable feedback and can lead to further understanding and achievement (Boaler, 2013, p. 149). A teacher marking a problem incorrectly provides the student with the notion they were wrong and places the importance on a single solution. Boaler

(2013) explained that by highlighting areas or steps on the problem completed correctly and explaining what individual challenges prevented success, the teacher conveys the importance of the process and encourages reflection promoting future success.

Boaler (2013) compiled scientific data and evidence justifying that growth mindsets promote higher levels of achievement in students. This mindset allows students to work and learn more effectively while possessing a desire for challenging problems. Boaler (2013) stressed the importance of students making mistakes on problems as this presents opportunities for learning and growth. “When students think about why something is wrong, new synaptic connections are sparked that cause the brain to grow” (Boaler, 2013, p. 147). New connections formed in the brain as a result of understanding mistakes helps students overcome similar challenges in the future (Boaler, 2013, p. 149). These statements presented and evidenced by Boaler (2013) echoed thoughts presented by Dweck (2000) regarding the necessity of mistakes.

According to Snipes and Loan (2017), although the majority of young students believe they possess a growth mindset, this value decreases as grade level increases and drastically lowers for students who have struggled academically in the past. Growth mindset provides students with the benefits of outperforming classmates, a more optimistic view of mathematics, and increased perseverance (Waithaka, Furniss, & Gitimu, 2017, p. 6). The positive attributes associated with a growth mindset emphasize the need to understand the factors and experiences students perceive as most influential in its development.

Self-Efficacy

Bandura (1997) defined self-efficacy as individuals’ beliefs of control over their life. Self-efficacy in school is a student’s personal perception of himself or herself. Cognitive abilities, motivational behaviors, and emotional responses are components that make up self-efficacy (Bandura, 1997, p. 2). Dweck's (2008b) theory asserts that individuals' beliefs are developed from infancy and influence personality. Environmental factors play a critical role from an early age in a child's development (Dweck, 2008b, p. 15), including their self-perceptions before they enter a school building. "Students arrive at school with an already well-developed self-image of competence or incompetence resulting from messages they have received" (Gregory & Kaufeldt, 2015, p. 10).

Students can possess high or low levels of self-efficacy. Students with high levels are more willing to accept challenges and remain persistent in finding solutions (Liu et al., 2017). Teachers often describe these students as goal setters who have the ability to stay motivated and manage anxiety well. Low levels of self-efficacy display through behaviors of helplessness and individuals are more likely to give up during the learning process (Liu et al., 2017, p. 4).

There is a connection between self-efficacy and mindset. Self-efficacy is improved through a growth mindset (Baldridge, 2010, p. 22). According to Baldridge (2010), high levels of self-efficacy and a growth mindset provide students with positive attributes for learning and overcoming challenges (p. 22). High academic self-efficacy and positive academic emotions in math correlate to student success through task choice, persistence, and academic aspirations. Self-efficacy and growth mindset remain two important factors in student success and their view of the course content (Liu et al., 2017).

Family/Caregiver Involvement and Educational Achievement

Schools, districts, states, and the federal government recognize the importance of family involvement on a student's education (Gibson, 2017). As students spend the majority of their time outside of school at home, it is likely they see their family as an influential factor in the development of their mathematical mindset (Lopez, Scribner, & Mahitivanichcha, 2001).

Strong relationships between families and school officials or teachers must occur for families to be actively involved in the education of their student (Lopez et al., 2001). One way schools and districts provide opportunities for guardian involvement is through the Parent Teacher Association (PTA). The PTA is a caregiver-driven organization that seeks to increase guardian involvement in schools through the development of relationships with teachers, staff, school administration, and other families (Woyshener, 2009). Additionally, Title I, a federally funded program and law created “to provide all children significant opportunity to receive a fair, equitable, and high-quality education, and to close the educational achievement gap” (NEA, 2016), was introduced to improve student reading and math skills through caregiver involvement (Jeynes, 2005). To receive funds, school districts must reach out to parents and families and involve them as well as design programs and activities that include them (Pearson, 2009). Caregiver involvement is a key component of the law, further emphasizing the importance of including and involving families in education. While this federal initiative highlights the importance of family involvement at all grade and age levels, parental and family involvement declines as students progress through the educational system (Wang & Sheikh-Khalil, 2014; Woyshener, 2009), leaving upper-level students lacking a home–school connection.

Family involvement is known to contribute to academic success (Wang & Sheikh-Khalil, 2014). Higher achievement and course attainment are found when families are involved in the educational process and students feel supported (Jeynes, 2005; Shumow, Lyutykh, & Schmidt, 2011). Support and encouragement from home sends a message to students about the importance and value of education.

Caregiver Interest in Mathematics

Levy (2011) summarized the work of numerous researchers when stating parents are “a crucial element in the development of children’s attitudes toward learning” (p. 25). Samuelsson and Granstrom (2007) as cited in Levy (2011) found connections between involved behaviors and supportive attitudes in parents and positive academic attitudes in their student (p. 25). Soni and Kumari (2015) discovered similar results when examining caregiver attitudes toward mathematics and student achievement. In a study conducted with 482 students and one of their parents, Soni and Kumari (2015) compared parents’ attitudes toward the mathematical attitudes and assessment scores of their child. They conducted a mediation analysis resulting in numerous connections between a parent’s mathematical attitude and the attitude and achievement of their child. Samuelsson and Granstrom (2007) as cited in Levy (2011), through a study examining students’ attitudes in mathematics in relation to their mathematical success, concluded that students with more positive attitudes toward mathematics had parents who displayed similar attitudes and showed interest in the student’s education (p. 29). Results from this study also indicated that caregivers who show no interest in a student’s math work tend to influence students’ development of negative mathematical attitudes (Samuelsson & Granstrom, 2007 as cited in Levy, 2011). Soni and Kumari (2015) along with Samuelsson and Granstrom (2007) as cited in Levy (2011) concluded that the more positive a caregiver was about mathematics, regardless of their own ability, the more likely a student was to display similar attitudes toward the subject leading to increased mathematical success. Success in mathematics frequently leads to an interest in the subject and the perseverance to overcome challenges (Turner, Steward, & Lapan, 2004, p. 48). “Parents are role models for attitudes towards mathematics” (Levy, 2011, p. 189). Parents, guardians, and caregivers model behaviors, thoughts, and feelings that their child can replicate. These thoughts, feelings, and behaviors displayed by guardians and emulated by students have the ability to enhance mathematical successes or limit future progress.

Guardian Influence on Mindset

Bandura (1971) introduced the concept of Social Learning Theory. This theory states that individuals learn through direct experience, interactions with others, or through observation (Bandura, 1971, pp. 2–3). Bandura (1971) explained that learning occurs not only when responses are performed, or given, but also through the observation of varying consequences based on actions. The individual observing "develop[s] thoughts or hypotheses about the types of behavior most likely to succeed. These hypotheses then serve as a guide for future actions" (Bandura, 1971, p. 3). Additionally, Bandura (1971) explained that, as a result of experiences and observations, individuals "come to expect that certain actions will gain them outcomes they value, others will have no appreciable effects, and still others will produce undesired results" (pp. 3–4). Knowledge of future consequences, learned through observation or direct experience, provides the motivation behind behavior and actions to achieve desired outcomes (Bandura, 1971).

Similar to Bandura's Social Learning Theory is Vygotksy's (1978) Social Development Theory. Vygotsky's theory emphasizes social interaction as a fundamental role in cognitive development and explains that social learning, or learning through experience and interactions, precedes development. Vygotsky believed "every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people, and then inside the child" (Vygotsky, 1978, p. 57).

Vygotsky (1978) believed a student first learns through interactions with others. Vygotsky explained that pointing a finger at a child in the beginning is a meaningless action, it is only through the reaction of others that this motion gains a meaning connecting individuals (p. 56). Without the reaction of another individual a child would not learn the meaning behind the gesture.

Students observe, interact and socialize with their guardians. They learn about their guardians' beliefs, expectations, and desires for the student by observing their actions, conversing, and interacting. These act as motivators for students. In a narrative context, the theories of Bandura (1971) and Vygotsky (1978) posit a student who observes a guardian comment about their own poor performance in mathematics or grumble about helping on homework may begin to associate these behaviors and thoughts with their own. Students quickly recognize that their guardian may not be upset with a poor score in mathematics and may lose interest in trying to achieve higher marks.

Guardian beliefs about mathematics influence the mindset of the child. The actions displayed and language used within a home send messages to students that may alter how they approach situations (Haimovitz & Dweck, 2017). Bandura's (1971) and Vygotsky's (1978) theories are further confirmed by Hochandel and Finamore (2015). Hochandel and Finamore (2015) thoroughly examined a study on grit and mindset conducted by both Dweck (2008a) and Duckworth (2017). This study and its examination concluded that mindset can be taught and that parents' actions, interactions, and reassurance of a student's intelligence have a profound influence on the mindset a student develops (Hochandel & Finamore, 2015, p. 49).

Instruction and Teacher Influence

Teacher preparation and quality are important factors that influence student achievement (Montt, 2011). As reported by Montt (2011), the quality of instruction depends on teachers' understanding of concepts and their ability to employ a variety of instructional strategies to reach students in the classroom (p. 62). To reach a wide variety of learners, teachers must be well trained in content and provided with professional development opportunities that promote growth and further understanding (Montt, 2011). For successful and impactful instruction to occur educators must consider and effectively implement four components of teaching: pedagogy, planning, assessment, and relationships (Beyranevand, 2017, p. xi).

Pedagogy

Pedagogy answers the question of how to teach (Klein, 2003) and many different instructional methods and styles result. The content demands of mathematics can limit the influence some pedagogical methods have on instruction (Klein, 2003), further complicating delivery methods. Mathematics standards "include both content standards and mathematical practices (process standards) outlining what each student should know and be able to do at the end of each grade (National Council of Teachers of Mathematics, 2019, para. 2). These standards, while created as a guide, limit what can be instructed and how content is introduced. A teacher may wish to incorporate an exploration activity that leads students to discover various methods of problem solving, but the demands of introducing, teaching, and assessing numerous required standards does not grant the time or the opportunity to include this type of activity. How a teacher learns and chooses to teach can impact student outcomes (Boaler, 2013; Chazan, 2000; Haimovitz & Dweck, 2017; Mosley, 2017).

A teacher's pedagogy stems from his or her educational philosophy or personal beliefs, which may be influenced by the school's culture and policies (Beyranevand, 2017, p. 23). The way a teacher perceives students and their abilities, interacts with individual students and classes, and instructs lessons influence their pedagogy (Beyranevand, 2017, p. 23). "At the heart of pedagogy is the ability to improvise and intercede in a timely manner with a wide variety of students and abilities as the learning is occurring" (Beyranevand, 2017, p. 23). Teacher actions impact the outcome—a student's education. As influential as a teacher's pedagogy is, a student's mindset can encourage or derail progress (Dweck, 2000, p. 20), rendering the pedagogy useless and requiring the educator to improvise and adapt.

Planning

Planning requires substantial time, effort, and energy of the teacher to develop and implement effective lessons that improve students' abilities and meet required standards. While planning, effective teachers consider numerous aspects that affect the lesson, including students in their classroom, meeting the objectives of the curriculum, mastering the content to be instructed, identifying potential misconceptions, and how to share the joy of mathematics (Beyranevand, 2017, pp. 1–15). Additionally, during planning teachers consider their pedagogy and have to create materials that support the objectives and lessons.

Teachers, specifically mathematics teachers, must consider the mindsets of students when designing lessons and materials to incorporate into the classroom (Boaler, 2013; Dweck, 2000). Dweck (2000) found that the mindset held by a student has the ability to control how the student perceives content as well as his or her ability to problem-solve (pp. 3–4). Teachers must consider how to present concepts to meet lesson objectives as well as vocabulary used to encourage and engage students in attempting challenging problems resulting in mathematical successes (Boaler, 2013, p. 145).

Assessment

Assessments are methods used to evidence student understandings or misconceptions (Lee, 2006, p. 43). Various forms of assessment exist, including more than the formally recognized paper and pencil test or student-teacher conversation (Lee, 2006). A typical classroom teacher employs two types of assessments: summative assessments and formative assessments. Summative assessments' primary objective is to "assign students a score on the basis of their knowledge" (Schoenfeld, 2015, p. 3). Summative assessments include end of unit tests, final exams, and high stakes testing such as the SATs or state testing. Summative assessments show what students know and can do (Schoenfeld, 2015, p. 13). Formative assessments' primary objective is to "provide students and teachers feedback about the student's current state of understanding while there are still opportunities for student improvement" (Schoenfeld, 2015, p. 3). Formative assessments include exit tickets, classroom polls, and quick quizzes. Students need the ability to express their understanding through a variety of mediums (Beyranevand, 2017, p. 51). These assessments provide teachers with the opportunity to provide meaningful feedback, offer students room for improvement, and develop a feeling of success for students (Beyranevand, 2017; Chazan, 2000; and Lee, 2006).

Effective teachers design, create, and implement a combination of summative and formative assessments that allow students to showcase their understanding and ability continuously and finitely. Schoenfeld (2015) stated that the ability to accurately display understanding through a combination of formative and summative assessments can increase a student's chance for success (p. 16). Dweck (2000) ascertained that an increased feeling of success from multiple methods of assessment such as projects, activities, station work, quizzes, tests, and field trips can lead to new mathematical attitudes and mindsets in students (p. 21).

Relationships

"Relationships with all stakeholders are an essential . . . aspect of education" (Beyranevand, 2017, p. 69). A comfortable and safe learning environment that encourages growth and risk taking begins with interpersonal relationships (Phelan et al., 1992, p. 698).

Phelan et al. (1992) confirmed that relationships are cultivated when teachers develop a positive rapport with students and students feel they know the teacher (p. 696). School classroom conditions influence what students do, how they view themselves as students, and how they understand the school as a learning environment (Phelan et al., 1992, pp. 701–702). Through a series of interviews with students Phelan et al. (1992) were able to conclude, “in classrooms where personalities are allowed to show, students respond more fully both academically and personally” (Phelan et al., 1992, p. 696).

Dweck’s (2007) statements about relationships echoed those of Bandura (1971), Vygotsky (1978) and Phelan et al. (1992) further demonstrating the importance of developing relationships in which the student trusts and feels comfortable with the teacher. A positive relationship between a teacher and a student promotes risk taking through support resulting in the students overcoming more challenges. Dweck (2007) attributed these relationships to growth mindset (p. 76) and further concluded that defensive behaviors within relationships may result from poor connections and fear of humiliation (Dweck, 2007, p. 76). A student would rather stay stagnant than risk being wrong and humiliated, further promoting a fixed mindset. Authentic learning begins with relationships (Beyranevand, 2017, p. 71).

Support, encouragement, and feedback provide students with motivation for perseverance and continued effort (Liu et al., 2017). Teacher attitudes are transferable to students (Krajick, Czerniak, & Berger, 2003). Supportive messages from teachers increase student effort and self-confidence while positively affecting cognitive, behavioral, and emotional engagement (Liu et al., 2017). Boaler (2013) and Haimovitz and Dweck (2017) agreed that teacher feedback is important for student success and alterations need to be made to current methods. Mosley (2017) explained that teachers acting as facilitators lead to student-driven discovery. This style of instruction and learning emphasizes Boaler's (2013) focus on process over product and contributes to a concrete understanding of concepts that can substantially influence the mindset of students more successfully (Mosley, 2017 para.17).

Needed Changes

Pedagogy, planning, assessment, and relationships contribute to effective instruction and increased learning (Beyranevand, 2017, p. xiii). Whereas these four components of teaching may increase understanding and contribute to the mindset of students, researchers such as Chen (2013) and Haimovitz and Dweck (2017) are calling for changes to mathematics curriculum both in content and instruction.

The United States' educational system's dependence on high stakes testing acts as an oppositional force to change and authentic learning. The demands and importance placed on high stakes testing leads to a focus on "rote memorization and performance comparisons across students at the expense of learning and creativity" (Haimovitz & Dweck, 2017, p. 1857). The attention and importance given to testing scores limits how teachers instruct and how students interact with content. An educational curriculum created and driven by high stakes testing focuses on students achieving the highest possible score, not the retention and application of knowledge and content. It is important to "teach for understanding (rather than filling children full of facts and formulas)" (Haimovitz & Dweck, 2017, p. 1856), yet the mathematics curriculum and educational system in the United States places importance on knowing facts and formulas with little focus on deeper understanding.

Individuals in education do not argue that high stakes testing is accompanied by countless negative side effects for students. As expressed by Chen (2013) and Haimovitz and Dweck (2017), authentic learning will begin when students are provided with a curriculum that promotes and encourages exploration and discovery rather than memorization and repetition. Students, educators, parents, and invested stakeholders feel the effects of the current educational system and acknowledge that change is needed, however changes to mathematics curricula have occurred slowly and are minimal at best (Boaler, 2013, p. 150).

A re-creation of curriculum that moves from formula- and testing-focused to student exploration and discovery of mathematical concepts/processes is needed. A change in curriculum design that allows the student to be an active participant in their learning rather than a passive observer creates and provides opportunities for authentic learning and deeper understanding (Chen, 2013; Haimovitz & Dweck, 2017). The re-creation of curriculum would better frame mathematics for students and allow for the incorporation of more mindset-focused instructional strategies. The inclusion of these various strategies and a curriculum that is designed to enhance student learning could lead to increased growth mindsets, higher achievement, and changed students' views increasing interest in mathematics (Boaler, 2013; Clough, 2008).

Mindset Focused Instructional Strategies

Mindset-focused instructional strategies are incorporated into classrooms through purposefully and explicitly taught lessons. Robinson (2017) and Dweck (2008a) emphasized the need to normalize mistakes and failures within the classroom. Students are aware and sensitive to what adults value about them (Dweck, 2008a), and they aim to please the adults around them by meeting expectations. Providing students with simple and easy problems can lead to a false sense of confidence and places importance on being able to reach a correct solution rather than understanding and effort. Providing students with opportunities and problems that challenge their abilities and allow for mistakes promotes a growth mindset (Dweck, 2008a, p. 13). Dweck (2008a) explained that process praise, or feedback about strategies, effort, and improvement rather than outcome praise, which focuses on the solution, encourages challenge-seeking behavior that leads to growth mindset in students. It is important for educators to actively and consistently act and communicate to students that they value hard work, effort, and learning from mistakes (Dweck, 2008a; Robinson, 2017).

Robinson (2017) emphasized the need for teachers to create tools that incorporate active learning methods to encourage growth mindsets (p. 18). She expanded on her statement by stating that teachers should focus on active learning methods such as memory retrieval, elaboration, and reflection. Dweck (2008a) agreed with these sentiments but expanded active learning methods to include peer interaction. These instructional strategies, which include a wide variety of educational activities including free recall and think-pair-share, engage students in their learning through physical activity (writing, moving, constructing) and help make learning "stick" (Robinson, 2017, p. 19). In addition to active learning strategies, both Dweck (2008a) and Robinson (2017) agree that educators can help students develop growth mindsets through explicit instruction about brain development and neuroplasticity. Robinson (2017) defined neuroplasticity as "the brain's ability to form and reform new neural connections in response to experiences and changes in the environment" (p. 18). Dweck (2008a) explained that "students can be taught that the brain is like a muscle that gets stronger and works better the more it is exercised . . . every time they stretch themselves, work hard, and learn something new . . . they become smarter" (p. 9). Strategies, methods, and lessons, when purposefully developed and explicitly taught to students can encourage the development of a growth mindset and improve student understanding and success in mathematics.

Leveling and Grouping

Leveling, also known as grouping, bases schooling practices on ideas about ability, placing students of similar abilities into the same class (Boaler, 2013, p. 145). The practice of grouping "bombards students with the messages that ability is fixed and that some students have talent and intelligence while others do not" (Boaler, 2013, p. 145). Boaler (2013) asserts that the concept of leveling was developed on fixed mindset beliefs (p. 149).

Students are aware of leveling even if it is not explicitly stated (Boaler, 2013, p. 146). According to Boaler (2013) leveling, or grouping, can harm students placed in lower and intermediate level courses while no academic advancement has been found for those placed in higher achieving levels (pp. 148–149).

> Students placed in the lowest tracks or in remedial programs tend to experience instruction geared only to rote skills, working at low cognitive levels on fill-in-the-blank worksheets and test orientated tasks that are profoundly disconnected from the skill they need to learn (Darling-Hammond, 2010, p. 55).

Strauss (2013) reiterated Boaler's (2013) and Darling-Hammond's (2010) distaste for leveling. All three researchers have found that leveling does not help to improve mathematical abilities and understanding but is counterintuitive, sending negative unspoken messages to students about their abilities.

Additional Factors Contributing to Mindset

Research defines numerous potential factors that may contribute to mindset including gender differences, peer influences, and prior experiences (Clark Blickenstaff, 2005; Dweck, 2008a; Furnham, Reeves, & Budhani, 2002; Jacobs & Eccles, 1985; Stockwell, 2017). Gender differences, examined by Clark Blickenstaff (2005), favor male students in mathematics while lowering standards and providing excuses for female students' poor performance in the subject. Peers, regardless of gender, impact student views of subjects and content (Snipes & Loan, 2017) bringing new meaning to the phrase *you are who you hang out with*. In addition to potential influences resulting from gender and peers, mindset is influenced by students' previous success and failures creating a difficult cycle to break (Mosley, 2017).

Gender Differences

Society has created a notion that boys are meant to be better in mathematics (Jacobs & Eccles, 1985, p. 20). Media, including news titles, cartoons, and advertisements have "a strong influence on public opinion and policy" (Jacobs & Eccles, 1985, p. 20), and often display males as superior in mathematics or related roles. Furthermore, educators may subconsciously promote the idea that boys are better at math (Furnham et al., 2002). Through observational studies, Clark Blickenstaff (2005) concluded that boys might be more academically prepared than their female counterparts because teachers subconsciously offer more support for boys to get the correct answer and hold them to a higher quality of academic work (p. 379). In addition to not receiving the same support, "many girls do avoid physics and calculus courses in high school and that makes it less likely they will choose a STEM major in college" (Clark Blickenstaff, 2005, p. 374).

Women are drastically underrepresented in mathematics and for those who do choose to enter the field, the retention rate is overwhelmingly low (Chen, 2013; Clark Blickenstaff, 2005). Stockwell (2017) highlighted the dominance of males in the same field when discussing college graduation rates. In 2016 a majority (63%) of STEM graduates were male (Stockwell, 2017), and while 37% of STEM graduates were female, Stockwell (2017) illuminated the startling reality that this percentage accounts for only 7% of female college graduates entering the workforce.

"This means that there are few role models in science, math, or engineering departments for young female students to follow" (Clark Blickenstaff, 2005, p. 376). The lack of strong role models or knowledge of someone in the field, active academic sexism, and intimidation of high-level courses with limited female peers are factors believed to contribute to the underrepresentation of females (Clark Blickenstaff, 2005). Dweck (2008a) connected this underrepresentation to mindsets when she stated, "there is increasing evidence that mindsets can play a key role in the underachievement of women . . . in math and science, as well as their lesser tendency to elect to pursue careers in math and science" (p. 5)

Parents may also subconsciously promote the idea that boys are better at math (Clark Blickenstaff, 2005). In a survey conducted by Furnham et al. (2002), it was discovered that parents feel sons are mathematically smarter than daughters (p. 24). The projection of this belief onto sons and daughters may limit or advance the success a student achieves (Clark Blickenstaff, 2005; Furnham et al., 2002). Additionally, in a study conducted by Dweck (2008a), "parents have been more interested in making students feel good about themselves in math and science than in helping them achieve" (p. 8). This approach can eliminate the responsibility of students performing well in mathematics by providing alternative excuses, such as telling the student they are not a *math person* and as a result promotes a fixed mindset (Dweck, 2008a, p. 8).

Peer Influence

Students spend the majority of their day at school with peers interacting and engaging with one another both academically and socially. Peers play an important role in developing and reinforcing attitudes (Snipes & Loan, 2017). Social groups are more likely to display similar attitudes about particular courses and reinforce perceptions whether positive or negative (Snipes & Loan, 2017). This affects students' thoughts, feelings, and views about mathematics. If a student is surrounded by peers who dislike math and display a specific mindset, the student is more likely to reflect these sentiments as well.

Mathematics is the only subject for which it is socially acceptable to admit to poor ability (Wai, 2012, para. 1). Sanabria and Penner (2017) confirmed Wai's (2012) statements when they noted that the social acceptance of poor math performance is exemplified when students share out poor tests scores without embarrassment, joke about not understanding without increasing effort, and push aside poor performance with excuses about ability. The social acceptability of being bad at math is not transferable across subjects—failing reading is perceived to be much worse than failing math (Wai, 2012, para. 1–2).

Prior Experience

A student's previous interaction and prior experience with mathematics are indicators for how a student will interact and perform with the subject in the future (Montt, 2011; Soni & Kumari, 2015). A student's previous interaction and prior experience includes, but is not limited to, previous success or failures within the subject, positive and negative relationships (or lack of) with teachers or educators, and views and perceptions of mathematical content. In mathematics, prior experiences can encourage or discourage student success. Montt (2011) explained how a consistent feeling of defeat and little academic success leads students to believe they are not capable of learning. The opposite is also true for students who experience success and have previously done well (Montt, 2011, pp. 62–63). These cycles continue into the next course students take. Breaking the cycle for poorly performing students is challenging, although not impossible, as views and mindset become harder to change with increasing grade and level (Mosley, 2017).

The Value of Student Perspectives

Student perspectives provide unique insights to what is happening in education. Students are the most directly affected by changes in educational policy and practice, but they are least often consulted, leaving their valuable insight unheard (Cook-Sather, 2002, p. 3). Student perspectives "can improve current educational practice, re-inform existing conversation about educational reform, and point to the discussion and reform efforts yet to be undertaken" (Cook-Sather, 2002, p. 3) as well as provide an understanding about the influence of environmental factors on learning (Noguera, 1999, para. 64).

"When perceptions and experiences of students are not taken into account, the policies adopted to help young people often miss the mark" (Noguera, 1999, para. 68). Researchers agree that students must be recognized as valuable contributors to educational conversations through the acknowledgment of their thoughts and feelings (Cook-Sather, 2002; Noguera, 1999; Phelan et al., 1992). Students must become part of the conversation if the education offered to them hopes to successfully prepare them (Cook-Sather, 2002, p. 5).

Conceptual Framework

United States' mathematics education falls behind many other developed and industrialized nations (Desilver, 2017, para. 1). This achievement gap hinders American students from competing globally and diminishes opportunities to obtain higher paying careers and leadership positions (Whitney, 2016, para. 4). Prominent researchers Haimovitz & Dweck (2017) and Clough (2008) described a crucial component to lessening and eventually eliminating the achievement gap as the beliefs and mindsets of students.

Mindset theory has emerged as an important field of study within education. Well known-researcher Carol Dweck (2000) first introduced this theory nearly two decades ago;

however, its application in mathematics education is still evolving. While Boaler (2013), Dweck (2008b), and Lee (2006), pioneer researchers in the field of mathematical mindsets, have delved into the topic, only the surface has been touched. Literature and research about mindsets in mathematics is minimal, contributing to a lack of understanding. While numerous studies exist that examine the effects of different mindsets, the ability to alter educational outcomes through the use of specific instructional strategies and potential mindset influences, there exists a deficit in research related to student perceptions of the factors and experiences they believe contribute to mathematical mindset development. A void in literature exists as studies have neglected to consider and examine the voices of the subjects themselves.

Entity and incremental theories are two implicit theories developed by Dweck (2008b) to describe why students may or may not put effort into developing skills, understanding concepts, and overcoming challenges. Accompanying the entity and incremental theories is Dweck's (2000) assertion that mindsets are not permanent, and individuals have the ability to fluctuate between the two. Entity theory or fixed mindsets limit students. This mindset creates an internal barrier lessening students' chances of academic success. On the contrary, incremental theory or growth mindset is associated with higher levels of success, optimistic views of mathematics, and increased resilience (Boaler, 2013, p. 143). A student's education is affected by the mindset they possess.

Dweck's (2000) theories are accompanied by the belief that the type of mindset an individual holds can be changed, regardless of age. High school students, therefore, are not too old or too young for their mindsets to be shaped, further developed, or changed. Understanding what students perceive as factors and experiences that contribute to their mathematical mindset allows for the ability to identify and alter or eliminate negative influences and increase or continue the inclusion of positive influences. Understanding how individuals perceive the development of their mindset creates a clearer picture about mindset development. Further understanding may lead to the identification of additional positive influences for growth mindsets and promote more success and beneficial attributes for students. The student perspective, including that about mindset, has the ability to alter and improve educational practices (Cook-Sather, 2002).

This study investigated the current mindset of 30 junior level (11th grade) public high school students enrolled in a college-prep mathematics course through the use of the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015). This scale was developed by De Castella and Byrne (2015) to determine an individual's current mindset. Students completed the scale independently and based on results that were shared during semistructured interviews, a total of 10 students were classified into two groups—entity theory and incremental theory. Semistructured interviews were conducted with these 10 students that collected data and identified influential factors and experiences students perceived as influences on their mathematical mindset. The results informed this study and provided both the researcher and reader with new insight into student perceptions associated with mathematics.

Conclusion

Mindsets and self-efficacy contribute to recent educational theories aimed to better understand how and why students develop certain beliefs about their mathematical abilities. Research and understanding of these theories is just beginning to unfold. Mathematics education has a spotted past with a reputation of being resistant to change (Klein, 2003). It is a challenging subject to teach (Beyranevand, 2017, p. xi) but provides necessary skills for employment (Clark Blickenstaff, 2005; Soni & Kumari, 2015).

Research has suggested that mindset and self-efficacy are correlated to student success, achievement, and mental and emotional wellbeing (Boaler, 2013; Dweck, 2000; Dweck, 2008b; Montt, 2011; Soni & Kumari, 2015). A limited amount of studies and information exists that examine mathematics success (Liu et al., 2017), mindset, and the influencing contributors. Research continues to grow in terms of how mindset and self-efficacy develop in students. Students are stakeholders in their educational experience and their perceptions about these influencing factors and experiences matter (Phelan et al., 1992). The effects of parental involvement, teacher influence, gender differences, societal perceptions, and prior experiences in mathematics need further examination (Bandura, 1997; Boaler, 2013; Dweck, 2008b). The inclusion of student perspectives in this study helped to further create a comprehensive understanding of these topics and their influence on students' ability and mathematical success.

CHAPTER 3

METHODOLOGY

This mixed methods study intended to examine the factors and experiences junior level (11th grade) public high school students enrolled in a college-prep mathematics course perceived influenced the development of their mindset associated with mathematics. Mindset, defined as the set of attitudes and beliefs held by an individual (Dweck, 2008b, p. 14), is a determining factor in student success (Mosley, 2017), and influences how students approach mathematics and feel about their abilities in these courses. Mindset literature at the time of the study lacked the perspective and inclusion of students' thoughts and feelings, leaving their valuable insight and ability to improve education unheard (Cook-Sather, 2002; Noguera, 1999). Findings from the study allowed the researcher to add students' perceptions to the mindset theory conversation.

The United States needs thoughtful change in mathematics instruction and education (ed.gov, 2012) if it hopes to improve the international ranking of its mathematics education (Desilver, 2017). Mindset is one factor that can enhance or limit the success of a student and improve or hinder the educational rankings as a country. As a precursor to educational change, the researcher sought to develop an enhanced understanding of mindset development through the inclusion of students' thoughts and beliefs, specifically in relation to mathematics. This research created an enhanced understanding through the exploration of the following research questions:

1. What factors and experiences impact the mindset associated with mathematics for junior level (11th grade) public high school students enrolled in a college-prep level mathematics course?

a. How do junior level (11th grade) public high school students enrolled in a college-prep mathematics course describe the beliefs and attitudes that they feel contribute to their mindset associated with mathematics?
b. What factors and experiences do junior level (11th grade) public high school students enrolled in a college-prep level mathematics course believe influence their mindset associated with mathematics?

To answer these research questions and accomplish the purpose of the study an exploratory case study methodology was selected and implemented. Exploratory case study methodology "afford(s) researchers opportunities to explore or describe a phenomenon in context using a variety of data sources" (Baxter & Jack, 2008, p. 544) and is a "form of inquiry that affords significant interaction with research participants, providing an in-depth picture of the unit of study" (Bloomberg & Volpe, 2016, p. 46). Important to case studies is the desire to explore a bounded phenomenon (Bloomberg & Volpe, 2016) to maintain the study's focus and progression. In line with this, the necessary bounds for this case study included junior level (11th grade) public high school students currently enrolled in a college-prep level mathematics course. The participating students were enrolled at a public high school located in northeastern Massachusetts during the 2019–2020 school year.

Baxter and Jack (2008) and Bloomberg and Volpe (2016) stressed the importance of in-depth data collection through the use of multiple data sources. A variety of junior level public high school students within the case study's bounds along with the use of open-ended, unbiased interview questions, and a mindset evaluation tool met this need. The information collected through these data sources was analyzed in relation to Dweck's (2008b) entity and incremental mindset theories to identify patterns and themes among the responses collected. A detailed discussion of data sources, instruments, and the process for analysis is included later in the chapter.

Setting

This study was conducted at a public secondary school for students in grades 9–12 located in northeastern Massachusetts. The secondary school offered students a college preparatory education with honors/AP, standard, and Level 3 (struggling) course tracks depending on student abilities. This study focused on junior level (11th grade) students enrolled in a standard level college-prep mathematics course. In addition to the customary required courses such as English, Mathematics, Science, and Social Studies, the high school offered elective courses in Art, Fine Arts, Humanities, Physical Education, and Business. Upon the successful completion of a course, students were awarded 5 credits for a semester-based course or 10 credits for a yearlong course. The study site, in compliance with state recommendations, required all students to earn a minimum of 60 credits per year for a total of 240 credits to graduate high school (Massachusetts Department of Elementary and Secondary Education, 2019). The details of the delegation of these credits across content areas are outlined in Table 1 included below. Table 1 highlights content areas such as Mathematics and English Language Arts requiring the most credits necessary for graduation in comparison to Health and Physical Education which require the least amount of credits.

Table 1

Delegation of Credits for Graduation at Study Site

Delegation of Credits for Graduation at Study Site	
Content Area	Number of Credits Required
Mathematics	40
English Language Arts	40
Science	30
Social Studies	30
Arts (Practical, Fine, Performing)	30
World Language	20
Health	10
Physical Education	10
Other (Electives)	30

In addition to the credit requirement, the state of Massachusetts requires that all students earn a minimum score of proficient on the Massachusetts Comprehensive Assessment System (MCAS) in Mathematics, English-Language Arts, and Science to be awarded a high school diploma. Students who earned a score of “needs improvement” in any of these subject areas were still eligible to receive a diploma if they fulfilled the requirements of an Educational Proficiency Plan (EPP). An EPP is an educational planning tool based on individual student strengths and weaknesses and it outlines how the school would demonstrate the student made progress toward proficiency in the content area (Massachusetts Department of Elementary and Secondary Education, 2019).

The public high school provides education for approximately 1,600 students living within the middle-class suburban community or those who had applied and were accepted through a school choice program. The majority (79%) of the student population came from Caucasian families followed by Asian (12.6%), Hispanic (3.4%), and African American (2.9%) families. The remaining 2.1% consisted of students from families of various ethnic backgrounds including Pacific Islander, Multi-Race, and Non-Hispanic (Massachusetts Department of Elementary and Secondary Education, 2019). The student population was split equally between males and females who ranged in age from 14 to 21 years old with 8.6 % of the student population classified as economically disadvantaged (Massachusetts Department of Elementary and Secondary Education, 2019).

Participants

The study used two sampling strategies: simple random sampling and stratified random sampling to select student participants. Simple random sampling selected a group of participants from a larger population. Each member of the population had an equal chance of being selected and every participant was chosen by chance (Easton & McColl, 1997). Stratified random sampling divided the population into groups and simple random sampling techniques were employed within each group to create a sample (Easton & McColl, 1997). Both of these sampling strategies and their relation to the study are discussed in more detail below.

Informed consent was an essential and required prerequisite obtained for each participant prior to the study (Nijhawan et al., 2013, p. 134). Before beginning the selection of participants, the superintendent, on behalf of the researcher, sent an email to the guardian of every student meeting the criteria of the study (junior level public high school students enrolled in a college-prep level mathematics course at the study site). The group email communication had guardian emails blind copied to uphold confidentiality as well as the researcher's University of New England email copied for easy response and reference. Additionally, the researcher provided parents/guardians with a printed copy of the email communication and consent form. These copies were trifolded, stapled, addressed to the parents/guardians of the student, and distributed to students in their homeroom. The e-mail communication (Appendix A) and its printed copy explained the study, provided important information, identified the researcher as a teacher at the study site, and granted parents/guardians the opportunity to opt their student into the study. For the chance to have their students included in the study, parents/guardians had two weeks to return the signed letter of consent (Appendix B) attached to the original email or provided in the printed copy. Parents/guardians had the option to return signed letters of consent electronically through email or as a printed copy by means of their child's backpack. Guardians who chose to return a printed copy were instructed to have their student return the document to the researcher. Students placed these documents in a locked box located in the back of the researcher's classroom. The researcher emptied the box daily and assigned a value (e.g., Student 1, etc.) to each returned signed letter of consent and its associated student. A document matching each student to his or her associated value and electronically returned letters of consent was stored in an encrypted file on the researcher's password protected personal laptop. Printed, signed copies of consent forms were stored in a locked filing cabinet in the researcher's personal office. To mitigate the perception of coercion, the invitation to participate in this study was distributed to all 400 junior students who were enrolled in all sections of the site's college prep level mathematics courses. The researcher taught 25–30 students out of the total enrolled student population. Junior students who were scheduled to take a future college prep level mathematics course that was outside their current enrollment were not eligible for participation in this study.

Using the students' previously assigned value (e.g., Student 1, etc.), simple random sampling was used to determine 30 students to participate in the first phase of the study. A random number generator selected 30 values and the researcher identified the participants through the use of the coded list. These students were contacted through district-provided student email (Appendix C) with their guardian copied to alert them of the selection. Additionally, a printed copy of the communication was distributed to the student during homeroom. Letters handed out during homeroom were trifolded, stapled, and addressed to the student. Both the printed copy and email provided students with information related to the study, informed them that their participation was voluntary, and provided a letter of assent (Appendix D) to sign and return. In addition to including important information about the study, the assent form identified the researcher as a teacher at the study site. Willing student participants had the option to return signed letters of assent electronically through email or as a printed copy. Students who chose to return a printed copy were instructed to return the document to the researcher. Students placed these documents in a locked box located in the back of the researcher's classroom. The researcher emptied the box daily and labeled each returned signed letter of assent with the student's previously associated value (e.g., Student 1, etc.). Electronically returned letters of assent were stored in an encrypted file on the researcher's password protected personal laptop. Printed, signed copies of assent forms were stored in a locked filing cabinet in the researcher's personal office.

Adequate provisions and accommodations meeting the needs of students on Individualized Education Plans and/or 504s were provided as needed (e.g., documents could be read to the student, large type copies could be provided as needed, etc.). Students had two weeks to return their letter of assent to participate in the study. If students did not assent to be in the study, the random number generator was used to pick additional students, so the sample size remained 30.

In the first phase of the study, participants took the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015) (Appendix E) by hand using a photocopy of the measurement scale and a writing instrument. This publicly available scale was used to self-assess the fixedness of the student participant's mathematical mindset (De Castella & Byrne, 2015). The Revised Implicit Theories of Intelligent (Self-Theory) Scale (De Castella & Byrne, 2015) was individually administered to students during a specified day and took place during the student's study block in a lecture hall, to minimize, if not eliminate, any interruptions to student learning time and school operations. A script (Appendix F) was used during administration to ensure all students were provided with the same information and instructions. The student assent form was read to students before administration of the scale to ensure they were aware of their rights and were participating voluntarily. To protect the confidentiality of participants, all completed copies of the scale were labeled according to the participant's previously assigned value (e.g., Student 1, etc.) instead of their name and were stored in a locked filing cabinet in the researcher's private office. The completed scales will be cross shredded and permanently destroyed one year after the completion of the study.

Based on the results gathered from participant responses on the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015), stratified random sampling was employed to select a total of 10 students from this prospective participant pool, 5 of each type of mindset (growth/fixed) for the second phase of the study. Stratified random sampling divided the participants into homogeneous groups (Hayes, 2019). For this study, two groups based on mindset were developed. The use of these two subgroups and selection from within them allowed the researcher to obtain a representative sample from the participant pool representing both types of mindsets seen in mathematics classrooms (Hayes, 2019). To select these participants, students were classified into groups based on their results from the scale. Once categorized, using the student's previously assigned value and the random number generator 5 participants from each group were selected. An email (Appendix G) was sent to students alerting them of the selection as well as a time and place for the interview. If a student no longer desired to participate additional students were selected using the same methods to guarantee a sample size of 10. If a student desired to withdraw from the study, they informed the researcher in writing through email. The researcher conducted semistructured interviews with the 10 students individually. The semistructured interviews took place during a student's study block in a private conference room for more efficient and effective data collection. Each student participant was interviewed once during the 2019–2020 school year. At the end of the interview students had the option to review the transcript for accuracy and to ensure it portrayed their thoughts and beliefs. Any and all electronic notes and transcripts that resulted from the interviews were stored in an encrypted file on the researcher's password protected personal laptop while printed or hand-written documentation was stored in a locked filing cabinet in the researcher's private office. All notes, files, and transcriptions will be stored for one year after the completion of the study at which time they will be cross-shredded and/or permanently deleted. All participating students were verbally thanked for their participation during each phase of the study.

Type of Data

The data for this study was extrapolated from two sources. The researcher collected the first layer of data through a publicly available instrument known as the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castell & Byrne, 2015). In addition, and as a comprehensive follow-up, the researcher conducted semistructured, individual interviews to elicit the perceptions of students on factors and experiences that influenced their mathematical mindsets. Each source of data for this study is discussed specifically below.

The Revised Implicit Theories of Intelligence (Self-Theory) Scale

De Castella and Byrne (2015) described the Revised Implicit Theories of Intelligence (Self-Theory) Scale (Appendix E) as a revision of Dweck's original scale used to determine mindset. The scale is found in the public domain and does not require permission for noncommercial use. De Castella and Byrne (2015) developed the scale to consist of 8 items or questions with 4 questions measuring entity self-beliefs (fixed mindset) and 4 questions measuring incremental self-beliefs (growth mindset). Participants responded on a 6-point scale from strongly disagree (1 point) to strongly agree (6 points) in relation to the items/questions asked. Additional response options on the scale included disagree (2 points), mostly disagree (3 points), mostly agree (4 points), and agree (5 points). Participating students selected one of the six given responses to indicate the extent to which they agreed or disagreed with the given item or question (De Castella & Byrne, 2015).

Semistructured Interviews

Interviews were the "process in which a researcher and participant engage in a conversation focused on questions related to a research study" (DeMarrais, 2004, as cited in Lyons, 2016, p. 34). To guide the conversation, the researcher developed semistructured student interview questions (Appendix H) based upon Mindset Theory (Dweck, 2008b) and the desire to understand the perceived factors and experiences that junior level public high school students enrolled in a college-prep level mathematics course believed contributed to their mindset associated with mathematics. The semistructured, open-ended interview questions focused on the interviewee identifying their past mathematical successes and failures, behaviors and attitudes towards the subject at the time of the interview, and potential factors and experiences (e.g., people, places, items, etc.) of influence (e.g., positive or negative) that supported their feelings about mathematics. Interview questions were designed as a catalyst for conversation and additional follow-up questions were asked as needed. Individual interviews were scheduled in advance and conducted in person once during the 2019–2020 school year. An interview protocol (Appendix I) developed by the researcher for consistency in the interview process was read at the beginning of each scheduled interview to remind students of their rights, the purpose of the study, and provide a transition to the questions. All participant interviews were recorded and transcribed by Rev Voice Recorder services. Transcripts were edited, if needed, to use previously assigned values (e.g., Student 1, etc.) in place of participant names. Electronic transcriptions and researcher notes were stored in an encrypted file on the researcher's password protected personal laptop and printed or hand-written documentation was stored in a locked filing cabinet in the researcher's private office. All documentation will be stored for one year after the completion of the study at which time they will be cross-shredded and/or permanently deleted.

Analysis

To analyze student responses on the Revised Implicit Theories of Intelligence (Self-Theory) Scale, De Castella and Byrne (2015) recommend applying reverse scoring to items 5 through 8. This method of scoring was applied to these items because they reflect incremental self-beliefs/growth mindset and therefore portrayed opposite views to the entity self-beliefs reflected in items 1 through 4. Reverse scoring accounted for this difference and allowed the final score on the scale to accurately reflect the participants' mathematical mindset. Items 1 through 4 were scored using the response/value the student selected. The final score was computed by averaging the ratings on all 8 items or questions. Average scores close to 1 represented participants with growth mindset beliefs while average scores close to 6 represented participants with fixed mindsets. The use of this mindset instrument tool allowed the researcher to determine the mindset of the participant, permitted the researcher to group students by their mindset, and allowed for potential connections between mindset and student perceived influences to be explored.

Through the use of NVivo, a computer-based data analysis software program, the researcher developed codes and used these to identify categories or themes to analyze the student interviews. This process of coding and categorizing allowed the data to be "segregated, grouped, regrouped, and relinked in order to consolidate meaning and explanation" (Grbich, 2007, p. 21). This process was multistep and required the creation of codes, examining the codes, grouping them into categories, and reviewing the categories to ensure they were independent, descriptive, and inclusive. All documentation was stored in encrypted files on the researcher's password protected personal laptop or in a locked filing cabinet in the researcher's private office. All files will be kept for one year after the completion of the study at which time they will be cross shredded and/or permanently deleted.

Participant Rights

Parental/guardian consent forms were distributed, signed, and collected prior to the distribution of student assent forms. Both the parental/guardian consent (Appendix B) and student assent (Appendix D) forms detailed rights related to the study including benefits of participating and anticipated risks, as well as measures taken to safeguard confidentiality. If a student did not assent to the study even after parental/guardian consent was obtained, they did not participate in the study. Additionally, the consent and assent forms included a statement that allowed the participant or guardian of the participant to withdraw from the study for any reason at any time without consequence. Confidentiality of participants was protected through the use of assigned values/pseudonyms (e.g., Student 1, etc.). These pseudonyms were used in all transcripts, notes, and drafts, and a key relating the values/pseudonyms to the participant was stored in an encrypted file on the researcher's password protected personal laptop to be permanently deleted one year after the completion of the study.

Potential Limitations

The study was designed to elicit and document the factors and experiences junior level public high school students enrolled in a college-prep level mathematics course believed contributed to their mathematical mindset development through the use of a mindset scale and individual, semistructured, follow-up interviews. Due to this design and focus, the study did not intend to make correlations or associations to student achievement or proficiency in relation to mathematical mindsets. The study was conducted at a single high school with a subgroup of the population who met specific criteria. The size and location of the study created a limitation of student demographics, including but not limited to age, gender, race, and socioeconomic status.

The results of the study were dependent upon the instrument and interview responses. Answers to both data collection instruments were self-reported and while it was assumed that all participants answered openly and honestly, it could not be guaranteed. Results of this study were limited to the responses participants contributed.

To mitigate bias in both data collection and analysis the researcher used a research strategy known as bracketing. The researcher reflected on her own personal biases, experiences, and knowledge before beginning data collection and analysis. The researcher kept these biases in mind and bracketed or made a note of them when they arose throughout the research process. This strategy allowed the data to drive the conclusions and alerted the reader to any potential biases that were consciously reflected on to maintain the study's integrity. Additionally, the researcher was aware of the duality of her roles at the study site. As both a doctoral student conducting the study and an educator within the building, the researcher needed to ensure that these roles did not conflict in a manner that compromised the study. When conducting interviews, the researcher limited her role as an educator and was aware of potential associations students may have had, such as viewing the researcher as a disciplinarian. The researcher acted in an ethical fashion, using previously developed semistructured interview questions and interview protocol so as to not compel or influence participant responses.

Conclusion

The mindset a student possesses is an indicator of whether or not the student will experience success (Mosley, 2017). While some mindset influences are known through the perspective of researchers and adults within the education field, additional research and data collection was needed to understand the student perspective. The researcher conducted an exploratory case study of 10 high school mathematics students using semistructured interviews to elicit their perspectives about factors and experiences they believed contributed to their mathematical mindset to fill the prior void in research and literature.

CHAPTER 4

RESULTS

The purpose of this study was to develop an understanding of high school students' perceptions about factors and experiences that contribute to their mathematical mindset. Additionally, the researcher intended to determine the relationship between these factors and experiences and their roles in the formation of one type of mathematical mindset over the other. To accomplish the goal and purpose, the researcher investigated the following questions:

1. What factors and experiences impact the mindset associated with mathematics for junior level (e.g. 11th grade) public high school students enrolled in a college-prep level mathematics course?
    a. How do junior level public high school students enrolled in a college-prep mathematics course describe the beliefs and attitudes that they feel contribute to their mindset associated with mathematics?
    b. What factors and experiences do junior level (e.g. 11th grade) public high school students enrolled in a college-prep level mathematics course believe influence their mindset associated with mathematics?

Table 2, “Research Questions and Data Sources” further details the research questions and their alignment to the various data collection instruments and sources of data.

Table 2

Research Questions and Data Sources

Research Question and Instrument Alignment		
Research Question	Mindset Scale/Instrument	Interview Questions
Overarching Question: What factors and experiences impact the mindset associated with mathematics for junior level (e.g. 11th grade) public high school students enrolled in a college-prep level mathematics course**?**		Questions 1b and 3–4
Supporting Research Question 1: How do junior level public high school students enrolled in a college-prep mathematics course describe the beliefs and attitudes that they feel contribute to their mindset associated with mathematics?	Items 1–8	Questions 1–2
Supporting Research Question 2: What factors and experiences do junior level (e.g. 11th grade) public high school students enrolled in a college-prep level mathematics course believe influence their mindset associated with mathematics?		Questions 1b and 3–4

In addition to the close alignment between the research questions and data sources, this study is also explicitly connected to the data sources and conceptual frameworks which consisted of Dweck's (2000) entity and incremental theories. The alignment between the data sources and theories connects and shows a balanced approach and inclusion of all components of the conceptual frameworks. Table 3, "Conceptual Frameworks and Instrument Alignment" displays the relationship between each data source, data source component, and Dweck's (2000) theories associated with the study.

Table 3

Conceptual Frameworks and Instrument Alignment

Theoretical Lens and Instrument Alignment		
Lens	Mindset Scale/Instrument	Interview Questions
Entity Theory	Question 1, 2, 3, and 4	1a–b, 2a–b, 3a–c and 4
Incremental Theory	Questions 5, 6, 7 and 8	

This mixed-methods study consisted of a hard copy mindset scale administered individually to student participants and interviews with 10 students conducted in a private setting at the research site. Chapter 4 summarizes the data collection process and techniques as well as the results and findings of the aforementioned data collection instruments as they relate to the research questions. Findings are presented in the order in which this study occurred. The researcher analyzed student participant results on the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015), first examining data grouped by mathematical mindset followed by analyzing the collective group data. Interview data is presented first by the examination of individual interviews and then by dissecting various themes found throughout the interviews. A summary of the results and findings is presented at the end of the chapter.

Data Collection Process and Techniques

After IRB approval from the University of New England (UNE) and the study site, the superintendent, on behalf of the researcher, approved the distribution of an email to recruit participants (Appendix A). This email included a consent form (Appendix B) and was sent to all junior level students' parents/guardians on Friday October 11, 2019. All parent/guardian emails were blind copied on the mass email communication. The researcher's UNE email address was copied in this recruitment communication for ease of reply for individual parents or guardians. In addition, the researcher distributed paper copies of the email and consent form labeled to the parent/guardian of each junior level student during the junior level student's homeroom period. In order to provide ample time for parents/guardians to consider their child's participation in this study, they had two weeks to sign and return the consent form to the researcher. The researcher received 47 signed consent forms by October 25, 2019. Fifteen signed consent forms were returned electronically through email to the researcher's UNE email account while the remaining 32 signed consent forms were physically returned to the researcher. As instructed in the consent form, parents/guardians who opted to return a physical copy of the consent form did so through their student. Students delivered the consent form to the researcher's classroom and placed the form in a locked box located in the back of the room. The researcher continued the process of obtaining consent for data collection at the end of each school day by emptying the locked box and checking her UNE email account. Upon emptying the box and checking email, the researcher reviewed each consent form, signed it ensuring its completion, and returned an electronic copy of the finalized form with both parent/guardian and researcher signatures to the email address provided by the parent/guardian on the consent form.

Prior to obtaining consent for student participants the researcher made an Excel spreadsheet. The spreadsheet was used to organize and assign students a pseudonym (e.g., Student 1, etc.). While the researcher created this Excel spreadsheet as an organizational tool, the assignment of pseudonyms for each student was an additional measure to protect the identity and privacy of each participant. The researcher included columns entitled "Consent" and "Assent" within the spreadsheet. The researcher used these columns as an additional method to ensure she had the proper permissions before communicating with a student participant.

Using the prepared spreadsheet, the researcher added each student with a signed consent form to the document and assigned the potential participant a pseudonym (e.g., Student 1, etc.). The researcher filed hard copies of signed consent forms in a locked filing cabinet located in the researcher's private office and saved electronic consent forms as encrypted files on the researcher's password protected personal laptop. The researcher repeated this process daily for two weeks starting October 11, 2019 and ending October 25, 2019, the deadline for returning consent forms. A second copy of the original email (Appendix A) and letter of consent (Appendix B) was sent as a reminder one week before the deadline on October 18, 2019.

The collection of student assent forms began after the collection of parent consent was completed. As outlined above, each potential student participant was assigned a pseudonym (e.g., Student 1, etc.), and all potential participants were included in the Excel spreadsheet. Through the use of a random number generator and the assigned values (e.g., Student 1, etc.), 30 participants were selected for participation in the first phase of the study. The researcher matched values to the associated student using the coded list in the Excel spreadsheet. Student participants were alerted to their selection and provided an assent form (Appendix D) through email (Appendix C). Students' parents were copied on each email using the email address provided on the returned consent form to alert them of their child's selection into the study as well. Similar to the consent process, the researcher distributed paper copies of the email (Appendix C) and assent form (Appendix D) to each selected student during his or her homeroom period. Selected junior level participants had two weeks beginning October 28, 2019 through November 11, 2019 to sign and return the assent form to the researcher. The signed assent form was returned electronically through email to the researcher's UNE email account or physically to the researcher. As instructed in the assent form, the 28 students who opted to return a physical copy of the assent form delivered the form to the researcher's classroom and placed the assent form in a locked box located in the back of the room. The researcher continued the process of obtaining assent at the end of each school day by emptying the locked box and checking her email. Upon emptying the box and checking her email, the researcher reviewed each assent form and signed it ensuring its completion. Student participants could request copies of signed assent forms, and upon this request, an electronic copy of the finalized form with both student and researcher signatures would be sent to the student's email address by the researcher. While this opportunity was offered, no student participants requested a copy of the signed assent form. Each returned letter of assent was labeled with the student's previously assigned value (e.g., Student 1, etc.) and the assent column in the Excel spreadsheet was marked noting its obtainment. The researcher filed hard copies of signed assent forms in a locked filing cabinet located in her private office and saved electronic assent forms as encrypted files on her password protected personal laptop. The researcher repeated this process daily until all 30 assent forms were returned.

As students returned their assent forms, the researcher scheduled a day for the student to take the Revised Implicit Theories of Intelligence (Self-Theory) Scale (De Castella & Byrne, 2015) (Appendix E). The researcher scheduled students during the next available study block in the student's schedule in the order the assent forms were returned. Students were alerted to the scheduled day through a conversation with the researcher. If the scheduled day was not convenient to the student, the student was given the opportunity to reschedule for a different day during this conversation. Two students requested to be rescheduled. Students completed the mindset scale by hand using a photocopy of the measurement scale and a writing instrument. It was administered individually to students during their study block. A script (Appendix F) was read by the researcher during the administration of the mindset measurement scale to ensure each student was provided with the same information and directions. The researcher also read the student assent form as a reminder for student participants about their rights and to guarantee the student was still a willing and voluntary participant. All completed copies of the scale were labeled with the student's previously assigned pseudonym (e.g., Student 1, etc.) in place of the students' names. Each completed scale was stored in a locked filing cabinet located in the researcher's private office.

Prior to beginning Phase I of the data collection, the researcher created and used Table 4, "Mindset Scale Responses" to aid in efficient data collection methods.

Table 4

Mindset Scale Responses

Mindset Scale Responses										
Pseudonym	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Final Score	Mindset Type
Student 1										
Student 2										

Table 4 identified the eight items contained in the mindset scale, a final score, and mindset type across the top row and listed the student by their assigned value (e.g., Student 1) in the left most column. After a student participant completed the scale, the researcher scored the scale. The researcher analyzed student responses on the Revised Implicit Theories of Intelligence (Self-Theory) Scale using the recommendations provided by the scale's creators De Castella and

Byrne (2015). Items 1 through 4 were scored using the response or value selected by the student while reverse scoring was applied to items 5 through 8. The final score for each student was computed by averaging the ratings on all 8 items. Average scores close to 1 represented participants with growth mindsets while average scores closer to 6 represented participants with fixed mindsets. Once finished analyzing the measurement scale, the researcher entered each participant's score, both on individual items and the final score into the spreadsheet in the appropriate location. A detailed discussion of the results from Phase I of the study are discussed later in the chapter.

The completion and scoring of all 30 student mindset scales marked the end of the data collection for Phase I. Once all scales were scored, entered into the spreadsheet and labeled according to their associated mindset, the researcher began Phase II of the data collection process and categorized the student participants into two subgroups based upon their mindsets. These subgroups were growth mindset and fixed mindset. At the recommendation of the scale's creators, De Castella and Bryne (2015), students with average scores between 1.00 and 2.99 were placed into the growth mindset subgroup while students with average scores between 3.00 and 6.00 were categorized into the fixed mindset subgroup. Using the random number generator and the students' previously assigned pseudonyms (e.g., Student 1), the researcher selected 5 students from each subgroup. These students were alerted of their selection through an email (Appendix G) informing the student of a time and place for their interview. Students were given the opportunity to reschedule their interview time if the time selected was not convenient to the student's schedule. All 10 students were able to meet on their assigned date and time, so rescheduling was not necessary.

The researcher conducted semistructured interviews with the 10 students individually during the student's study block. Students met the researcher outside a predetermined and disclosed conference room within the school building. The researcher welcomed the student into the room and closed the door to ensure the privacy and confidentiality of the student and their responses. The researcher began the interview by reading the student interview protocol (Appendix I) followed by asking previously created semistructured interview questions (Appendix H). The researcher took notes electronically on a password protected personal laptop and asked follow-up questions as needed. At the end of the interview students were presented with the opportunity to review their transcript for accuracy after it was transcribed to ensure it portrayed their thoughts and beliefs. All students waived their opportunity to review their transcript. Each student was verbally thanked for their participation in the interview.

All interviews were recorded and transcribed using REV transcription services. The researcher submitted all recordings to be immediately transcribed upon completion of the interview. Upon receiving the transcribed transcripts of each interview from REV, the researcher individually uploaded each file to NVivo, a computer-based data analysis software program. Through the use of NVivo, the researcher analyzed the data collected through the use of codes, categories, and themes. All electronic notes and transcripts generated as a result of the interviews were stored as an encrypted file on the researcher's password protected personal laptop. No handwritten documentation was developed during the interviews.

Description of Participants

To answer the research questions and accomplish the purpose of this study a mixed method, exploratory case study consisting of two phases was implemented by the researcher. Participants for both phases of the study were selected from the same population, junior level public high school students enrolled in a college-prep level mathematics course at the study site. Simple random sampling was used to select students for Phase I of the study while stratified random sampling was applied to select students for Phase II of the study.

Phase I Participants

Phase I of this study included 30 junior level public high school students currently enrolled in a college-prep level mathematics course. These students met with the researcher individually for approximately 10 minutes to complete a mindset scale. Extensive demographic data was not collected from these students. Gender identification, age, ethnic background, and other defining characteristics cannot be assumed and therefore are not reported.

Phase II Participants

The participants for Phase II of this study were grouped based on their results from the mindset scale completed in Phase I. Students were categorized into either a growth mindset or fixed mindset subgroup and five students from each subgroup were randomly selected for interviews resulting in a total of 10 participants. Table 5 represents each student profile as self-reported by the participant and addresses each student's pseudonym assigned when their parent or guardian returned the consent form, age, gender identify, mindset determined from Phase I of this study, and the educational services or supports accessible to the student. Students' names are not reported to protect their identity and to uphold confidentiality.

Table 5

Self-Reported Demographics of Interview Participants

Self-Reported Demographics of Interview Participants				
Participant Pseudonym	Gender Identity	Age	Mindset	Educational Services/ Supports Received
Student 2	Male	16	Fixed	None
Student 3	Female	16	Growth	504
Student 4	Female	16	Fixed	None
Student 18	Male	16	Growth	Not Reported/Unknown
Student 22	Female	16	Growth	Not Reported/Unknown
Student 26	Male	18	Fixed	ELL
Student 27	Male	16	Growth	Not Reported/Unknown
Student 29	Female	17	Fixed	None
Student 33	Female	16	Fixed	Not Reported/Unknown
Student 39	Female	16	Growth	Not Reported/Unknown

Of the 10 participants, four were male and six were female. All but two participants were 16 years old; the remaining two students, student 29 and student 26 were a 17-year-old female and an 18-year-old male respectively. Exactly five students were classified as having a growth mindset and the remaining five students were classified as having a fixed mindset. Two students, Student 3 and Student 26, self-reported receiving educational supports, three students self-reported receiving no such supports, and five students did not report any educational support status. Although these students did not report receiving any educational supports or services, they did not explicitly state that they did not receive these services. Their educational support status cannot be assumed and is listed as not reported/unknown. Every student was a junior enrolled in a college-prep level mathematics course at the study site.

Analysis Methods

The Revised Implicit Theories of Intelligence (Self-Theory) Scale completed in Phase I of this study included eight closed-ended questions/items. All questions and responses in this phase of the study included the responses from 30 student participants. Every participant was a junior high school student enrolled in a college-prep level mathematics course during the 2019–2020 school year at the study site. Each question on the scale asked student participants to indicate how strongly they agreed or disagreed with a statement related to their perceptions of their own mathematical intelligences. Students could select a response of "Strongly disagree," "Disagree," "Mostly disagree," "Mostly agree," "Agree," and "Strongly agree." To identify the value or importance of student participant responses and help with scoring, the data was re-coded into six categories as noted in Table 6.

Table 6

Data Analysis Recoding Phase I: The Revised Implicit Theories of Intelligence (Self-Theory) Scale

Data Analysis Recoding Phase I The Revised Implicit Theories of Intelligent (Self-Theory) Scale	
Code	Descriptor
1	Strongly disagree
2	Disagree
3	Mostly Disagree
4	Mostly Agree
5	Agree
6	Strongly Agree

The completion and scoring of all 30 student participant mindset scales marked the end of data collection for Phase I of this study. Once each student participant completed the Revised Implicit Theories of Intelligence (Self-Theory) Scale, their responses were analyzed using the recommendations provided by the scale's creators, De Castella and Byrne (2015) to determine the student participant's mathematical mindset. Items 1 through 4 on the mindset scale were scored using the response or value selected by the student. Reverse scoring was applied to items

5 through 8. The final score for each student participant was computed by averaging the ratings on all eight items. Average scores close to a value of 1 represented participants with mathematical growth mindsets, while student-participants with scores closer to 6 were categorized as having a fixed mathematical mindset.

Results for each individual student's scale was entered into the Excel program by the researcher. A table was formatted, designating a column for the student's pseudonym, each of the eight items/questions of the Revised Implicit Theories of Intelligence (Self-Theory) mindset scale, final score, and mindset type. A univariate analysis for data grouped by mindset type and the collective data was run to examine mean, median, and mode where appropriate.

Presentation of Scale Findings Grouped by Fixed Mindset

After scoring the Revised Implicit Theories of Intelligence (Self-Theory) Scale, using computed averages, students were grouped by mindset. For the sake of this study, the researcher used the recommended analytical approach of the scale's creators De Castella and Byrne (2015) and defined students with fixed mindsets as participants whose computed score fell between 3.00 and 6.00. Out of the 30 student participants who completed the scale, 7 student participants (Student 2, Student 4, Student 25, Student 26, Student 29, Student 33, and Student 42) were classified as possessing a fixed mathematical mindset. As a collective group, these student participants had an average score of 3.54; however, scores ranged from 3.0, as scored by student 42 to 4.38, as scored by Student 33. The closer the score was to 6, the stronger the fixed mindset of the student. Both the mode and the median of the 7 students average scores was 3.38. The value of 3.38 not only represented the most occurring average score (it occurred twice) but also the midpoint, or middle value of the data set. These values were computed by examining each item individually and as a collective. The table in Appendix J, *Intelligence Scale Results for*

Students with Fixed Mindsets, provides a detailed breakdown of the student participants' individual responses on each item presented in the mindset scale. Additionally, the table shows the calculated mean, median, and mode for each item and overall scores.

Analysis of Item 1, Item 5, and Item 7 on the Revised Implicit Theories of Intelligence (Self-Theory) Scale resulted in mean values above, although close, to 3. Item 1, with a mean of 3.14 presented students with the statement "I don't think I personally can do much to increase my intelligence," Item 5 with a mean of 3.43 provided students with the statement "with enough time and effort I think I could significantly improve my intelligence level," and Item 7 with a mean of 3.29 asked student to reflect on the statement "regardless of my current intelligence level, I think I have the capacity to change it quite a bit." Item 5 and Item 7 were scored using reverse scoring as recommended by the scale's creators. The averages, or means, reflected the student participant's disagreement toward the statements. All three items (Items 1, 5, and 7) asked students to reflect on their own ability, coupled with effort and time, to improve or increase their intelligence. The averages of 3.14, 3.43, and 3.29 correlated to fixed mathematical mindset beliefs. These students displayed a key belief of fixed mindsets, the belief that their intelligence is static and unchangeable.

Upon analysis of the fixed mindset grouped data, Item 3 and Item 6 resulted in similar computed means. Item 3, "my intelligence is something about me that I personally can't change very much," had a mean of 3.86. Item 6, "I believe I can always substantially improve on my intelligence," mean of 3.71 was computed using reverse scoring. Both values were close to 4 and showed a stronger relation to a fixed mathematical mindset than Items 1, 5, and 7. Items 3 and 6 asked students to reflect on intelligence change without mention of time, effort, or other individuals. The statements strictly focused on the ability for individual intelligence to change or improve. As a collective group, the student participants classified as having a fixed mindset felt personal intelligence change or improvement is not possible.

Examination of Item 2 and Item 4 in the mindset scale resulted in means at or above 4. Item 2 provided student participants with the statement "I can learn new things, but I don't have the ability to change my basic intelligence." A mean of 4.29 was computed as three students (Student 25, Student 33, and Student 42) selected a value of 4 or "Mostly agree," three students (Student 2, Student 4, Student 26) selected a value of 5, or "Agree" while Student 29 selected a response of 3, "Mostly disagree." Item 4 presented student participants with the statement "to be honest, I don't think I can really change how intelligent I am." The collective mean computed for this item was a 4, although the mode was a 5. The high frequency of responses agreeing with the statements presented in both item 2 and item 4 showed a relation to fixed mathematical mindsets.

When analyzing each of the eight items presented in the Revised Implicit Theories of Intelligence (Self-Theory) Scale for student participants grouped by fixed mindsets, only one, Item 8, had an average score that was below 3. Item 8 provided student participants with the statement "I believe I have the ability to change my basic intelligence level considerably over time" (De Castella & Byrne, 2015). Students 2, 25, 26, 29, and 42 selected a value associated with agreement with the statement and the remaining two students, Students 33 and 4, chose the value that corresponded to "Mostly disagree." The average score of 2.57 on item 8 is only slightly below the 3 mark, however, it reflected a collective perspective closer to a growth mathematical mindset than that of a fixed mathematical mindset.

Items 1 through 7 had computed means that reflected entity, or fixed mathematical mindset beliefs while Item 8's computed mean reflected incremental, or growth mindset beliefs. The medians and modes for all eight items were consistently at or above 3. These values show student participants' high frequency selection of values correlated to fixed mathematical mindsets. While responses to individual scale items or statements varied item to item and participant to participant, analysis of these responses showed strong beliefs that individual intelligence cannot be altered or changed even with substantial effort or given time. Additionally, student participants with fixed mindsets felt they could not change how intelligent they were, even if they learned and understood new concepts or curriculum.

Presentation of Scale Findings Grouped by Growth Mindset

The majority of student participants who willingly participated in Phase I of this study by completing the Revised Implicit Theories of Intelligence (Self-Theory) Scale, were classified as possessing a growth mathematical mindset. Twenty-three out of 30, or 76.67% of participants made up this group. The table in Appendix K, *Scale Results for Students with Growth Mindsets,* provides a detailed list of these students, their individual responses on each item, their average score, and computed means, medians, and modes for the collective data.

For the sake of this study, students with growth mindsets were defined as students whose computed score fell from 1.00 to 2.99 per the recommended analytical approach of the scale's creators. As a collective group, these student participants had an average score of 1.81; however, scores ranged from 1.00, as scored by student 6 to 2.63, as scored by student 16. The closer the score was to 1, the stronger the growth mindset of the student. Both the mode and the median of the 23 students' average scores was 1.75. The value of 1.75 represented not only the most frequently occurring average score (it occurred five times) but this value also represented the middle of the data set. The values were computed by examining each of the eight items individually, as a collective group, and by investigating and analyzing each individual student's responses.

When analyzing each of the eight items presented in the Revised Implicit Theories of Intelligence (Self-Theory) Scale for student participants grouped by growth mindsets, only two items, Item 2 and Item 3, had an average score at or above 2. Additionally, Item 2 and Item 3 were the only items on the mindset scale in which a minimum of 1 student participant selected a response of 4, or "Mostly agree." Student 1 and Student 30 elected to mark a response of 4 for Item 2, while one student participant, Student 31, marked the same score for item 3. No student participant grouped by growth mindset elected a response of 5 or 6 on any of the 8 items. Item 2 provided student participants with the statement "I can learn new things, but I don't have the ability to change my basic intelligence." The computed mean for Item 2 was 2.32. Item 3, "my intelligence is something about me that I personally can't change very much," had a mean of 2.00. While items 2 and 3 possessed the highest computed means, the values of both easily fell within the accepted range of values for growth mindset. The scores show the collective group's overall disagreement with the statements.

Analysis of Item 1, Item 6, and Item 7 on the Revised Implicit Theories of Intelligence (Self-Theory) Scale resulted in mean values of 1.73 or 1.86. Item 1, with a mean of 1.86 presented students with the statement "I don't think I personally can do much to increase my intelligence," Item 6 with a mean of 1.73 provided students with the statement "I believe I can always substantially improve on my intelligence," and Item 7 with a mean of 1.86 asked students to reflect on the statement "regardless of my current intelligence level, I think I have the capacity to change it quite a bit." Item 6 and Item 7 were scored using reverse scoring as recommended by the scale's creators. The medians for all three items computed to a value of 2. Items 1 and 7 were found to have a mode of 2 while Item 6's mode was found to be 1. These most frequently occurring values, middle values, and averages, or means, reflected the student participants' agreement with the statements presented in items 6 and 7 and disagreement with the statement in Item 1. These three statements asked students to reflect on one's own ability to generate intelligence change without mention of time, effort, or other individuals. As a collective group, the student participants classified as having a growth mindset felt personal intelligence change or improvement was possible.

Examination of scale Items 4, 5, and 8 resulted in mean scores at or slightly above 1.5. These 3 items had the lowest computed average score values showing a stronger connection to growth mindset. Item 4 provided students with the statement "To be honest, I don't think I can really change how intelligent I am." Item 8 specified "I believe I have the ability to change my basic intelligence level considerably over time." A mean of 1.59 was computed for both Item 4 and Item 8. Only one student participant, student 16, selected a response of or related to 3 "Mostly disagree" on the two items while all other participants chose a response of or related to 2 "Disagree" or 1 "Strongly disagree." Item 5, with a mean of 1.50 provided students with the statement "with enough time and effort I think I could significantly improve my intelligence level" and was the item with the lowest average. Similar to Items 6 and 7, Item 5 and Item 8 were scored using reverse scoring as recommended by the scale's creators. The mean score of 1.50 on Item 5 represents student participants' strong agreement with the statement. The average scores of 1.59 on Items 4 and 8 and 1.50 on Item 5 reflected a strong perspective related to growth mathematical mindset.

Items 1 through 8 had computed means that corresponded to incremental, or growth, mathematical mindset beliefs. The medians and modes for all eight items were consistently at or below 2. These values showed student participants' high frequency selection of values correlated to growth mathematical mindsets. While responses to individual scale items or statements varied item to item and participant to participant, analysis of these responses showed strong participant beliefs that individual intelligence can be altered and changed with substantial effort and given time. Responses and mean scores associated with student participants classified as having a growth mindset displayed the sentiment that these students felt they could change how intelligent they are.

Presentation of Scale Findings Collectively Grouped

The collective group of junior level public high school students who participated in Phase I of this study completed the Revised Implicit Theories of Intelligence (Self-Theory) Scale. The 30 students answered eight items by selecting a response on a scale ranging in value from 1, "Strongly disagree" to 6 "Strongly agree." No student selected a response of 6 on any item. The table *Scale Results for All Students* (Appendix L) displays all student participant responses. Responses are displayed showing individual students and items. Additionally, the table in Appendix L provides means, medians, and modes for the collective group as well as each item presented on the mindset scale. All students and values that are discussed further in this section are in relation to those from that table.

The first item on the Revised Implicit Theories of Intelligence (Self-Theory) Scale asked participants to indicate how strongly they agreed or disagreed with the statement "I don't think I personally can do much to increase my intelligence." As displayed in Appendix L, student scores ranged in value from 1 to 4 with an average of 2.13. No participant selected a response of 5, "Agree," or 6 "Strongly Agree." The median and mode of responses were 2. Thirteen students, or 43.33% of participants selected a response value of 2, or "disagree" as their response while 3 students (Students 2, 26, and 33) or 10% of participants selected a response of "Mostly agree." The majority of students did not find validity in the statement.

The second item on the mindset scale provided students with the statement “I can learn new things, but I don’t have the ability to change my basic intelligence” and again asked them to select a value based on their level of agreement. The table in Appendix L shows Item 2’s range was larger than that of Item 1 and included responses ranging from 1 to 5. No participant selected a response of 6, “Strongly agree.” A majority 46.67%, or 14 students, provided a response of “Disagree” (2). While a total of 23 students selected a response that was related to some level of disagreement with the statement, 11 students selected values that fell in the middle of the scale. This large percentage (36.67%) of student participants selecting one of the two middle values and the question’s average score of 2.77 displayed a lack of a strong defining relation to either growth mindset (score close to 1) or fixed mindset (score close to 6).

Item 3, “My intelligence is something about me that I personally can’t change very much” resulted in student selection of response values between 1 and 5. No student participant selected a response relating to a value of 6 or “Strongly agree.” While the mode for Item 3 echoed that of Items 1 and 2, responses showed more variability with fewer responses related to a single value.

The fourth item on the Revised Implicit theories of Intelligence (Self-Theory) Scale asked participants to indicate how strongly they agreed or disagreed with the statement “To be honest, I don’t think I can really change how intelligent I am.” The vast majority of participant responses were categorized as “Strongly disagree” and “Disagree.” A total of 11 student responses were given for each of these categories. A detailed list of these students can be found in the table *Intelligence Scale Results for Students with Fixed Mindsets* (Appendix J). The associated values of 1 and 2 for these labels were the mode for Item 3. Students 2, 4, 16, and 42 selected a response of “Mostly disagree,” one participant, Student 26, choose a response of

"Mostly agree" and 3 student participants, Students 25, 29, and 33, marked a response of "Agree." A computed response mean of 2.1 reflects a majority of growth mindset responses selected by student participants.

The fifth item on the mindset scale provided student participants with the statement "with enough time and effort I think I could significantly improve my intelligence level." All student responses for Items 5 through 8 required reverse scoring as recommended by the scale's authors, De Castella and Byrne (2015). All scores are given as values after the completion of the reverse scoring for Items 5 through 8. The table in Appendix L displays Item 5's range as containing selected values of 1 through 4. No student participant selected a response that would be associated with scores of 5 or 6. Forty percent of participants' responses corresponded to a value of 1. Students 2, 29, and 33 selected a response related to fixed mindset views. The small number of participants selecting a fixed mindset related value reinforces Item 5's alignment to growth mindset with a collective average of 1.97.

Item 6, "I believe I can always substantially improve my intelligence" resulted in student responses corresponding to values between 1 and 5. No student participant selected a response related to a value of 6. Eleven student responses, as shown in the table in Appendix L, were translated to a value of 2 forming the mode of Item 6. The mode was similar to that of the item's average, 2.3. While the average value of 2.3 is more closely related to a growth mindset than a fixed mindset, this relation is not as strong as the relation portrayed in items 5 and 1 whose averages were closer to 1.

The seventh item on the Revised Implicit Theories of Intelligence (Self-Theory) Scale asked participants to indicate how strongly they agreed or disagreed with the statement "regardless of my current intelligence level, I think I have the capacity to change it quite a bit."

After reverse scoring was applied to student participant responses, values of 1, 2, and 3 contained a similar amount of student participant responses. While the value of 1 was Item 7's mode with 10 responses, values 2 and 3 has 9 student responses each. Individual student responses can be found in the table in Appendix L. Ninety-three percent of participants selected a response that was related to growth mindset views.

The final item, Item 8, on the mindset scale provided student participants with the statement "I believe I have the ability to change my basic intelligence level considerably over time." Similar to item 7, 93% of participants selected a response that was considered to relate to a growth mindset; however, the mode of Item 8 was a response value of 2 after reverse scoring was applied.Examining the eight items as a collective group of 30 student participants resulted in means varying from 1.97 on Item 5 to 2.77 on Item 2. These mean values represented stronger connections to mathematical growth mindsets than to fixed mathematical mindsets. Figure 2 displays the percentage of student participants classified with each identified mathematical mindset.

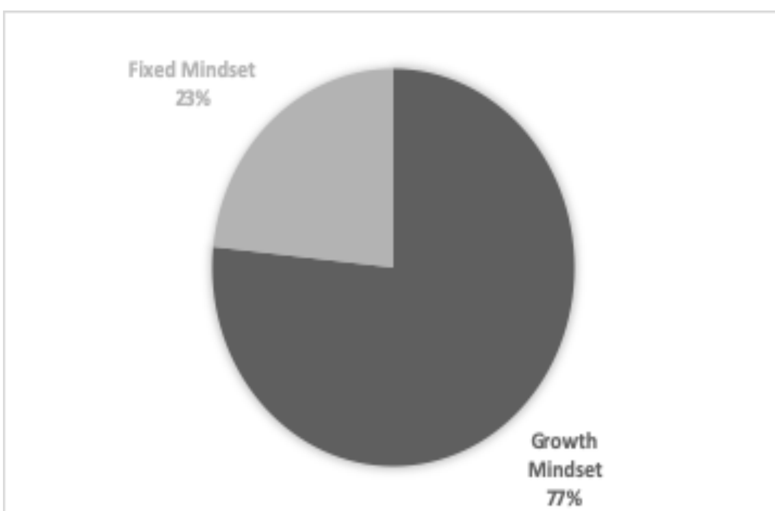

Figure 2. Student Participants Classified by Mathematical Mindset

Figure 2 illustrates the vast majority of students who possessed a growth mathematical mindset compared to the small minority of students classified as having a fixed mathematical mindset. The large percentage of student participants (77%) classified as having a growth mathematical mindset skewed the collective group data to reflect the perspectives and personal perceptions related to growth mathematical mindsets.

Presentation of Individual Interview Results

Individual interviews allowed the researcher to understand student perspectives and perceptions about factors and experiences that student participants believed contributed to their mathematical mindset at the time of the interview. Phase II of the study consisted of 10 individual interviews with student participants. The participants for this phase of the study also participated in the first phase of the study and were selected using stratified random sampling. The student participants were grouped by mindset after completing the Revised Implicit Theories of Intelligence (Self-Theory) Scale. Using previously assigned pseudonyms, 5 participants from each group were randomly selected for an interview. Students 2, 4, 26, 29, and 33 were selected to represent students with fixed mindsets while students 3, 18, 22, 39, and 47 were selected to represent students with growth mindsets. Each individual student participant provided the researcher with valuable insights about mathematical mindsets. These insights are detailed below.

Individual interviews varied in duration and length/word count. All student participants were asked the same four interview questions as detailed in Appendix H, Student Interview Questions. The duration of each interview and length/word count of each transcript directly depended on student participant responses and explanations. Table 7 “Duration and Word Count of Individual Interviews" displays the duration in minutes and word count of the transcript for each individual interview participant as well as any associated averages.

Table 7

Duration and Word Count of Individual Interviews

Duration and Word Count of Individual Interviews		
Interview Participant	Interview Duration (minutes)	Word Count
Student 2	19	2954
Student 4	12	2441
Student 26	16	3280
Student 29	8	1492
Student 33	10	1866
Student 3	9	1765
Student 18	7	1622
Student 22	11	2104
Student 39	7	1427
Student 47	12	2293
Average	11.1	2124.4

Student 2, a student participant classified as possessing a fixed mathematical mindset, had the longest interview duration of 19 minutes. An actively involved male student athlete, Student 2 defined himself as an individual who typically performs well in math classes and highly enjoys the subject. He defined himself as a student who excels due to self-interest, not due to being "pushed" or expected to perform. During the course of the interview, Student 2 was able to accurately identify his classification of a fixed mathematical mindset. When asked to think about factors and experiences that may have contributed to this mindset, Student 2 immediately cited teacher influence and prior experience in his response to interview question 3. He spoke of an educator who allowed for struggle when learning and working with new mathematical concepts. Concepts were not presented in a traditional manner by this teacher. He noted that students were required to find the process themselves. Student 2 explained that this style of teaching highlighted the process not the product, allowed him to remember and recall information more easily, helped him see his strengths in mathematics, and ignited his interest in the subject. In addition to talking about his teacher, Student 2 spoke of his family, specifically his siblings, a younger sister and autistic brother, who have not had the same success as he when reflecting on interview question 3. Student 2 compared his progress to that of his sister's for whom math "doesn't click" even with the same parents and educational track. Most profound was Student 2's discussion about his autistic brother. Student 2 explained that regardless of how hard doctors, therapists, and his parents have worked and the amount of effort and frustration his brother has had to endure, he felt there are concepts that his brother was not, is not, and will not be able to understand or work with. When asked a follow-up question by the researcher to interview question 3c, Student 2 stated " I think when you look at those different levels [of intelligence], it is clear that yeah, everyone can learn, but there are absolutely limitations to what can be understood and this makes learning easier or harder. Just because it is possible for me doesn't mean it is for my brother."

Student 3, a varsity cheerleader and gymnast with a challenging home life, described math, along with English, as her favorite subject. When asked about her feelings toward mathematics in interview question 1, Student 3 explained that "some days it'll [math] be really hard . . . but I always end up figuring it out and then it comes easier." The student participant continued to detail her ability to work through challenges. Reflecting on interview question 3b about prior math experiences, Student 3 spoke of how having an approachable teacher who encourages exploration is important as she is more likely to ask questions, enhancing her understanding. Student 3 continued to explain how in a previous math course the teacher appeared cold and would put students down, so she stopped asking questions. Student 3 spoke about the confusion she felt and how this confusion was reflected in lower than average scores. Student 3, during the course of her 9-minute interview, defined her mathematical mindset as growth when responding to interview question 2, which matched the results on her Revised Implicit Theories of Intelligence (Self-Theory) Scale. Student 3 was the only student who, when thinking about factors and experiences in interview question 3, connected her mathematical mindset to her sports. Student 3 stated,

> It's a lot like gymnastics actually. It requires determination. I'm not going to get a skill if I don't work for it. If I don't work at the math problem, I won't get it, so it's really effort—putting a lot of effort into it will push you forward.

Student 3 praised her coaches for instilling this perspective on and off the mats. Lastly, in response to interview question 4, Student 3 explained that her home life was challenging due to strained relationships but defined her mother as having had the biggest influence on her mindset development. Student 3 spoke of times her mom helped with homework, listened and tried to understand her school struggles, as well as never letting her settle for less than her best.

A 12-minute interview with Student 4, a female participant who enjoyed her role in multiple music-related activities, revealed a student with wavering mathematical confidence. This student spoke of a spotted academic past and never being "a superstar" after being asked to reflect on her feelings about math in interview question 1 and her prior math experience in interview question 3b. She spoke at length about moving from an honors level to college prep level course and that while it allowed her to experience more success in the lower level course, it made her question what she could and could not do in relation to math. Student 4 has not tried to move back up to the honors track. Student 4 was defined as having a fixed mathematical mindset according to the scale; however, Student 4 was the only student of the 10 interviewed that did not accurately identify her mathematical mindset type during interview question 2. While disagreeing with the results at first, after further explanation of each mindset, Student 4 agreed that she displays more qualities of someone with a fixed mindset than a student with a growth mindset. When questioned about experiences and influencing factors, Student 4 spoke of her 7th grade math teacher who made everything feel "new and different—it was exciting" in response to interview question 3a. Student 4 continued on to speak of her father, an accountant, who always pushed her to try harder in math and helped with homework. Of the factors, experiences, and people discussed, Student 4 felt her past experience in math courses had the biggest impact on her mathematical mindset as expressed in response to interview question 4.

Student 18, a self-proclaimed outdoorsman and soccer player was classified by the Revised Implicit Theories of Intelligence (Self-Theory) Scale and self-identified in interview question 2 as having a growth mindset. Student 18 felt his views of math were changed for the better by his 5th grade teacher when asked about his shifting views of mathematics in interview question 1b. For Student 18, this educator showed empathy and care, and helped students recognize that there are multiple methods for solving a problem. In the 7-minute interview, Student 18 also identified his relationship with his parents as influential in response to interview question 3a. He explained that his parents taught him "the more effort I put in the more I'll get out of it." The student participant's work ethic was extremely important to him and he made it clear that while he had support and encouragement both at home and school, he still had to “put my head down and work.” After reflecting upon interview question 4, Student 18 felt that parents and teachers, as well as working hard defined the factors, experiences, and individuals, that influenced his mathematical mindset.

Student 22, classified as having a growth mathematical mindset had an interview duration of 11 minutes. Student 22, a female junior, was involved in numerous extracurricular activities at the time of the interview including theater and band and held numerous leadership positions in these activities. In response to interview question 1 Student 22 described enjoying the black and white nature of computations and the ability to prove your methodology, leaving little room for interpretation. While she enjoyed math at the time of the interview, after reflecting on interview question 1 b, Student 22 explained that this was not always the case. She disliked math until reaching high school. When asked to think about factors and experiences that may have contributed to her mathematical mindset in interview question 3a, Student 22 recalled a teacher freshman year that showed her “if I try hard enough, I can get what I’m trying to get to.” This teacher helped her “own” her learning. Additionally, while continuing to reflect on interview question 3 Student 22 offered a distinctive perspective on the influence of leveling on learning. She spoke of not feeling “good enough for honors and that affected how I did and how I thought about it [concepts].” Student 22 explained that it took time and encouragement from teachers to realize that being in an honors class does not make you intelligent and being in college prep does not mean you are incapable of solving complex or challenging problems. Student 22 concluded that this lesson was most influential to her mindset when reflecting on the interview discussion in interview question 4.

Student 26 is an 18-year-old male who moved to the United States in 2016. English was a barrier during his freshman year of high school but is one he had nearly eliminated by the beginning of his junior year. Student 26 was a member of the high school swim team, held multiple part-time jobs, and enjoyed learning about and working on his car. This student explained that while math could be fun, he could find it confusing. He performed best when concepts were connected to previously learned methods and the world. Student 26 explained that this confusion leads to a distaste for math. When asked to define his mathematical mindset in interview question 2, Student 26 believed he possessed a fixed mindset which matched the results on his Revised Implicit Theories of Intelligence (Self-Theories) Scale. When reflecting on the factors and experiences that may have led to his fixed mindset in interview question 3, the first factor that came to mind was a teacher Student 26 had in his previous country. He spoke fondly of this teacher, an individual who put time and effort into making sure he understood. Student 26 stated that he has not since had as invested a teacher and has learned to memorize for testing, but quickly forgets concepts and processes after. This method of learning made the student appear bright in mathematics when he felt his understanding was minimal. Student 26 was the only student who provided insight on peer influence during his 16-minute interview in response to interview question 3a. The student participant explained that talking with friends about math can make his confidence waver. Student 26 stated "They make it sound like it's an easy class, that it's not a hard class. To me it's not true. It's a hard class to me and I feel like I can't talk with them about it." Student 26 continued to explain that he did not want his friends to think he was less intelligent and therefore did not seek their help.

Student 29 was a well-recognized female swimmer winning numerous races and state titles. In addition to performing well in swimming, the student participant competed for the high school track team and helped design the yearbook while holding a part-time job outside of school. During the 8-minute interview Student 29 expressed her distaste and dislike for math in response to interview question 1. Student 29's previous experiences had always included lots of struggle which began at a young age. She explained that she needs more time to understand concepts then the progression of the course allows. When reflecting on people who had contributed to her mathematical mindset, Student 29 spoke of teachers and parents accepting her struggles in math in response to interview question 3. She explained,

> I've had a couple of teachers give me extra help and say "I know that you're not really a math kid, and well, you're just going to have to work around it" but I still don't know what that is.

When speaking about parental support, Student 29 explained her mom had a similar experience with math in high school and because of this felt her mom was supportive and "not as hard on a math grade as she would be an English grade." Student 29 felt her interactions with teachers, parents, and her prior experience and feelings about math equally contributed to her fixed mathematical mindset.

Student 33 is a self-described academic loather who attends school for socialization. Outside of school, Student 33 enjoyed being with friends, taking advantage of newly found freedoms that come with having a driving license, working at her part-time job, and making trips into the city. During her 10-minute interview, the female student expressed continual frustration with math concepts since upper elementary school. She explained "since I struggle with it, I view it as being harder, and when it's harder I don't try as much as I should." Student 33's perception of her mathematical mindset aligned with the results on the Revised Implicit Theories of Intelligence (Self-Theories) Scale categorizing Student 33 as possessing a fixed mindset. This student participant was the only participant that did not speak about guardian influence when asked about what factors and experiences contributed to her mindset in question 3 but did speak of encouragement from her grandfather. She also spoke about teachers and wanting to improve her abilities when she felt the teacher was invested in her success. Student 33 cited prior mathematical experience, specifically feeling discouraged after receiving a poor grade on an assignment she perceived as working hard on, as a major influence on her mathematical mindset in interview question 4. Additionally, Student 33 believed that intelligence is something you are born with, and that this contributed to her fixed mathematical mindset as well.

Student 39's interview lasted 7 minutes. The female athlete and musician described her view of mathematics as varied. The student described her like of mathematics, or lack thereof, as dependent on the content being presented in response to interview question 1. Student 39 also stressed that although she may not enjoy a specific math lesson or concept, that does not mean she will not try her hardest. She continued to echo the sentiments of always trying her hardest in all four interview questions. A focus on perseverance and overcoming challenges directly connects to growth mindset, which the scale used in Phase I reported and the student self-identified with in interview question 2. While Student 39 was one of the shortest interviews in duration, she provided the researcher with valuable information about her perceptions on the factors, or individuals, that most significantly influenced her math mindset. In response to interview question 3a, which asked Student 39 about people in her life who may have influenced her views of mathematics, Student 39 credited her mom and teachers. The student's mother worked in a math related field and would frequently help with homework. Student 39 continued to share how her mother would casually check in to see how the student felt she was progressing and offer help if needed. Student 39 stated, "my mom always helped me understand math, which made me like it better." When reflecting on the impact of teachers, Student 39 spoke of teachers who made time to help her, checked her work, and offered extra support in and out of the classroom in response to interview question 3. While both her mom and teachers were influential, Student 39 felt her teachers had the biggest impact on how she felt, viewed, and approached math.

Student 47, the last student to be interviewed, was a male participant who did not participate in many school activities due to a demanding work schedule. Student 47's interview had a duration of 12 minutes during which this student shared that he did not mind attending school but could find it boring at times. He stated that math could leave him frustrated and that he would frequently give up on a problem and move to the next rather than trying to see it through to its completion. Student 47's Revised Implicit Theories of Intelligence (Self-Theory) Scale labeled this student participant as possessing a growth mindset. Upon hearing these results in interview question 2, Student 47 did not feel this was an accurate label or reflection for his mindset in math. This student wondered if he had had a successful day in his math course prior to completing the scale as "there's some moments where I have a growth mindset I guess, but it definitely is fixed most of the time." Student 47 felt if he had just had a successful class it may have altered how he interpreted and responded to the questions. Contrary to the majority of student participant interviews, Student 47 did not feel his parents helped shape his mathematical mindset. Instead, when responding to interview question 3a, Student 47 spoke about a lack of help at home. Similar to all other interviews, Student 47 did cite teachers as being influential in his mindset development, especially those who tried to help him improve. Student 47 took ownership in his actions and stated, "If I'm willing to do it, I'm willing to ask for the help, but sometimes I'm not willing to ask for help" and told the researcher that he knows he is his own biggest roadblock when reflecting on his mindset and its most influential factors and experiences in interview question 4.

Student 2, Student 4, Student 26, Student 29, and Student 33 represented students with fixed mindsets. Student 3, Student 18, Student 22, Student 39, and Student 47 represented students with growth mindsets. While each interview was conducted individually on different days, every student provided the researcher with valuable information about their personal perceptions on the factors and experiences that influenced the development of their mathematical mindset at the time of the interview. Student participants spoke of family support, teacher influence, pressure from peers, and their own attitudes. Commonalities and differences between the transcripts were coded, analyzed, and grouped into themes to be discussed later in Chapter 4.

Presentation of Interview Results Grouped by Theme and Mindset

In Phase II of the study, student participants were asked a series of four open-ended questions and presented with follow-up questions if needed as indicated in Appendix H, "Student Interview Questions." The interview questions resulted in students addressing their current feelings about mathematics, reflecting on their mathematical experiences, and identifying factors and experiences they perceived as influential to their mathematical beliefs and mindsets. As a result of the data collected from the 10 junior level public high school students enrolled in a college prep math course, three major themes were identified and are discussed in detail below. The three extrapolated themes are:

1. Teacher influence on a student's mathematical mindset
2. Influence of a student's prior mathematical experience on their mathematical mindset
3. Family influence on a student's mathematical mindset

The three above themes manifested as a result of student participant answers and discussions to the interview questions detailed in Appendix H. The details of the alignment of these themes across interview questions are outlined in Table 5, "Themes and Interview Questions Alignment," included below. Table 8 highlights the relationship between interview questions 1 and 3 to all three themes in addition to interview question 2's relation to only one of the themes, Theme 3.

Table 8

Theme and Interview Question Alignment

Theme and Interview Questions Alignment	
Theme	Interview Question
Theme 1: Teacher influence on a student's mathematical mindset	1a, 1b, 3a, 3b, 4
Theme 2: Influence of a student's prior mathematical experience on their mathematical mindset	1a, 1b, 3b
Theme 3: Family influence on a student's mathematical mindset	1a, 1b, 2, 3a, 3b, 4

Theme 1, a teacher's influence on a student's mathematical mindset, addressed student perceptions on the influence a teacher had on their view, beliefs, and mindset associated with mathematics. This theme emerged as students offered authentic and genuine perspectives and feelings about a variety of educators they had encountered throughout their educational experience and related it to their mathematical mindset at the time of the interview. Theme 2 examined the influence of a student's prior mathematical experience on their mathematical mindset. This theme materialized as students spoke of prior successes and failures, changes in attitudes, or specific experiences in prior mathematics courses. The final theme, family influence on a student's mathematical mindset, focused on student perceptions of family members' impact on their mathematical mindset through actions, language, and the family members' prior experiences with mathematics. Student participants defined family members, consisting of parents, legal guardians, grandparents, and siblings, as having had an influence on their mathematical mindset. These three major themes and their corresponding student data are discussed in detail below. Each theme is dissected in relationship to the responses of each student subgroup (e.g., growth mindset, fixed mindset).

Theme 1: Teacher Influence on a Student's Mathematical Mindset

Theme 1 emerged immediately based on the data collected from individual interviews with the student participants. This theme is presented first as 6 out of the 10 student participants (Student 18, Student 22, Student 26, Student 29, Student 39, and Student 47) identified teachers as one of, if not the only influential factor contributing to their mathematical mindset at the time of the interview. While Student 2, Student 3, Student 4, and Student 33 did not identify an educator as a top influence, all four of these remaining students did speak of teacher influence during their individual interview. Below, this theme is dissected using student responses in relationship to their mindset as determined by the Revised Implicit Theories of Intelligence (Self-Theory) Scale. While all students spoke of teacher influence, their responses varied based on their defined mindset.

Growth Mindset. Student participants defined as possessing a growth mindset spoke positively of prior and current (at the time of the interview) math educators. Student 3, Student 18, Student 22, Student 39, and Student 47 offered a student perspective on the importance of student-teacher relationships, the need to make learning “fun,” and a teacher’s desire to help their students.

Positive relationships with teachers were described by all five growth mindset student participants during their individual interviews. Student 3’s statement about relationships with teachers in response to interview question 3 best summarized the group’s thoughts and feelings. Student 3 stated, “I’ve always had good math teachers that I’ve been able to grow a relationship with, and I feel like . . . if you have a good relationship with the teacher you can like . . . learn better.” The student participants connected a positive relationship between teacher and students to increased understanding. Student 47 expanded this thought when answering interview question 4 by explaining “once I feel comfortable with a teacher, I’ll ask more questions.” These questions allowed Student 47 to “learn something from the teacher, which is usually better for me because I’m no longer just sitting through a class—it makes it not boring.” Student participants shared throughout interview questions 1, 3, and 4 that a relationship with a teacher not only enhanced their understanding, but also got them excited and engaged in their learning.

Students 18 and 39 spoke about teachers who made math “fun.” Whereas both individuals described educators at the study site, Student 18 also spoke of his 5th grade teacher and Student 39 reflected on experience with a 7th grade teacher. When answering interview questions, Student 18 stated, “my 5th grade math teacher, she made it a lot more fun to learn by how she would teach us.” This same student participant, during interview question 3, reflected upon his prior experience and the factors and experiences that made learning fun, asserting, “they’d [5th grade math teacher] throw in little games that we could do or puzzles to solve, being able to apply what we were learning made it more fun.” Student 39 had similar remarks, stating “I like the math teachers who make it [class] fun. I had one teacher who always used silly comparisons to explain equations. It always made me laugh and I never forgot the equations." While student participants' view of "fun" varied, they all described enjoyment of mathematics when in classes associated with the word.

Student 18, Student 22, Student 39, and Student 47 all described a math teacher who went above and beyond classroom instruction to help them as being influential to their mathematical mindset. Student 18 explained, "she'd pull you in if you needed the help. She wouldn't really give you the option—she wanted you to understand." Student 22 stated, "if a teacher is willing to teach and reteach it shows they care, they want to help you, and when a teacher wants to help me, I'm going to try more." Student 39 mentioned teachers' willingness to help multiple times during their individual interview. Student 39 summarized her feeling on teachers offering help when asked if she felt one factor or experience influenced her mindset more than others in student interview question four. She responded, "my teachers because they would just take the time out of their day. Even if they didn't have much time, they would just sit down with me and help me understand it more." Student 47 defined a "good teacher" as one who tried to help. A teacher who took time to offer individualized help, engaged the student by making learning fun, and developed a positive relationship with student participants was perceived by growth mindset participants as the most influential factors in the development of their mathematical mindset.

Fixed Mindset. Student participants defined as possessing a fixed mindset offered an alternate view to that of their growth mindset peers. The majority of these students, Student 4, Student 26, Student 29, and Student 33 described negative interactions with mathematics educators when discussing various factors they perceived as contributing to their mathematical mindset. Student 2 was the only student within this subgroup to speak positively of former and/or current math educators.

Student 4 described a middle school math teacher of whom she felt targeted her due to her lack of understanding. Student 4 described this individual as “cold” and “unwilling to help.” Throughout the interview conversation Student 4 did not describe a positive relationship with any teacher but focused on negative interactions that led to a dislike and disinterest in the subject. Similarly, Student 33 reflected on asking for help or clarification from a teacher. This student explained that if she still did not understand the concept or instruction after the second explanation, that her teacher would appear to be annoyed. Student 33 spoke of how she eventually stopped asking questions which led to confusion and a dislike of the class.

Students 26 and 29 quickly spoke of receiving help from some teachers but elaborated and fixated on negative feedback and lack of encouragement from others. Student 26 stated, “some teachers didn’t encourage me at all. They made me hate it [math] because they were like, “Yeah, it’s so easy, why can’t you get that concept?” and they would just explain it the exact same way as before.” Student 29 also spoke about the use of negative statements by previous math teachers. She explained, “I’ve had a couple of teachers give me extra help and say “I know you’re not really a math kid and well, you’re just going to have to work around it” but they wouldn’t help me find a way.” Both Students 26 and 29 admitted to struggling in math courses and seeking teacher help; however, they were met with sentiments that made them think poorly about their abilities rather than receiving the help they were searching for.

Student 2 was an outlier in the subgroup of fixed mindset student participants. Student 2 spoke positively about all of his teachers who he felt offered help, challenged him to think critically, and allowed students to “rediscover processes.” Similar to his growth mindset peers, Student 2 described teachers who made learning fun and desired to get to know him as a person rather than just a student.

Student responses related to Theme 1, teacher influence on a student's mathematical mindset, varied based on mindset classification. Students with a growth mindset spoke positively about their teachers, the relationships between them, engaging instructional methods, and the ability to seek and find help. Students defined as possessing fixed mindsets felt belittled by their math teachers. These particular students did not feel that the help they asked for and received was beneficial to their understanding and were quick to cite a lack of encouragement from their educators. While participant views varied, all 10 student participants, regardless of their mathematical mindset classification, perceived teachers as an important contributing factor to their mathematical mindset at the time of the interview.

Theme 2: Influence of a Student's Prior Mathematical Experience on Their Mathematical Mindset

Theme 2 emerged early when analyzing the data collected during individual student participant interviews. This theme is presented second as 5 out of 10 student participants (Students 4, 18, 29, 39 and 47) identified prior experience as a contributing factor to their mathematical mindset at the time of the interview. Student 4 defined prior experience in mathematics alone as the most influential factor in the development of her mathematical mindset. Students 18, 29, 39 and 47 perceived prior experience in addition to at least one other factor as having substantial influence on the development of their mathematical mindset. This theme is examined below using student responses in relation to student participant mindsets as determined by the Revised Implicit Theories of Intelligence (Self-Theory) Scale. While all students discussed prior math experiences during the course of their interview, perceptions of its importance and influence varied based on their defined mindset.

Growth Mindset. Participants defined as having a growth mindset at the time of their individual interview provided the researcher with a student perspective on the influence of prior mathematical experience and its relation to mathematical mindsets. Student 3, Student 18, Student 22, Student 39 and Student 47 spoke of an enjoyment of the subject, previous successes in math, and the connection between instruction and problem solving.

All growth mindset student participants had a favorable view and enjoyment of mathematics at the time of their individual interview. Only two students, Student 3 and Student 22, when asked to describe their feelings about math in interview question 1, responded that mathematics had always been their favorite subject. Student 3 proclaimed, “I’ve never had huge issues with math . . . some days it can be hard, like if it’s something new, but I always end up figuring it out.” Student 22 expressed their enjoyment with the subject and its “set way to do everything.” Reflecting on the same questions, Students 18, 39, and 47 expressed an enjoyment and like for mathematics at the time of the interview but reminisced on a time in which this sentiment was not the case. Student 18 reminisced on disliking math until reaching middle school. Student 18 described math as becoming “a lot of fun” making it “a lot easier for me to understand” when he reached fifth grade. His changed view of the subject allowed Student 18 to become engaged in his learning and sparked a curiosity for the subject. Similar to Student 18, Student 39 described varied feelings about mathematics as she progressed through school. Student 39 enjoyed specific content areas such as Algebra more than others, like Geometry, and while her feelings would alter, Student 39 stated, “I’m more of a math person than an English person” when explaining her connection and comfort with the subject. Finally, Student 47 reflected on a time when a math course “got way too hard . . . everything I learned I was a week behind everyone else.” This student was placed into a different (lower) level course and found substantial success with the subject. According to Student 47, math was “not my favorite, it’s not my least favorite [subject]”; however, he still found enjoyment in math courses.

Previous success in mathematics was discussed by all five growth mindset student participants during their individual interviews. Student 47 expressed an excitement for being able to connect numbers to problem solving. He exclaimed “it’s cool how all the numbers go into place and when you figure that out how those numbers go into place on your own it’s an awesome feeling, it’s like, “wow, I just did that!” Student 47 continued to explain that this sense of accomplishment stays with him as he progresses through more challenging concepts. This gave Student 47 the confidence to try more complex problems. Student 39 spoke similarly of overcoming a challenge, but through seeking out help and continuously trying to solve the problem. Student 39 reflected on the excitement she experienced when she finally reached the correct answer after multiple attempts. Student 39 stated “so I learned you just have to stick with it and if I do that, I’ll get to the answer.” While Students 47 and 39 focused on individual perseverance, Student 18 described a middle school teacher who introduced and instilled new study habits and note taking methodology. He stated that using these methods made it “easier for me to understand.” Student 18 used a building-block analogy to explain that once he understood one concept, he could begin working on understanding the next. Student 18 believed that being able to connect previous concepts to current content allowed him to achieve high marks in his courses. Student 18 attributed his ability to develop the necessary connections to his middle school experience.

Student 3 did not discuss connections between multiple math concepts; however she did speak of earning high grades in previous math courses. Student 3 felt she earned these grades through hard work and her study habits in and outside of school. Earning a “good” grade encouraged Student 3 to continuously try as prior grades were proof that she was capable. Student 22 offered a unique perspective as she reflected on the time when she did not get placed on an honors level track. She discussed how, while she still enjoyed math, she thought negatively about her abilities. Student 22 stated, “it was like a mindset of like, well I’m not good enough for honors.” Student 22 continued her thought reflecting on how this way of thinking began to affect her progress. It was only after having to seek extra help and earning a high score on a quiz that Student 22 “got back on track and began working hard.” While Student 22 was still not considered an honors math student at the time of the interview, she felt accomplished in her current course. Student 22 felt she worked hard to understand the concepts and got to “help my friends and kids in my class, which has been a lot of fun.” Student 3, Student 18, Student 22, Student 39, and Student 47 had different prior experiences and interactions with mathematics, but each of them identified a moment in time that provided them with motivation to try, apply, and achieve to the best of their ability.

Students 18, 22, and 47 reflected on the importance of forming connections in mathematics. Student 18, as discussed previously, talked about connections between concepts when explaining a building-block analogy. Student 18 stated that without connections concepts would become “abstract and confusing.” Students 22 and 47 individually discussed the importance of connecting mathematical concepts to the real world. Student 47 reflected on having “aha!” moments because of the application of concepts. Student 22 felt that seeing these types of connections made the concept more meaningful and provided more reason for understanding it. Student 18, Student 22, and Student 47 all credited part of their success to these connections.

Fixed Mindset. Student participants classified as possessing a fixed mindset at the time of their individual interviews offered an alternate view on the effects of prior mathematical experience on mathematical mindsets. Student 3, Student 4, Student 26, Student 29, and Student 33 provided the researcher with information about the student perspective on the influence of prior mathematical experience specifically as it related to negative feelings about one's mathematical ability, struggling with concepts, curriculum pacing, and the applicability of mathematical concepts.

Student 2 was an anomaly in the group of fixed mindset student participants, exclaiming, "I enjoy it [math] a lot. I think it's interesting . . . I think I'm good at it." A positive mathematical attitude was not a commonality among Student 2's peers. Students 4, 26, 29, and 33 expressed negative feelings about mathematics. These feelings were accompanied by memories of struggles left unaddressed and concepts not understood. Student 4 stated, "I haven't really been that great at math . . . I just feel like I'm not a superstar at math." She continued to talk about struggling to understand math concepts and eventually giving up. Student 4 explained she would try to continue on with her limited understanding, creating additional challenges in future concepts, confounding her confusion further. Similar to Student 4, when reflecting on his study habits, Student 26 spoke of confusion. He stated "I just memorize them [equations] and I go to the test, just list them because that's what I know. But I don't know what they are actually asking me to do." Student 26 knew the formulas but did not know how to apply them. This inability to use the equation led to frustration, confusion, and a distaste of the subject for Student 26. Student 29 echoed similar sentiments when she exclaimed, "I've hated math since I learned how to count . . . It doesn't come easy and I feel like I always have some sort of mental block." Furthermore, Student 33 also held negative associations with mathematics. She stated "math is one of my harder subjects. There's a lot of things [concepts] I struggle with in math." Students 4, 26, 29, and 33 all reflected on prolonged struggles and an inability to overcome them leading to negative mathematical perceptions.

Student 4, Student 26, and Student 29 discussed curriculum pacing in mathematics courses and their desire to get more time with concepts. These 3 students expressed the need for more time to further understanding and that this lack of time had led to a pattern of confusion and struggle. Student 4 reflected on how some classes "move very fast, so if you miss one concept it can set you behind, and then it makes me more confused." Student 26 reflected "it takes me a little more time than everybody. . . It makes me feel anxious about it because I can't keep up." Student 26 expressed that his anxiety stems from knowing he has to understand one concept to apply and learn the next. Student 29's perceptions furthered her peers' thoughts when she stated, "It takes me extra time to understand what's actually going on and then remembering it isn't easy either." Students 4, 26, and 29 all had a desire to understand concepts, but felt the pace of the curriculum inhibited their ability to do so.

Three of the 5 student participants classified as having a fixed mathematical mindset at the time of their interview spoke to the researcher about the applicability of the mathematical concepts they were learning. Student 2, Student 4, and Student 26 expressed the need to see connections between concepts and the real world. Student 2 described a former teacher who introduced math concepts through real world connections. Student 2 spoke about having to use the connection to discover the concepts, equations, and methods. He felt this teacher's instructional style differed from many others and he "wish[ed] more teachers would do that . . . it just made it all a natural progression and I would really remember it." Student 4 expressed that "it was kind of hard for me to see how equations and everything fit into each other. And then it was hard for me to enjoy the class because of that." When asked as a follow-up question by the researcher about enjoying classes in which Student 4 could see concepts connect to one another and the world outside of school, Student 4 exclaimed that those were the math classes she enjoyed most. Lastly, Student 26 stated, "I cannot connect them [concepts and equations] all together." Student 26 described the frustration he feels when the connection does not exist. When Student 26 gets stuck and does not recognize a connection he is more likely to give up and move on to something else. Students 2, 4, and 26 valued clear connections in their learning to solidify their understanding and increase their enjoyment of the subject.

Student responses related to Theme 2, influence of a student's prior mathematical experience on their mathematical mindset, varied based on the student participant's mathematical mindset classification. All 10 student participants spoke with the researcher in great detail about their prior mathematical experiences and its influence on their mathematical mindset at the time of the interview. While participants with both growth and fixed mindsets discussed their mathematical feelings past and current, previous successes or failures (confusion), and the desire for connection between concepts and the real world, their perspectives and perceptions varied widely.

Theme 3: Family Influence on a Student's Mathematical Mindset

Family influence on a student's mathematical mindset materialized as a theme when data analysis determined all 10 student participants spoke of a family member's influence, or lack thereof, during their individual interview. For the sake of this study and to keep the data analysis process transparent, family is defined to include parents/guardians, grandparents, siblings, and cousins. Four out of 10 student participants (Student 2, Student 3, Student 18, and Student 29) identified at least one family member as an influential factor contributing to their mathematical mindset. Student 4, Student 22, Student 26, Student 33, Student 39 and Student 47 did not identify family as an influential factor contributing to their mathematical mindset; however, all six of these remaining students spoke in depth about family during their interview. This theme is discussed in detail below using student responses in relation to their mindset as determined by the Revised Implicit Theories of Intelligence (Self-Theory) Scale.

Growth Mindset. Student participants defined as possessing a growth mindset at the time of the interview offered detailed descriptions of their family's involvement (or lack of) in their mathematics education. Student 3, Student 18, Student 22, and Student 39 provided a student perspective on the influence of family attitudes toward mathematics and family support/help at home. Student 47 was an outlier within the group and the only student with a growth mindset to not include family as an influential factor. When asked question 3a, relating to people who may have influenced the way the student participant looked at math, Student 47 responded "probably not my parents because I've sort of just done math homework by myself."

Four out of five growth mindset student participants spoke about their family's attitudes and feelings toward mathematics. Student 47, the aforementioned outlier, explained that his parents did not care for the subject. This was the only growth mindset student participant who associated his guardian with a negative mathematical perspective. On the contrary, Student 18 described his parents as individuals who enjoyed math and expressed a desire to follow in their footsteps. Student 18 dreamed of entering a career similar to that of his father who is a mechanical engineer at a premier laboratory. Student 18 explained "my dad also loves math" and "my parents always told me the harder you work the better you're going to do, and the better you do means you're growing, anything is possible with math." Similar to Student 18, Student 39 was raised in a home with a parent employed in a math-related career who offered positive support and encouragement. When asked to reflect on individuals who may have influenced her views of mathematics in question 3a, Student 39 expressed substantial influence from her mother, a chemist. Student 39's mother offered positive encouragement and spoke about the potential "doors math can open" if the student participant worked for "understanding versus just earning a really good grade, like an A." Student 3 also spoke fondly of a parent. This student's mother worked as a teacher, and consistently checked in with the student participant. She spoke of how her mother has told Student 3 about her own struggles in the subject but that her mother grew to enjoy math by the time she finished college. Student 3 explained "she put a positive spin on everything, like even when I was struggling with something in math, she'd tell me that once I'd get it, I'd be better off because I had to struggle." The majority of student participants provided information on family and their attitudes toward math; however, Student 22 did not provide the researcher with this same information. Student 22 did not speak about or discuss her family's attitudes toward math. The researcher did not prompt the student to provide information related to family attitudes as authentic, non-coerced responses were sought.

Three out of the four students who spoke about their family's mathematical feelings and attitudes also detailed their family's willingness to help. The three students, Student 3, Student 18, and Student 39, who described family members with positive feelings about mathematics were the same three students who described receiving help, support, and encouragement at home. When speaking about her mother, Student 3 stated, "she's always helped me with homework . . . she knows what it is like and she's always there to help me if I do need help." Student 3 explained that her mother was less focused on the grades she achieved and more concerned about her understanding and ability to apply concepts. Similarly, Student 18 described his father as an individual who "really helped me learn." He spoke of parents who encouraged him to try harder to grow his understanding and he received the support needed to do so. Additionally, Student 39 spoke fondly of her mother, an individual who “always helped me understand math.” Student 39 recalled many nights of receiving help from her mother on homework problems or learning new methods of problem solving because her mom saw her struggling with the method Student 39 has learned. Student 39 stated that these interactions did not always go smoothly, but that she was thankful her mother took the time to try and help. Student 22 did not describe her family’s mathematical attitudes; however, she did reflect on receiving help at home when struggling and having watched siblings receive math related help. Student 22 explained that seeing her sibling struggle and require help “has kind of shown me even if I think I’m not doing well, I’m doing better than I think I am. I mean, I guess everybody struggles at some point; I just have to push past it.” All four students who spoke of receiving help from a family member also discussed resilience and the desire to overcome challenges. These same four students, Students 3, 18, 22, and 39, emphasized family as a contributing factor to their mathematical mindset. The four students who identified this connection positively spoke of family attitudes and/or mathematical support from family members.

Fixed Mindset. Student participants defined as having a fixed mindset at the time of the interview provided insight on family involvement in their mathematics education. Student 2, Student 4, Student 26, Student 29, and Student 33 provided a student perspective reflecting on similar areas as their growth mindset peers including family mathematical attitudes as well as family members’ mathematical abilities. Each student offered valuable perceptions of how family was a factor in the development of their mathematical mindset.

Students 2, 26, 29, and 33 all spoke positively of family members; however, the positivity was different than that of their growth mindset peers, focusing on the acceptance of poor academic performance in math courses and negative feelings toward mathematics. Student 29 told the researcher that her mother sympathized with her because she too was “bad” at math in high school. In addition to this sympathy, Student 29 explained “she’s not as hard on a math grade as she would be an English grade.” Student 29 took comfort in her mother’s view of math grades as she explained, “I’m not as worried when I don’t do good on a [math] test.” Student 29 had determined what her mother defined as an acceptable grade and worked to achieve that value, never surpassing it. Likewise, Student 33 discussed a parent with negative views of mathematics who accepted struggle and lower math grades. While Student 33 has positive support through her grandfather, she explained that his help was sought because “my mom doesn’t get math, she’s bad at it too, so if I need help, I have to talk to my grandfather.” Student 33 shared that she does not always call her grandfather when she needs help because “I’d be calling, like, everyday” and “my mom knows I struggle, so it’s okay.” Students 29 and 33 spoke of family members who accepted poor math grades more readily and sympathized with the students’ struggles. Student 26 has a mother similar to the parents described by his peers, but also a father who demanded more. Student 26 discussed how his parents’ conflicting views of mathematics could make his confidence waver. Student 26 described a mother who understood and accepted his struggles because she too “performed poorly in math” and a mathematically talented father who “expects more than I can do.” Student 26 consistently questioned his abilities as he felt “sometimes they [mom and dad] make me suspect that I’m doing something wrong when it’s the complete opposite.” He spoke about how he did not like the conflict of these feelings and as a result avoided completing math assignments at home.

Student 2 offered a unique view about family and mathematical views. Student 2 briefly mentioned his parents as he focused on the struggles of his siblings. He noticed an “enormous discrepancy between what my math abilities were like when I was little . . . versus what my sister's were." Student 2 attributed his fixed mindset beliefs to these discrepancies in abilities and further explained "when we've looked at the way my parents have said the same thing, the way that [my sister] has been processing math compared to the way I was at the same age, it's just completely different . . . there are concepts even now that she just struggles to grasp." Additionally, Student 2 spoke of a severely autistic brother who could not "grasp basic concepts despite people having tried . . . he just doesn't get it." Student 2 felt his parents' effort, help, and view of math was the same for him and his siblings. Because his siblings could not process and achieve at the same level as Student 2, he believed knowledge and ability were innate traits that limited what some could achieve. When asked a follow-up question by the researcher asking if his parents would agree, Student 2 hypothesized that his parents "likely feel the same way—they definitely don't expect the same from my sister as they expect from me." Student 2 felt his parents held him to higher math expectations than his siblings, who encountered and experienced more struggles and challenges with the subject.

Student responses related to Theme 3, family influence on a student's mathematical mindset varied based on mindset classification. Whereas student participants with growth mindset and fixed mindset spoke positively about their families, their attitudes, support/help, and struggles the underlying messages associated with each were vastly different. Student participants with growth mindset spoke of individuals with positive views of mathematics and a desire to help the student understand. Student participants with fixed mindsets spoke of family members for whom math was also a struggle, low expectations in mathematics, and ability differences between siblings. Regardless of their mathematical mindset, all 10 student participants perceived family members as an important factor that contributed to their mathematical mindset as expressed during their individual interviews.

Conclusion

Although the three themes were presented individually, they are all aligned, connected, and share similar information about student perceptions of factors and experiences that contributed to their mathematical mindset at the time of the study. The themes were developed after coding interview data and identifying categories or themes to which the codes aligned. The three emergent themes, (1) teacher influence on a student's mathematical mindset, (2) influence of a student's prior mathematical experience on their mathematical mindset and (3) family influence on a student's mathematical mindset were developed to be inclusive of all student participants' thoughts and perceptions.

The next chapter, Chapter 5, relates the previously described data analysis to the study's research questions. Chapter 5 connects the results described in this chapter to the existing research and Dweck's (2000) mindset theory, which provided the conceptual framework for the research study. Research findings, conclusions, implications, and recommendations for future research are addressed in Chapter 5 as well.

CHAPTER 5

CONCLUSION

This researcher sought to understand and document junior level public high school students' perceptions of factors and experiences they believe contributed to their mathematical mindset. Through a mixed-methods approach to research, the study, conducted at a suburban Massachusetts high school. addressed the following research questions:

1. What factors and experiences impact the mindset associated with mathematics for junior level (e.g., 11th grade) public high school students enrolled in a college-prep level mathematics course?
    a. How do junior level (e.g., 11th grade) public high school students enrolled in a college-prep mathematics course describe the beliefs and attitudes that they feel contribute to their mindset associated with mathematics?
    b. What factors and experiences do junior level (e.g., 11th grade) public high school students enrolled in a college-prep level mathematics course believe influence their mindset associated with mathematics?

A total of 30 junior level public high school students enrolled in a college-prep mathematics course participated in Phase I, or the mindset scale portion of the study. Ten of these 30 student participants were randomly selected and participated in Phase II, or the individual interview portion of the study. The results of this study are summarized and explored for further understanding in this chapter. Recommendations for future action and further studies, as well as limitations are discussed. Conclusions drawn from the results of the research are presented at the end of the chapter.

Research Findings

The goal of this study was to understand what factors and experiences high school students perceived as having contributed to their mathematical mindset. Analysis of student participants' responses on both the mindset scale (Phase I) and individual interviews (Phase II) provided the researcher with three major themes that were thoroughly discussed in Chapter 4. The themes identified based on the student data were as follows:

1. Teacher influence on a student's mathematical mindset
2. Influence of a student's prior mathematical experience on their mathematical mindset
3. Family influence on a student's mathematical mindset

The three themes identified above directly correspond to this study's research questions. The themes are dissected and discussed using student participant responses in both phases of the study. By investigating and discussing the research finding using the students' voices, the researcher was successfully able to identify the student's described beliefs and attitudes contributing to mathematical mindsets as asked in research question 1a and student perceived influential mindset factors and experiences as asked in research question 1b. Results derived from research questions 1a and 1b allowed the researcher to conclude which factors and experiences junior level public high school students perceived as greatly impacting their mathematical mindsets as asked in overarching research question 1 and as identified in the three previously mentioned themes. The following section will discuss the research findings for each of the three themes in relation to the research questions and their connection to the literature.

Theme 1: Teacher Influence on a Student's Mathematical Mindset

The first and most significant theme to emerge from student data was the influence a teacher had on a student's mathematical mindset and like or dislike of the subject. Six out of 10 student participants identified teachers as an influential factor contributing to their mindset. The remaining four students did not identify educators as a top influence; however, all four of these remaining student participants spoke of teacher influence during their individual interview. Students with growth mindsets spoke of positive student-teacher relationships, the educator's desire to help the student succeed, and the ability to make learning "fun." On the contrary, students with fixed mindsets spoke negatively of their interactions with previous math educators, reflecting on unmet needs and dismissive remarks. This study supports statements reported by Beyranevand (2017) which concluded that successful and impactful instruction occur through effective implementation of pedagogy, planning, assessment, and relationships. Research findings echoed the importance of Beyranevand's (2017) teaching components as student participants discussed the importance of instructional strategies related to pedagogy, planning, assessments, and student-teacher relationships.

Pedagogy answers the question of how to teach (Klein, 2003). Planning involves the methods and implementation behind the "how" of teaching content. Dweck (2000) explained that the mindset of a student has the ability to control how the student perceives content and affects their ability to problem solve. This must be considered when planning and teaching. Similarly, data collected from student participants favored educators who made learning "fun" by incorporating a variety of instructional methods, including multiple methods of presentation and hands-on, or tactile learning. Many students, during their individual interviews, provided examples of lessons that met their needs and labeled these lessons as "fun." Students identified and desired educators who considered their individual educational needs and developed lessons and expectations that expanded knowledge. In addition, literature stated that how a teacher learns and chooses to teach can impact student outcomes (Boaler, 2013; Chazan, 2000; Haimovitz &

Dweck, 2017; Mosley, 2017). The data collected from student participants during the study supports the aforementioned statement found in literature.

Assessments, a third area necessary for effective instruction, are methods used to evidence student understanding or misconceptions (Lee, 2006, p. 43). Multiple methods of assessment introduce more variety into the classroom, allowing students increased opportunities for success. Dweck (2000) ascertained that an increased feeling of success from multiple methods of assessment can lead to new mathematical attitudes and mindset in students (p. 21). Dweck's (2000) focus on improvement of mindsets through increased successes was a recurring topic as student participants reflected on their prior mathematical experiences during their individual interviews and spoke of previous successes and/or failures. Students who spoke of success and overcoming challenges were associated with possessing a growth mindset while those who spoke of receiving poor marks or giving up possessed a fixed mindset.

Beyranevand (2017) stated "relationships with all stakeholders are an essential . . . aspect of education" (p. 69). Student participants reiterated this sentiment during student interviews as student-teacher relationships were an important topic of conversation for participants with both types of mindsets. Student participants with growth mindsets described learning environments and relationships with educators and provided perspectives that reflected conclusions found in previous literature. In this previous literature, Phelan et al. (1992) noted that a comfortable and safe learning environment that encourages growth and risk begins with interpersonal relationships (p. 698). Bandura (1971), Dweck (2007), and Vygotsky (1978) stressed the importance of positive relationships between teacher and student as these relationships result in students overcoming challenges. Similar to these remarks, each student participant spoke of a teacher who encouraged or discouraged their effort and perseverance in the classroom. Students who felt encouraged were able to advocate for meaningful help, thus clarifying their understanding. These students felt appropriately challenged and engaged in their learning. They formed a trusting relationship with the teacher. Students who described feeling discouraged cited teacher refusal of help or of receiving poor help. These students expressed feelings of helplessness, confusion, and at times anger. They gave up on themselves because they perceived their teacher already had. A positive student-teacher relationship was not established. Student participant data agreed with literature and emphasized the need for supportive messages from and positive relationships between students and teachers to increase student effort and mathematical self-confidence (Boaler, 2013; Dweck, 2007; Haimovitz & Dweck, 2017; Lee, 2017).

Theme 2: Influence of Students' Prior Mathematical Experience on Their Mathematical Mindset

An important result that was derived from student participant data was the influence of a student's prior mathematical experience on their mathematical mindset. Student interview questions 1 and 3 specifically asked students to reflect on their prior mathematical experience and as a result a vast amount of data was collected on the topic. Students with growth mindsets reflected on mathematical successes, overcoming challenges, and earning high marks. With the exception of one student participant, Student 2, fixed mindset student participants spoke of confusion, being placed on a "lower" (college-prep versus honors) mathematical track, and poor grades/performance. The data collected inferred that prior mathematical experience could predict current mathematical mindsets. The student perception found throughout this study mirrored the sentiments expressed in literature, which indicated that a student's previous interactions and prior experiences with mathematics are indicators for how a student will interact and perform with the subject in the future (Montt, 2011; Soni & Kumari, 2015).

Theme 3: Family Influence on a Student's Mathematical Mindset

Theme 3 materialized after data analysis determined all 10 student participants spoke of a family member's influence (or lack of) on their mathematical mindset during their individual interview. Students with growth mindsets spoke of invested family members who offered words of encouragement, spoke positively and optimistically about mathematical content, and frequently interacted with mathematics themselves (through career, enjoyment, or helping the student participant). In this research study, students with fixed mindsets predominantly spoke of family members who did not help with homework, accepted lower grades in mathematics courses, and sympathized with their student due to similar interactions and experiences with math. Student participants displayed similar thoughts, feelings, and actions toward math as their family members at home. This connection between family and a student's feelings about mathematics was also reflected in literature. Levy's (2011) statement that family members are "a crucial element in the development of children's attitudes towards learning" (p. 25), accurately depicts this study's findings as well. While the majority of student participants saw their family members as supportive, the difference in type of support received from family members was evident between mindsets. Students who possessed growth mindsets received support that included interaction (i.e., academic support) and offered encouragement and an underlying message of resilience or working harder. On the contrary, students with a fixed mathematical mindset received support that offered acceptance of their current abilities and poor performance as well as dismissive remarks about having to help or mathematics itself. For these student participants with fixed mathematical mindsets there were no supports offered by family members to encourage improvement or further understanding.

Bandura's (1971) Social Learning Theory and Vygotsky's (1978) Social Development Theory convey similar beliefs from their authors on how individuals learn. Bandura (1971) stated that individuals learn through direct experiences, interactions with others, and/or through observation (pp. 2–3). Vygotsky emphasized social interaction as a fundamental role in cognitive development explaining that social learning, or learning through experiences and interactions, precedes development. Students observe, interact, and socialize with their family members. These observations, interactions, and socializations allow the student to learn about their family member's beliefs, expectations, and desires resulting in motivators (or lack of) for students. The ideals presented by Bandura (1971) and Vygotsky (1978) rang true throughout the student data collected in this study. Students mimicked the sentiments of their family and knew their expectations. These expectations, regardless of how high or low, acted as motivators for the student participants influencing how a student would interact with and as a result perform in mathematics.

The researcher used mindset scales and individual student interviews to collect data in an attempt to begin to understand high school students' perceptions of factors and experiences contributing to their mathematical mindset development. Three themes emerged through the data analysis process and provided needed insight on the student perspective. Research findings associated with Theme 1, teacher influence on a student's mathematical mindset, supported statements and findings of Beyranevand (2017), Bandura (1971), Boaler (2013), Dweck (2000), and Vygotsky (1978), which emphasized the need for positive and supportive student-teacher relationships. Teachers have the ability to improve student mindset and understanding through the support and encouragement they offer to students. Theme 2 identified a connection between a student's prior mathematical experience and his or her current perceptions and beliefs about the subject. Montt (2011) and Soni and Kumari's (2015) previous findings provided similar perspectives with different populations. The crossover and replication of Theme 2 concepts found in multiple studies by various researchers highlights the importance of prior mathematical experience. Theme 3's research findings displayed the influence a family member can have on a student's mathematical mindset. Findings and literature agree that family is "a crucial element in the development of children's attitudes toward learning" (Levy, 2011, p. 25) and mathematics. The three themes discussed above further the findings and conclusions found in literature and continue to emphasize the importance and influential nature of teachers, prior mathematical experience, and family members on a student's mathematical mindset.

Recommendations for Further Action

The results of this research showed that mathematics educators and family members play influential roles in the development of a student's mathematical mindset. Mathematics teachers at the study site have had professional development on mathematical mindset and its implications; however, this did not guarantee an understanding of mindsets nor did it ensure the implementation of a wide variety of instructional strategies to reach all students, promote risk taking, and encourage growth. In addition, other education professionals, such as special education liaisons and paraprofessionals, who interact with students and work to improve their math understanding have not received training or professional development in relation to mathematical mindsets. The district in which the study took place has created messages for families regarding mindset through various forms of social media; however, not all families are aware of this content available to them and therefore have not interacted with it.

It is recommended that the school district seek out opportunities for training of mathematics teachers and staff members such as paraprofessionals and special education teachers who interact with students in relation to mathematics to increase understanding of the impacts and implications of both growth and fixed mindsets. Additionally, these training sessions should address methodology, instructional strategies, and language use to promote the development of growth mindsets associated with mathematics. Furthermore, it is recommended that the school district develop and implement a plan that communicates how and where family members can access information on mindsets and provides suggestions for helping their student achieve through mindset-focused strategies. These recommendations are based on the results of the mindset scale and student responses to interview questions 1 through 4. The data collected in this study showed a need in these aforementioned areas. These suggestions were developed in an effort to increase an understanding of mathematical mindset both in and outside of the classroom in an attempt to maximize positive outcomes associated with mindsets for all students.

Recommendations for Further Study

Educators at the study site had noticed a rapid shift in the mindset of students and the educational track to which they aligned. In addition, educators at the suburban public high school located in Massachusetts felt fixed mindsets had become prevalent among students in mathematics courses and as a result, students were quick to display behaviors of helplessness and avoidance (K. Doulamis, personal communication, December 15, 2018). As a result, there had been observable impacts to students' mathematical self-esteem, confidence, and ability to communicate their needs. The results of this study were valuable as they provided insight on the student perspective on factors and experiences that contributed to their mathematical mindsets.

Teachers at the study site believed fixed mindsets were becoming more prevalent among students in mathematics courses; however, data collected in Phase I of the study did not align with the teachers' perceptions. Of the 30 student participants who completed the mindset scale, 22, or 73% of student participants were identified as having a growth mindset while the remaining 8, or 17% of student participants were classified as possessing a fixed mindset. In addition to diverging from teacher perceptions of students' mathematical mindsets, these results did not align with results in literature which stated approximately half (50%) of all students possess a fixed mindset (Dweck, 2008a). A future study should examine the disconnect between what teachers are seeing in their classrooms and the results of student mindset scales. In addition, if conducted, the researcher of such a study may desire to use a different instrument to measure the mindset of students. The mindset scale used in this study was not directly connected to mathematics and could be used for any content area or to investigate an individual's overarching mindset. It is recommended that a future researcher find or develop a scale in which the questions or items specifically mention mathematics.

The results of this research study, while informative, identified areas that necessitate further investigation. During student interviews only 1 of the 10 student participants spoke about the impact of peer influence on their mathematical mindset. The lack of student perspective about peer relationships provided during the individual interviews did not validate nor disprove the importance of peer influence on mathematical mindsets. Instead, the lack of data related to student perceptions of peer influence on their mathematical mindset eliminated the ability to substantiate or disprove the literature, illustrating a need to investigate this area further.

This research study examined high school students' perceptions of factors and experiences contributing to their mathematical mindset development. The study focused on student mathematical mindset at the time of the study, their performance within the subject, and student beliefs of what contributed to their approach of the subject. The study did not extend outside the school building and did not investigate the implications of mathematical mindsets within the workforce. While most jobs obtained by high school students do not require high level thinking or skills, Soni and Kumari (2015) detailed that society requires individuals have a minimum level of mathematical competency required for employment (p. 159). Students obtaining jobs that involve calculating sales, handling money, or organizing data require mathematical knowledge. Research by Mallowset al. (2016) and Silverstein (2016) concluded an individual's opportunities become limited when math skills are lacking. Further examination of mindset and math skills in the workforce is needed to ascertain further conclusions about the implication of mathematical mindsets outside of school.

The population of the study was specific to one suburban public high school located in an affluent community and therefore the results may not relate to public high school students in poorer or more diverse communities. To increase understanding of the factors and experiences that students perceive as influential to their mathematical mindsets, additional studies that replicate this study are needed. Only 8.6% of the student population at the study site was considered economically disadvantaged (Massachusetts Department of Elementary and Secondary Education, 2019). The national average of economically disadvantaged students is nearing 50% (U.S. Department of Education, 2016), a value substantially higher than that of the study site. Conducting the study in a school with a socioeconomic status closer to the national average may yield varying results necessitating further investigation.

The methodology selected and designed by the researcher was implemented to act as a catalyst for additional mathematical mindset conversations and studies. Multiple methodologies were available to the researcher and are readily available for further study. If the study were to be conducted again, the researcher may want to alter the methodology to incorporate focus group discussions with students in addition to or in place of individual interviews. “Focus group discussion is used as a qualitative approach to gain an in-depth understanding of social issues . . . through interactive discussion of a topic” (Nyumba, Wilson, Derrick, & Mukherjee, 2018, pp. 20 & 25). Focus groups would allow peers to engage with one another, extending the conversation past the original remarks obtained in individual interviews and potentially leading to further understanding of mathematical mindsets.

A limitation of this study discussed later in chapter 5 was the age of the study’s sample. The study focused strictly on junior level students enrolled in a college prep level mathematics course. Student participants ranged in age from 16 to 18 years old; however, the range of ages within a high school containing grades 9 (freshman) through 12 (senior), typically 14 to 19 years old, is much larger. A younger freshman may offer insight into different perceptions just as an older senior student may as well. Because the age/grade of students was a limiting variable within the study, information and perceptions from high school students of other ages/grades is unknown. A future study that works with students of varying ages and grades may help fill this void.

Well known researchers Dweck (2000) and Boaler (2013) promote the theories of fixed and growth mindsets. In addition, they state that the type of mindset a student holds has the ability to be changed, regardless of age. This study illuminated factors and experiences students perceived as contributing to their growth or fixed mathematical mindsets. Armed with this new knowledge additional studies that introduce positive influences more frequently and eliminate negative influences in an attempt to change fixed mathematical mindsets are needed to begin developing strategies to help educators encourage this positive change and influence on math education.

Limitations

Significant limitations related to the size and population of participants existed. The study was limited to the perceptions of participants in one suburban public high school. While the participants reflected a representative sample of the study site, the demographics and socioeconomic status of the participant group limits the applicability of results. The majority of student participants for this study came from middle class Caucasian families. Factors such as prior experience and family members' influence, and the perceived influence of each of these factors, were likely affected by students' race and socioeconomic status and may not be identified in the same manner for students who identify as other races or hail from a different socioeconomic background. Finally, the study surveyed and interviewed only junior level (11th grade) students. These students are at the midpoint of their high school careers. The thoughts and perceptions of these students may not apply or relate to students in other grades or of other ages.

Conclusion

The goal and purpose of this study was to understand high school students' perceptions about factors and experiences that contributed to their mathematical mindset and may have encouraged the formation of one type of mathematical mindset over the other. Junior level public high school students enrolled in a college-prep level math course were approached and offered the opportunity to share their perceptions as participants in this study. To gather data and understand the student perspective, the researcher utilized two data collection instruments: a mindset scale and individual interviews. The data collected from these instruments resulted in the emergence of three themes: the importance of teacher influence on a student's mathematical mindset, prior experience's influence on a student's mathematical mindset, and family members' influence on a student's mathematical mindset. The data collected revealed a need for positive student-teacher relationships through the use of encouraging language and engaging lessons. Additionally, the data illuminated a need for positive support and optimistic language at home. Whereas student participants provided the researcher with numerous thoughts about factors and experiences related to their mathematical beliefs and mindsets, the data showed the three themes related to teacher influence, prior experience, and family influence were most important. These factors and experiences helped or harmed the development of growth mindsets within students. Fortified with this information and a new understanding on the student perspective, school district leaders must begin having conversations. These powerful conversations have the ability to bring about meaningful change through the factors and experiences students perceive as most influential to promoting the development of mathematical growth mindsets.

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APPENDIX A: EMAIL/ COMMUNICATION TO PARENT/GUARDIAN ABOUT STUDY AND CONSENT

Dear Parent/Guardian,

My name is Jaclyn Vitale. I am a math teacher at your child's High School. I am working on my Doctoral Degree in Education at the University of New England. I am working on a study that is designed to discover the factors and experiences students believe impact the development of their math mindset.

Mindsets are the beliefs and attitudes students hold about learning. They are an important part in students experiencing success. As teacher, I want all students to experience success, especially in math. The desire to understand what students believe prevent or promote their success in math led me to my study. I also want to bring student voices into research. Information students provide may help improve teaching methods and learning activities to better meet students' needs.

I cannot gain this important information without talking to students. Attached is a Consent for Participation in Research form. This form explains my study, its purpose, how the study will be handled and other information. If you are willing to have your student participate in this study, please sign and return the consent form by [date—two weeks from sent]. Participation is voluntary. Your child will have the ability to choose to participate or not. You may return the signed consent form to me electronically by email. Or, a printed copy can be delivered to me by your student and placed in the locked box in the back of room 213.

Should you have any questions, please contact me by email (jvitale@une.edu) or phone (978-***-**** ex 5554). I look forward to working with your child.

Thank-you,
Jaclyn Vitale
Mathematics Educator
UNE Ed.D Student

APPENDIX B: PARENT/GUARDIAN INFORMED CONSENT FORM

UNIVERSITY OF NEW ENGLAND
CONSENT FOR PARTICIPATION IN RESEARCH

Project Title: Student Perspectives on Mathematical Mindset Influences

Principal Investigator: Jaclyn Vitale

Introduction:

- Please read this form. You may also request that the form be read to you. The purpose of this form is to give you information about this research study, and if you choose to allow your child/ward to participate and document that choice.

- You are encouraged to ask any questions that you may have about this study, now, during or after the project is complete. You will have two weeks to decide whether or not you want your child to participate. Your child's participation is voluntary.

Why is this research study being done?
Your child is being asked to participate in a study. This study is designed to discover what factors and experiences students believe influence their math mindset. It will also look at their beliefs and attitudes about math. Your child is being asked to participate because they are a junior who is currently enrolled in a college-prep math class. This information may help to improve instruction and success in students.

I am a math teacher at the study site. I am the researcher of this study. This study is being conducted as part of my degree program at the University of New England.

Who will be in this study?
Junior students currently enrolled in a college-prep level math course are able to participate in the study. Students whose parents/guardians have given consent will be assigned a pseudonym or value (e.g., Student 1). Using these pseudonyms or values, thirty students will be randomly selected by a random number generator to complete a mindset scale. The researcher will identify the students through the coded list. Ten of these thirty students will be selected for individual interviews.

What will I be asked to do?
Your child may be asked to take part in a mindset scale and/or an interview. The mindset scale is a series of eight statements. It is used to determine their math mindset. For example, your child will be given the statement "I don't think I personally can do much to increase my intelligence" and asked to respond on a scale ranging from strongly disagree to strongly agree. Students will

complete the scale individually with the researcher. The mindset scale will take about 10 minutes to complete. It will take about 15–30 minutes for the individual interview. Students will take the scale during their school study block. The interview will occur during your child's school study block. This will minimize, if not eliminate, any interruptions to their education.

Interviews will be audio recorded and transcribed. All audio recordings and written or typed notes will become property of the researcher. All information and documentation will be stored in a secure location. Notes, transcriptions or documentation not being used or needed will be cross shredded and destroyed.

Should your child withdraw from the study at any time or for any reason, all your child's data will be destroyed and not used.

What are the possible risks of taking part in this study?
The study poses little risk to your child. Unintended negative outcomes that result from participation in the study are limited. The mindset scale and/or interview questions may involve mild discomfort. Discomfort can occur when individuals are asked to think about or reflect on their feelings and experiences. If at any time during either activity, your child is uncomfortable or does not want to answer a question, they may skip the question. Your child can stop taking the scale. Your child can stop the interview.

What are the possible benefits of taking part in this study?
There are no direct benefits for the subject participating in this study. There may be an indirect benefit to others, the school, and math curriculum.

This study has the potential to improve the quality of teacher instruction and understanding about students' math mindset. This may lead to future professional development opportunities and further success for students.

What will it cost me?
Your child will not receive any financial compensation, gift, reward or academic credit for their participation. Participation in this research will not cost anything.

How will my privacy be protected?
Your child's identity will be treated as confidential. This means no one will know your child's responses. Results of the study may be published but will not give your child's name nor include any identifiable references or information; however, any records or data obtained as a result of your child's/ward's participation in this study may be inspected by the persons conducting this study and/or by the University of New England's Institutional Review Board, provided that such inspectors are legally obligated to protect any identifiable information from public discourse,

except where the disclosure is otherwise required by law or a court of competent jurisdiction. These records will be kept private in so far as permitted by law.

How will my data be kept confidential?

Data will be stored in password-protected files on my lap-top computer. Pseudonyms will be used in place of all student names on all documentation. This includes data collected from the mindset scale and interviews.

What are my child's rights as a research participant?

- Your child's participation is voluntary. Your child's decision to participate will have no impact on their current or future relations with the University.
- Your child's decision to participate will not affect their current or future relationship with the researcher or their school.
- Your child may skip or refuse to answer any question for any reason.
- If your child chooses not to participate there is no penalty to them. They will not lose any benefits that they are otherwise entitled to receive.
- Your child is free to withdraw from this research study at any time, for any reason.
    - If your child chooses to withdraw from the research, there will be no penalty to them. They will not lose any benefits that you are otherwise entitled to receive.
- You will be informed by e-mail of any significant findings developed during the course of the research that may affect your willingness to allow your child to participate in the research.
- If your child sustains an injury while participating in this study, their participation may be ended.

What other options do I have?

- You may choose for your child not to participate.

Whom may I contact with questions?

- The researcher conducting this study is Jaclyn Vitale. I am also a math teacher at the study site.
    - For more information regarding this study, please contact Jaclyn Vitale at 978-***-*** ex 5554 or at jvitale@une.edu
- If you choose to participate in this research study and believe you may have suffered a research related injury, please contact Dr. Heather Wilmot at hwilmot@une.edu

· If you have any questions or concerns about your rights as a research subject, you may call Mary Bachman DeSilva, Sc.D., Chair of the UNE Institutional Review Board at (207) 221-4567 or irb@une.edu.

Will I receive a copy of this consent form?

- You will be given an electronic copy of this consent form. It will be sent by e-mail. Please provide your email address below.

Parent/Guardian e-mail address

Parent's/Guardian's Statement

I understand the above description of this research and the risks and benefits associated with my child's participation as a research subject. I agree for my child to take part in the research if they assent to do so voluntarily.

____ ______________________

Parent's/Guardian's signature Date

____

Parent's/Guardian's Printed name Child's /Ward's Printed name

Researcher's Statement

The Parent/Guardian named above had sufficient time to consider the information, had an opportunity to ask questions, and voluntarily agreed for their child/ward to be in this study.

____ ______________________

Researcher's signature Date

____

Printed name

APPENDIX C: EMAIL/ COMMUNICATION INVITATION TO STUDENT FOR STUDY PARTICIPATION

Dear Student,

My name is Ms. Vitale. I am a math teacher at your high school. I am working on my doctoral degree in education at the University of New England. I am working on a study that is designed to discover the factors and experiences students believe impact the development of their math mindset.

Mindsets are the beliefs and attitudes students hold about learning. They are an important part in students experiencing success. As teacher, I want all students to experience success, especially in math. The desire to understand what you believe prevents or promotes your success in math led me to my study. I also want to bring student voices into research. Information you provide may help improve teaching and learning activities for students.

I cannot gain this information without talking to students. Your parent/guardian has already learned about my study. They have agreed to allow you to participate if you choose. Your participation is completely voluntary. Attached is an Assent for Participation in Research form. This form explains my study, its purpose, how the study will be handled, and possible benefits along with other information. If the study is one in which you are willing to participate, please sign and return the assent form by [date—two weeks from sent]. You may return the signed assent form to me electronically by email or bring a printed copy to room 213. There will be a locked box in the back of the room for you to place your form in.

Should you have any questions, please contact me by email (jvitale@une.edu) or phone (978-***-**** ex 5554), or stop by room 213. I am excited to work with you!

Thank-you,

Ms. Vitale
Mathematics Educator
UNE Ed.D Student

APPENDIX D: STUDENT ASSENT FORM

UNIVERSITY OF NEW ENGLAND
ASSENT TO PARTICIPATE IN RESEARCH

Project Title: Student Perspectives on Mathematical Mindset Influences

Principal Investigator: Jaclyn Vitale

Introduction:

- I am Ms. Vitale. I am a math teacher at your high school. I am doing a research study. Your parent or guardian has said that you can take part if you want to. You don't have to take part if you don't want to.

- Please read this form. If you like, the form can be read to you. This form gives you information about the study. If you decide to be in the study, this form will also show that you voluntarily made that choice.

- Please ask any questions that you want about this study. You can ask them now, during the study, or once it is complete.

- You will have two weeks from the date you are invited to participate in this study to decide whether or not you want to be in the study. Remember, it's your choice to be in the study, you don't have to be in it.

Why is this research study being done?

This study is being done so I can better understand the factors and experiences you believe have impacted your math mindset, or how you think about, feel about, and approach math. By listening to your thoughts, ideas, and stories, I can get a better idea about why you feel the way you do about math. This information might help to make educators more aware of mathematical mindset influences to help improve instruction and allow for more success for students. You are being asked to participate due to your current grade level (junior in high school) and because you are currently taking a college-prep level math course. I, Jaclyn Vitale, a math teacher at the study site, am the researcher of this study. This study is being done as partial fulfillment of my doctoral degree program at the University of New England

Who will be in this study?

Junior students currently enrolled in a college-prep level math course are able to participate in the study. A sample of these students currently taking a college-prep level math course will participate in the study. Students with parent/guardian permission through a consent form were assigned a pseudonym/value (e.g., Student 1). Using this pseudonym/value thirty students were randomly picked by a random number generator to complete a mindset scale for the first phase of the study. You were chosen as one of these thirty students. If you choose to participate in this study, you will need to sign an assent form. If you do not want to be part of the study, another student whose parent/guardian has given permission through a consent form will be randomly selected. After all thirty students have taken the mindset scale, students will be placed into two groups based on their mindsets. Five students from each group will be randomly chosen for individual interviews.

What will I be asked to do?

You may be asked to take part in a mindset scale activity and/or an interview. The mindset scale is a series of eight statements used to determine if you have a fixed or growth mindset in math. For example, you will be given the statement "I don't think I personally can do much to increase my intelligence" and asked to respond on a scale ranging from strongly disagree to strongly agree. The mindset scale will take approximately 10 minutes to complete. The mindset scale will be given during your study block in lecture hall 1 in the high school. You will complete the scale individually with the researcher. Instructions for the mindset scale will be read to you by the researcher. The items on the scale can be read to you. If you are selected to participate in an interview and you are willing to do so, the interview will take approximately 15–30 minutes. The interview will be in a private conference room at the high school. The interview will take place during your study block. This will minimize any interruptions or distractions to your academics.

Your interview will be audio recorded and electronically translated so I can read what you said. All audio recordings and written/typed notes will become property of the researcher, so the information you share can be used in the study. All information and documentation will be stored in a secure location. Notes, transcriptions, or documentation not being used or needed will be cross shredded and permanently destroyed.

You can stop participation in the study at any time. If you do, all the information you shared will be destroyed and will be not be used or examined further.

What are the possible risks of taking part in this study?

There are little risks for participating in this study. The mindset scale and/or interview questions may involve mild discomfort. Discomfort sometimes happens when you are asked to think about or reflect on your feelings and experiences. If at any time during either activity, you feel uncomfortable or do not want to answer a question, you may skip the question. You can stop taking the scale. You can stop the interview.

What are the possible benefits of taking part in this study?

There are no direct benefits. There may be an indirect benefit to others, the school, and the math curriculum. This study has the potential to improve the quality of teacher instruction and understanding about students' math mindset. This may lead to future professional development opportunities and further success for students.

<u>What will it cost me?</u>
You will not receive any money, gift, reward or academic credit for participating. This study will not cost you anything.

<u>How will my privacy be protected?</u>
Your identity will be treated as confidential. This means no one will know your responses. Results of the study may be published but will not give your name and will not include any identifiable information.

<u>How will my information be kept safe?</u>
Data will be stored in encrypted, or password-protected files on the researcher's personal password-protected laptop computer. Pseudonyms, or a different name used in place of your own, will be used for all student names as well as the for the name of the school on all documentation, including data collected from the mindset scale and interviews.

<u>What are my rights if I decide to be in the study?</u>

- Whether you are in study is up to you. You can choose to take part, or not to take part. Whatever you choose is fine and won't help or hurt your current or future relationship with the University or the people doing the study.
- Your choice whether or not to take part will not affect your relationship with the researcher or your school.
- You can skip or decide not to answer any question for any reason.
- If you don't want to take part in the study, nothing bad will happen. You will not lose any benefits that you are otherwise entitled to receive.
- You can change your mind and stop being in this study at any time, for any reason.
    - If you do stop being in the study, nothing bad will happen. You will not lose any benefits that you are otherwise entitled to receive.
- By email, I will tell you if I learn anything important that may make you change your mind about being in the study.
- If you get hurt while being in this study, I may take you out of the study.

<u>What other options do I have?</u>

- You may choose not to be in the study.

Whom may I contact with questions?

- The researcher conducting this study is Jaclyn Vitale, a mathematics teacher at your school.

  - For more information regarding this study, please contact Jaclyn Vitale at 978-***-**** ex 5554 or at jvitale@une.edu

- If you take part in this study and think you may have been hurt by the study, please contact Dr. Heather Wilmot at hwilmot@une.edu.

- If you have any questions or concerns about your rights while taking part in this, you may call Mary Bachman DeSilva, Sc.D., Chair of the UNE Institutional Review Board at (207) 221-4567 or irb@une.edu.

Will I receive a copy of this assent form?

- You may request a copy of this assent form. Copies of assent forms will be electronically sent to your school email account.

Participant’s Statement

I understand what this study is for, and I understand that my parent or guardian has said I can be in the study if I want to. I also understand it is my choice, and I don’t have to be in the study if I don’t want to. I do want to be in the study.

____ ____________________

Participant’s signature Date

____

Printed name

Researcher’s Statement

The participant named above had sufficient time to consider the information, had an opportunity to ask questions, and voluntarily agreed to be in this study.

____ ____________________

Researcher’s signature Date

____

Printed name

APPENDIX E: REVISED IMPLICIT THEORIES OF INTELLIGENCE (SELF-THEORY) SCALE

National Mentoring Resource Center (NMRC)
Measurement Guidance Toolkit
Ready-to-Use Measures

DOMAIN: Academics
OUTCOME: Growth Mindset for Intelligence
MEASURE: Revised Implicit Theories of Intelligence (Self-Theory) Scale

The following questions are exploring students' beliefs about their personal ability to change their intelligence level. There are no right or wrong answers. We are just interested in your views. Using the scale below, please indicate the extent to which you agree or disagree with the following statements.						
	Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly agree
1. I don't think I personally can do much to increase my intelligence.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
2. I can learn new things, but I don't have the ability to change my basic intelligence.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
3. My intelligence is something about me that I personally can't change very much.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6

4. To be honest, I don't think I can really change how intelligent I am.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
5. With enough time and effort I think I could significantly improve my intelligence level.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
6. I believe I can always substantially improve on my intelligence.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
7. Regardless of my current intelligence level, I think I have the capacity to change it quite a bit.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6
8. I believe I have the ability to change my basic intelligence level considerably over time.	◻ 1	◻ 2	◻ 3	◻ 4	◻ 5	◻ 6

The full measure can be found here. A shorter 3-item version that includes only the items referring to fixed views of intelligence can be found in Dweck's book, *Self-theories: Their Role in Motivation, Personality, and Development*, or here.

APPENDIX F: SCRIPT FOR ADMINISTRATION OF THE REVISED IMPLICIT THEORIES OF INTELLIGENCE (SELF-THEORY) SCALE

Good Morning & Welcome!

I want to begin my saying thank-you. Without your willingness to be here and honest answers, I would not be able to complete my study. Today you'll be taking the Revised Implicit Theories of Intelligence (Self-Theory) Scale. This scale, created by De Castella and Byrne, is used to determine your mindset through a series of eight items/questions.

I will hand you a photocopied version of the scale and assign you a number. I ask that you please write this number, not your name, at the top of the page and do your best to respond to all eight questions honestly in relation to math as scores can be calculated only for the scales in which all eight questions are answered. Your responses to each question will be based on the extent to which you agree or disagree with the item/question. You'll have six different choices to select from that range from strongly disagree to strongly agree. The scale is at the top of the page for your reference. Please know there are no right or wrong answers. The questions are intended to help you reflect on your beliefs about your ability to change your intelligence level. You may have the scale items read to you.

Once you have completed the scale, please turn it in to me. I will use the scoring system created by De Castella and Byrne to score your scale and determine your mindset. Once all scales have been completed, I will group your responses into two categories and randomly choose five students from each category to participate in an interview. I will make you aware of your results during this interview. If you are not selected for an interview but wish to know your results, I am willing to share these with you once all interviews are completed. Please come find me for such.

While you have already read and signed the assent form, I would like to read through it one more time.

READ ASSENT FORM

If you no longer wish to participate or have any questions, please let me know

TIME FOR QUESTIONS

I will now pass out a copy of the Revised Implicit Theories of Intelligence (Self-Theory) Scale to you. Please try your best to answer all questions honestly and in relation your math experience. Please make sure you write your assigned number and not your name on the top of the paper. Thank-you!

APPENDIX G: STUDENT EMAIL/LETTER FOR INTERVIEW SELECTION

Dear (student name),

I am excited to let you know that you were one of ten students randomly selected to participate in phase two of my study. This phase includes one individual interview. Questions will relate to your math experiences, feelings, and beliefs. This interview will help me understand the important factors and experiences that you believe have contributed to your math mindset. During this interview, you will find out your results from the Revised Implicit Theories (Self-Theory) Scale. Please know that your confidentiality is important to me. Your name and any identifying factors will not be used when discussing the study or sharing results.

Participation in this phase of the study is still voluntary. If you no longer wish to participate, please let me know as soon as possible so another student can be selected to take your place.

I have scheduled your interview for [date] at [time] in [location]. You do not need to bring anything with you. If this time does not work for you and you still wish to participate, please let me know and we can schedule a day and time that better fits your schedule. The interview will take approximately 30 minutes.

If you have any questions or concerns, please let me know. I look forward to learning from you.

Ms. Vitale
Mathematics Educator
UNE Ed.D. Student

APPENDIX H: STUDENT INTERVIEW QUESTIONS

1. How do you feel about math?
   a. What do you believe makes you feel this way?
   b. Have you always felt this way about math? Why? (If not, what changed?)

2. You previously took the Revised Implicit Theories of Intelligence (Self-Assessment) Scale. This scale was used to determine your current mindset associated with math. There are two types of mindsets—growth mindset and fixed mindset. Students with growth mindset feel their intelligence can be changed. They believe hard work, effort, and perseverance improves achievement. Students with fixed mindsets believe their intelligence is a trait they were born with. They believe their intelligence can only develop to a certain point as they grow and learn. What do you believe the Scale labeled your mindset (growth or fixed)?
   a. Why do you believe this is your mindset?
   b. The scale tells us you have a __________ mindset.
      i. (result different than student thought) This result is different than you expected, why do you think the scale is reporting this result?
      ii. (result same as student thought) This results matches your expectations. What led you to believe you have a _______ mindset?

3. I'd like to know and understand your thoughts and perceptions about your current math mindset. What do you believe influenced or shaped how you think about and approach math both in and out of school?
   a. Are there people in your life who influence the way you look at math?
      i. If so, who are they and how/what kind of influence did they cause?
   b. Have your past math experiences influenced how you view math today?
      i. If so, how?
   c. Are there other factors or experiences that have contributed to how you view/approach math?

4. We've talked about a lot of different factors and experiences that you believe have contributed to your current mathematical mindset over the course of this interview. Do you feel there is one (or more) of these factors or experiences that had more influence than another?

APPENDIX I: STUDENT INTERVIEW PROTOCOL

Thank you so much for meeting with me, (student name). I know that you have little free time and I thank you again for choosing to spend some of it with me today. I am excited to talk with you and learn about your thoughts on the factors and experiences that you believe have contributed to your mathematical mindset. To help with my note taking, I will be recording the interview. I am doing this because it will be impossible for me to write down all the important information you will share and I want to make sure your thoughts are heard. The only individuals who will have access to these recordings and my notes are faculty advisors, dissertation committee members, and myself. The recordings will be deleted within one calendar year of our meeting today.

Thank you for submitting the signed assent form. I want to remind you that all of the information you share is confidential, your participation is voluntary, and you may stop the interview at any time.

Your name and your school's name will not be used in the report. If you talk about a specific student or staff member during the course of this interview, please do not use their real name or other identifying information (e.g., parent's name, age, teacher, etc.). You can use a pseudonym for the individual and/or general role to describe their relation (e.g., teacher, mother, sister, classmate, etc.).

As a teacher here, it is important for me to say that during this interview I am acting as a doctoral student and researcher and am not here to be a disciplinarian. This interview should only last approximately 20 minutes I will ask you several questions that may include clarifying or following up questions relative to your answer or the original question asked. There are no right or wrong answers. I only ask for your honesty. You can skip any question. You can stop the interview at anytime.

Interview transition questions:

1. Before we get started, do you have any questions for me about the study?
2. I was hoping you could tell me a bit about yourself to help me understand you better such as your age, grade level (junior correct?), gender, interests and activities.

End of Interview:

Thank-you once again for taking the time to meet with me. I know you are very busy, and I appreciate you making the time to meet with me and providing me with thoughtful, reflective, and honest responses.

As you are aware, I have recorded this interview. I want to give you the opportunity to review your transcript if you wish to. This is not a requirement of your participation but does allow you the chance to make sure that your thoughts, beliefs, and message was properly recorded. Would you like to review your transcript? (If yes, present the student with digital copy of transcript; if no, continue with script).

If you have any questions in the future or are curious to what the study finds, please feel free to email or find me and ask. Thank-you once again and have a great rest of your day.

APPENDIX J

INTELLIGENCE SCALE RESULTS FOR STUDENTS WITH FIXED MINDSETS

The Revised Implicit Theories of Intelligence (Self-Theories) Scale Results for Students with Fixed Mindsets

Student	Item 1	Item 2	Item 3	Item 4	Item 5*	Item 6*	Item 7*	Item 8*	Average
2	4	5	3	3	4	4	4	2	3.63
4	3	5	3	3	3	3	3	4	3.38
25	2	4	4	5	3	3	3	1	3.13
26	4	5	5	4	3	4	3	3	3.88
29	3	3	5	5	4	4	2	1	3.38
42	2	4	3	3	3	3	3	3	3
33	4	4	4	5	4	5	5	4	4.38
Mean	3.14	4.29	3.86	4	3.43	3.71	3.29	2.57	3.54
Median	3	4	4	4	3	4	3	3	3.38
Mode	4	4	3	5	3	3	3	4	3.38

*reverse scoring applied

APPENDIX K

SCALE RESULTS FOR STUDENTS WITH GROWTH MINDSETS

The Revised Implicit Theories of Intelligence (Self-Theories) Scale Results for Students with Growth Mindsets

Student	Item 1	Item 2	Item 3	Item 4	Item 5*	Item 6*	Item 7*	Item 8*	Average
1	2	4	3	1	1	1	1	1	1.75
3	2	2	2	2	2	2	2	2	2
5	1	2	1	1	1	1	1	1	1.13
6	1	1	1	1	1	1	1	1	1
8	3	3	1	1	1	2	2	1	1.75
10	2	2	2	2	1	2	3	2	2
13	3	2	2	1	2	2	2	2	2
14	1	2	1	1	1	1	1	2	1.25
15	2	3	2	2	1	2	1	1	1.75
16	2	3	2	3	2	3	3	3	2.63
18	1	2	1	2	2	2	1	1	1.5
20	2	2	2	2	1	1	1	1	1.5
22	2	1	2	1	2	2	2	2	1.75
24	1	2	2	1	1	1	1	1	1.25
27	1	2	2	1	2	2	2	2	1.75
28	1	3	1	2	1	1	1	1	1.38
30	2	4	3	1	2	3	3	2	2.5
31	3	2	4	2	1	3	2	2	2.38
37	2	2	3	2	1	2	1	2	1.88
39	2	2	2	2	2	2	2	2	2
44	2	2	2	2	2	2	3	2	2.13
47	3	3	3	2	3	3	2	1	2.5
Mean	1.86	2.32	2	1.59	1.5	1.86	1.73	1.59	1.81
Median	2	2	2	2	1	2	2	2	1.75
Mode	2	2	2	2	1	2	1	2	1.75

*reverse scoring applied

APPENDIX L

SCALE RESULTS FOR ALL STUDENTS

The Revised Implicit Theories of Intelligence (Self-Theories) Scale Results for Students

Student	Item 1	Item 2	Item 3	Item 4	Item 5*	Item 6*	Item 7*	Item 8*	Average	Mindset
1	2	4	3	1	1	1	1	1	1.75	Growth
2	4	5	3	3	4	4	4	2	3.63	Fixed
3	2	2	2	2	2	2	2	2	2	Growth
4	3	5	3	3	3	3	3	4	3.38	Fixed
5	1	2	1	1	1	1	1	1	1.13	Growth
6	1	1	1	1	1	1	1	1	1	Growth
8	3	3	1	1	1	2	2	1	1.75	Growth
10	2	2	2	2	1	2	3	2	2	Growth
13	3	2	2	1	2	2	2	2	2	Growth
14	1	2	1	1	1	1	1	2	1.25	Growth
15	2	3	2	2	1	2	1	1	1.75	Growth
16	2	3	2	3	2	3	3	3	2.63	Growth
18	1	2	1	2	2	2	1	1	1.5	Growth
20	2	2	2	2	1	1	1	1	1.5	Growth
22	2	1	2	1	2	2	2	2	1.75	Growth
24	1	2	2	1	1	1	1	1	1.25	Growth
25	2	4	4	5	3	3	3	1	3.13	Fixed
26	4	5	5	4	3	4	3	3	3.88	Fixed
27	1	2	2	1	2	2	2	2	1.75	Growth
28	1	3	1	2	1	1	1	1	1.38	Growth
29	3	3	5	5	4	4	2	1	3.38	Fixed
30	2	4	3	1	2	3	3	2	2.5	growth
31	3	2	4	2	1	3	2	2	2.38	Growth
33	4	4	4	5	4	5	5	4	4.38	Fixed
37	2	2	3	2	1	2	1	2	1.88	Growth
39	2	2	2	2	2	2	2	2	2	Growth
40	1	2	2	1	2	3	3	2	2	Growth
42	2	4	3	3	3	3	3	3	3	Fixed
44	2	2	2	2	2	2	3	2	2.13	Growth
47	3	3	3	2	3	3	2	1	2.5	Growth
Mean	2.13	2.77	2.43	2.13	1.97	2.33	2.13	1.83	2.23	
Median	2	2	2	2	2	2	2	2	2	
Mode	2	2	2	2	1	2	1	1	1.75	

*reverse scoring applied