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Mathematical Identity Formation: Preparing Students with Learning Disorders for Post-Secondary Education and Careers

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DePaul University

College of Education

MATHEMATICAL IDENTITY FORMATION: PREPARING STUDENTS WITH LEARNING DISORDERS FOR POST-SECONDARY EDUCATION AND CAREERS

A Dissertation in Education
with a Concentration in Curriculum Studies

by

Ravi Anil Shah

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Submitted in Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

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ABSTRACT

Formation of identity for individuals engaging in mathematical study influences the utilization and value of the subject matter. In curricular studies surrounding mathematics, a need for research pertaining to the development of mathematical identity for students with learning disorders continues to exist. In this transformative design study, a questionnaire-style instrument created for quantitative data collection provides detailed information about students with learning disorders and their identity formation related to achievement in mathematics. The quantitative aspect of this study helps to understand mathematical identity formation by analyzing levels of Confidence, Motivation, Anxiety, and Career Interest. The results show a statistically significant correlation between all four of these categories. Further investigation of the data presents differences between male and female gender groups when comparing levels of Confidence and Anxiety. The quantitative data analysis procedures inform the qualitative narrative and thematic data analysis of journal entries that were completed by the same sample of students with learning disorders. This secondary analysis shows a correlation between Confidence and both Career Interest and Anxiety. The results of this transformative design study, involving both quantitative and qualitative sources of data, positively contribute to scholarship surrounding mathematical identity formation for students with learning disorders, and how this identity can influence plans for post-secondary education and careers related to mathematics. The results of this study implicate the importance of positive mathematical identity development to create overall access and equity for students with learning disorders.

Keywords: mathematics curriculum, mathematical identity, learning disorders, gender, post-secondary education, careers, equity

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Achieving a personal goal is directly influenced by the supportive individuals that have played a part, even in the smallest ways. Each of these individuals has made an impact that has led me to this accomplishment. The influence I may now be able to make in the field of education is because of this achievement. I hope to also positively guide the individuals I encounter moving forward.

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And to my wife – for your patience, care, support, and love – Rakhi, I could not have done this without you. Our partnership and teamwork makes life better with each day. Thank you.

DEDICATIONS

To those who dare to be different:

It is from our differences that we create our world,

Different thoughts, ideas, lives,

Seek out ways to bring your differences

To the conversation, to education,

Be heard.

And be loud when you tell your story and where you come from because

Difference is your biggest strength.

CHAPTER 1:

THEORIZING MATHEMATICS CURRICULUM & REDEFINING DIFFERENCE

The experience of receiving formal education has an impact on forming an individual's traits, values, and identity. As an educator, it is vital to consider the influence each curricular decision can make in creating a positive environment for students. The vision is to cultivate a school environment where individuals are trusting educators to help them navigate through learning experiences in a supportive manner. In regards to learning, educators have the ability to help students understand content based on their previous understanding or skills, approach to learning, and learning achievement levels. When educators understand students' learning styles and make up a school environment, students can reach their highest potential because they are taught how to bring out their best qualities. With this understanding, students can learn from an educator who has their best interests in mind. The strengths of their learning styles are given attention, and this leads to an overall positive experience in the classroom.

The values of education presented through instruction in a mathematics class can help develop the importance of mathematical knowledge for real-world applications. Current instruction allows students to learn mathematical skills and topics of mathematics; however, there is little influence on the development of the use of these skills. The cultural capital that students bring to the classroom environment can help connect content to experiences, making the learning of mathematics applicable outside of the classroom. When students are receiving a mathematics education, they are often not given the opportunity to make personal connections to the content they are learning in the classroom. It is suggested that learning mathematics based on past experiences can influence the role of mathematics in future experiences. The level of this influence is based on the value that students give to the education that they are receiving (Seah &

Peng, 2012). In the United States, mathematics education is dependent on standardized tests and preparation for higher-level courses. However, certain students do not adequately understand the subject to fit these standardized methods of learning. In turn, students who do not plan for a career field related to mathematics do not find value in learning mathematics content. When taking into consideration the values that each student brings to the classroom to approach the teaching of the subject, even mathematics education can become one that influences the development of student experiences in schooling, transforming it into a mathematical education that is applicable outside of the schoolhouse.

Teaching mathematics has an integral place in schooling in our current educational system. It is a subject area that is given importance by most K-12 schools, some of which require students to take mathematics throughout twelve years of schooling. The curriculum that is presented to students allows for learning various topics within mathematics, even during the high school years. Current pedagogical practices require students to learn facts, memorize formulas, and simply use numbers to solve for one final correct answer. Many historical decisions have ultimately led to this approach to teaching mathematics. Events throughout time, especially at the turn of the twentieth century, have led to this rote approach to learning mathematics. Educators often must come to terms for how to present this material so that it is applicable to students' lives, while also covering the required amount of content. Educators are forced to be less creative when teaching mathematics, with the focus put on raising scores and reaching standards.

What is the role of mathematics in the cultivation of an individual's contribution to society? Why is it important to make certain all members of our world are developing their ability to think mathematically? The current issue related to mathematics curriculum is students' inability to find importance in learning the subject, especially if they are not considered high performers. However, with the dependency on technological changes and the economic advancements that individuals can make with a strong math background, an effective presentation of mathematics education is more important now than ever. Decision-makers throughout time have used situations in the real world at the time to determine the mathematics education students should receive. Past decisions that have remained influential could be less applicable in today's society and the changing world. A broader look into the role of mathematics education influencing our students and providing tools that can lead to positive changes in society leads to an examination of how mathematics can be more connected to the issues in our world. This can help to bridge the gap between learning basic facts and applying the mathematics that is learned. All students, no matter what social or cultural background they may come from, can use mathematics to benefit the world in which they live. Reevaluating the decisions that have been made for how math education should be presented in schooling is a necessary step to help connect mathematics to students' roles in society. Explanations help support the idea that mathematics education can be used as a tool of equity so that students from various backgrounds have the means necessary to compete in a world that is filled with opportunities in the fields of mathematics.

An effective way to bring about change in the presentation of mathematics curriculum is to include connections to students' lives. There are many issues around the world that directly influence our students; an understanding of how mathematics can be used in a global sense can lead to an appreciation of the subject matter. As students leave schooling in order to fulfill their roles in society, it is important that they have a strong set of mathematical skills so that they are able to confidently engage in global issues, evaluate data, and use their skills to make positive changes. Suggestions on how educators can introduce pedagogical practices so that students are able to develop this engagement with math skills and real-world issues help to clarify the connection, and grave importance, of math in the real world. The accessibility to mathematics for all learners leads to the utilization of the subject matter for post-secondary education and career opportunities.

Addressing Problem of Practice

Educational theory has the potential to frame research when studying a particular problem of practice. Teaching mathematics to various students at the high school level has led to the obvious conclusion that the subject matter is challenging and competitive in nature. Potential value that can be created towards the subject is constrained by the negative experiences in learning mathematics, especially for students who have learning disorders. These students build specific perspectives surrounding the subject of mathematics, and the constant testing and standardization culture strays specific students away from pursuing career fields related to mathematics. Students who struggle with the subject should have access to effectively learn the powerful potential of utilizing mathematics as a tool in their future lives, rather than question how mathematics may or may not be used in their future lives. Finding ways to make this potential known for students with learning differences can play an important role in re-framing any negative experiences with the subject matter.

Robert Heiner (2010) explains that the social experiences we come across in our day-to-day interactions lead to a reflective process involving differing viewpoints. Challenging these viewpoints is a natural response, leading to the creation of what is considered a social problem. Wanda Pillow (2003) further explains social policies set by policyholders are related to the construction of social problems. Individual discourses can lead to the policy options that develop through critical thinking, helping individuals think about how society can function so that people can feel confident about the ways in which they solve issues at hand. This process has an effect on the school practices, social constructs, positionality, and experiences that adolescents come across as a student, impacting the overall formation of their identity.

The phrases “learning disorders” and “learning differences” are used to describe the group of individuals that are included for the purpose and focus of this study. While “learning disorders” refer specifically to the neurological diagnoses that impact student learning, “learning differences” is used in a broader context to also describe individuals who approach the context of learning different than what is considered typical. This area of research is important for learners who do not mold to the set expectations in a learning environment. For this reason, the research presented and goals of the study are important for students with learning differences – to include all learner types. Although the sample for this study includes individuals with diagnosed learning disorders, the research conclusions presented are important for all students with learning differences. This terminology is used at the research site to shift the focus of this significant research need towards all individuals who learn differently.

Mathematical deficiencies or neurodevelopmental disorders such as developmental dyscalculia, issues of working memory, language-based disorders, or processing speed, may affect student ability to learn mathematical skills like problem solving and arithmetic processing. These neurological differences may influence the formation of identity reflective of overall mathematical skill. The identity may mark a negative sense of self, leading to an unmotivated state of mind when engaging in mathematical studies or choosing to pursue a field related to mathematics. The transition of schooling from elementary to high school level classes can be challenging for students. The curiosity and questioning of the content taught in schools becomes a part of the daily learning experience. The assessment and accountability measures that are used in our current system of education, however, serve specific people to create an unequal educational experience for students with learning disabilities and reduce employment opportunities (Apple, 1992; Geary, 2011; Grotlüschen et al., 2016). Specifically in relation to learning mathematics, memorization and quick facts are used to assess students of their mathematical knowledge rather than an attempt to connect mathematics to areas of interest and applications that are personally important (Bynner, 1997; Lane & Conlon, 2016). Increasing student success in mathematics based on standardized assessments, especially in a competitive world surrounding Science, Technology, Engineering, and Mathematics (STEM) fields, has become a focus for many schools (Geary, 2011; Rosenberg-Lee et al., 2015).

As students are making decisions towards their college and career paths, those diagnosed with learning disorders that affect their mathematical thinking, such as developmental dyscalculia, are at a disadvantage. Based on standardized assessment measures, individuals with these specific learning disorders are labeled as weaker mathematics students, leading to negative experiences and an overall disinterest in the subject matter (Apple, 1992; Butterworth et al., 2011; Wadlington & Wadlington, 2008). The numeracy issues that impact both children and adults hold them back from developing a stronger mathematical competency that can be helpful in being successful in career fields related to mathematics, even though these issues are not attributable to intelligence (Bynner, 1997; Geary, 2011; Rivera-Batiz, 1992). The various other strengths and levels of intelligence students have that could lead to careers in fields related to mathematics are overlooked by the early failures in the subject matter, which may create a decline in motivation to pursue these fields (Apple, 1992; Geary, 2011; Grotlüschen et al., 2016; Lane & Conlon, 2016; Rivera-Batiz, 1992). The history of curriculum and the decisions that have been made in setting up specific assessment expectations for students does not take into account the students who learn differently due to their learning disorders (Ansari, 2008; Apple, 1992).

An apparent need exists in understanding the mathematical learning experiences of students living with learning disorders. Research related to this topic can help impact the pedagogical decisions that are made by educators and developers of curriculum for learning mathematics. The importance also lies in allowing students with developmental dyscalculia, who may or may not have formal diagnosis of the disorder, to develop and use strategies that allow them to be successful in high-school level math courses. **This research study aims to show connections between students with learning disorders and their identity formation in relation to achievement in math-related subjects and fields, in an attempt to understand the experiences that may have led to this identity formation. The researcher will explore what meaning students with one or more identified learning disorders ascribe to their overall confidence, motivation, and anxiety in high-school level mathematics at a small independent school in Chicago.** The researcher's relationship with the school has been established as a lead mathematics teacher of the department. The subjects that were targeted for enrollment in this research are current and past students at the high school, some of who have previously taken or are currently in the researcher's classes. Through questionnaire responses and document analyses of journals, the purpose of this transformative research project is to find patterns or indications of the interest that students with learning disorders have in future roles that involve the use of mathematics, whether this includes college major choices or career field interests.

In current societies, one in four adults are negatively affected by mathematical incompetency (Butterworth et al., 2011; Rosenberg-Lee et al., 2015). The impact of this research can help students make progress in mathematical subject matters that are related to their career interests, rather than being placed into lower levels of mathematics that impede their ability to take part in career fields that require knowledge and skills related to mathematics. The rationale for taking part in this study is to understand the shared experiences of students who face learning disorders when studying high school level mathematics and how teachers can take advantage of helping these students apply mathematics to their career interests. Other specific learning disorders, such as dyslexia and dysgraphia, have specific intervention techniques in place to help teachers work with students in developing important skills. However, there is still a gap of research on the topic of mathematical learning disorders. This research project has potential for helping school leaders and educators with curricular decisions surrounding mathematics education including high school math teachers working with students that face difficulty in learning mathematics. In order to help these students with learning disorders be more successful, it is important for educators to be able to teach mathematics in a way that supports access and equity related to choosing future career fields that require knowledge of mathematics.

Theoretical Perspectives in the Study of Curriculum

Theory allows us to re-think the ways in which we view the world around us. We can go through daily educational experiences trying to serve the larger goals of society to perpetuate inequalities – or we can make an influential impact by utilizing theory as a powerful means to reframe our mindset to understand and engage the world around us (Levinson, 2011). The goals of curriculum and its formation in the way we currently use it, especially mathematics curriculum, have been influenced by historical decisions. For society today, a critical theoretical lens helps us to question why certain structures hold their place. When making important curricular decisions, theory helps to make *informed* decisions based on areas of society that are unequal in nature. The utilization and purpose of theory, therefore, is to answer why certain structures have determined how we think about curriculum and its true role and purpose in education (Schiro, 2008). Identifying theoretical explanations in the world of education has become an important process, engaging both personal and professional aspects of our participation in the field. The function of theory in identifying current curricular practices, including the problems of practice, is extremely important in providing explanation for the systems we have in place. In the scholarly world, theoretical perspectives help to challenge and alter identities; the experiences we have in our personal lives help to inform beliefs and ways of thinking that impact us professionally.

Becoming theoretical is an important task for scholars involved in thinking about curriculum. Influential theorists and supporters of education have provided perspective to help support the value of becoming theoretical as an integral aspect for the development of society. Their ideas can be constantly questioned and ever changing as our world and its perspectives evolve. Curriculum plays an important role in formulating the education-related experiences that students face through schooling. However, it important to note that education does not occur only through schooling, and that curriculum does not include only the materials and pedagogical decisions related to content. Curriculum is a much larger system, defining the characteristics of our societal structures. Curriculum helps to explain the purpose of education and what is worth knowing in order to make positive changes (Schiro, 2008). The fundamental inequalities that exist in our world are influenced by important decisions that are made particularly to provide continuity to systems and structures. As we think about the role of curriculum and education, it is important to realize the potential of questioning the status quo, what we may be accepting as normative practices.

Path to Current Position

As we think about the influence of theory and our interactions with various theoretical perspectives, it is important to acknowledge the changes that occur to the formation of our own identity. Elizabeth St. Pierre (2001) explains the importance of personal experience and its effect in forming theoretical perspectives. We must maintain our own theoretical perspectives as we think of what others offer. The construction of self is a critical process, and theory helps to give explanation to our own ways of thinking and experiences. However, it is more important to acknowledge that other perspectives may exist, and that an understanding of intersectionality plays a role in this acknowledgement. Each individual in society brings their experiential perspective to the forefront of their theorizing process. Understanding that this process is different for each individual is essential. Applying this mindset allows to experience a transformation in ways of thinking.

In our roles as educators, we must take an understanding of theory and its relationship to our practice. In *Beyond Critique: Exploring Critical Social Theories and Education*, Brian Levinson (2011) states that the misunderstood definition of theory is believed to pertain to things that may not actually occur in our world. Levinson (2011) explains, however, that theory and practice should work hand-in-hand. Particularly, utilizing critical social theories can help to understand the world around us, and approach creating change towards the inequalities that exist. He frames the perspectives of different theorists, such as Karl Marx with theories influencing overall capitalism and Pierre Bourdieu’s connection of postmodern feminism to practice. These important critical social theories help to understand how practice does in fact influence the theoretical lens that can be used by educators when reflecting upon others’ experiences.

Mathematics has been an integral subject matter in the student learning experience. Pioneers of curriculum have determined what is deemed necessary to learn in order to gain a complete educational experience, and learning mathematics has served the nation's agenda to teach specific skills to students in order to be successful in life after schooling. As an avid supporter of education and schooling to serve as an all-rounded experience, my decision to pursue the field of education began with a simple goal in mind. Mathematics is a challenging subject matter for most students, and a number of reasons are used to pacify the negative experience of learning mathematics – due to multiple attempts and often failures in trying to effectively learn the subject matter. Initially, my goal to teach mathematics came with finding simple ways to explain concepts that were viewed as being too difficult to learn. I enjoyed school as a young student. I took it upon myself to make learning a hobby, making it aware to my teachers that I was happy to learn. My love for being in school went past the extracurricular activities and recess. I formed relationships with my teachers to show them that I valued the educational experiences and their positive influence. These childhood experiences positioned my perspective on teaching as a profession, and they gave me insight into the potential influence of being an educator.

My current position as an educator for marginalized students labeled by diagnoses of learning disorders has helped pave the way to focus on the importance of scholarship and research as it relates to issues of inequity. Teaching mathematics to students with learning differences has revealed an important epistemological perspective. The potential of mathematics being used as a tool for equity requires a shift in theoretical viewpoints. Theory plays an important role in viewing the current issues in education. It helps to challenge the practices that are utilized when curriculum is developed, and our personal experiences help formulate ways of thinking when approaching situations in our professional roles (St. Pierre, 2001). As educators, our identity goes through a transformation while interacting with various theoretical perspectives, which help influence our own positionality and its place within a much larger system. My own experiences have brought me to comprehend myself in terms of theory (St. Pierre, 2001). As I have experienced teaching mathematics, I have found an importance in applying theory to ways of thinking in order to formulate important scholarship towards creating equality. Reflecting on my experiences has allowed me to realize the importance of theorizing to create change in my role as an educator.

In thinking about the various experiences that are acquired throughout a teacher's career, the cultural and social aspects of society are often not given chance for reflective measures. The ideologies that develop and permeate throughout curriculum development have aspects of social practices that are put into play. These aspects of culture and society then lead to the development of educator ideologies that are used in the classroom. The practices implemented in the classroom are teacher-developed, but the consciousness that surrounds the various decisions that educators make to use in day-to-day pedagogy are influenced by the policies put in place for educators to follow.

Intersectionality allows us to think about the various perspectives and experiences of the members of society. The intersection of race, gender, and class, for example, helps to understand an individual's place in the world and the ontological perspective that is held by various individuals based on their intersections in society. In my own experience as a South Asian male teacher, my way of thinking has truly transformed in facing the world around me. Oppression was experienced being a minority in our country's system of schooling as a first generation American. However, I was never given the voice, power, or even the opportunity to build motivation towards changing the inequalities that forced my ethnic background to witness favoritism towards privileged beings in the world around me. With my fellow non-White peers, I learned to ignore many of the offensive remarks made throughout my childhood, and still found a way to express and be proud of my heritage, culture, and race.

As I moved forward to becoming an educator and working in schools, I did not have the theoretical perspective of using my experiences as a South Asian male to help understand my students in different ways. In contrast, the social constructions of minorities in schools influenced my way of thinking. I did my best to help students of color, but it was a challenging time. I loved working with my students, but my *personal* never permeated my *professional*. I still saw minority students as others, and I could not get myself to use my personal experiences to make connections with students in similar positionalities. It was through my further studies, especially at the doctoral level, that I was able to reflect upon my own experiences, how they influence the decisions that I have made, and why it is important to have my voice heard.

Before gaining a better understanding of the inequalities that exist, the theoretical lens I used pertained only to the teaching and learning of mathematics. Throughout my transformation, however, I realized the questions and issues that needed attention were much larger. It is important to think about the micro-level of inequalities that exist in learning mathematics as a subject matter, and to also think about the macro-level of the importance in learning mathematics in a broader sense. Accepting a poststructuralist theoretical viewpoint in regards to mathematics curriculum allows potential for the influence of mathematical measurements on development of one's identity and place in society to be unleashed. This must take into account the positionality of each person, and the intersectionality of their various positions.

In re-thinking the decisions I make when reflecting on practice, it is important to take into account the study of curriculum and its potential influences. The theoretical lens utilized with regards to the development of curriculum can make a difference in students' experiences. A poststructuralist viewpoint helps to create positive curricular discourses and practices. As I move towards making important curricular changes beyond materials used to teach the subject matter, it helps to reflect upon the important ways curriculum theorizing can influence my students in positive ways. Experiencing theoretical viewpoints has allowed me to re-think my role as a South Asian male educator. I must take my own perspectives and experiences to help formulate the ways in which I approach teaching and learning for my students. My experiences in schooling should influence how I provide important tools for my students, giving them the opportunity to make changes to societal structures. With this theoretical approach to developing curriculum, change to societal inequalities can become a reality.

Critical Social Theoretical Lens

Epistemology is regarded as a theory of knowledge, where epistemological viewpoints help us distinguish belief from opinion. Epistemology provides guidelines in processing information that we are and aren't expected to believe as true. In order to think about the specific disadvantaged group of students with learning disorders, this research study has been designed to utilize critical social theories. These theoretical viewpoints allow us to understand the dominated aspects of the current social structures and why they exist (Levinson, 2011). Specifically, both feminist and critical race theory can be used to draw out important connections to other marginalized groups that have not yet been given opportunity for a position within the social structure. These theoretical views help to restructure a lens that can be used to teach mathematics to students with learning differences. Issues related to minority groups in gender and race can be applied to the group of atypical learners. The formation of identity involves a certain sense of belonging in community practices, including the spaces and informal experiences that are a part of an individual's environment.

Importance of understanding epistemic orientation as a lens for teaching students with learning differences comes from a feminist viewpoint (Thayer-Bacon et al., 2013). A transformational theory of teaching accepts the idea that people understand the world around them in different ways (Burton, 2012; Stone, 2013). The framework connects subjective to objective perspective. An epistemic orientation takes an individual's stance and perspective, with a goal to view information based on the knower of said information (Stone, 2013). Understanding the difference between subjective and objective information is important because it helps determine the direction that should be taken for teaching and learning when working with students. This lens helps to recognize who is determining the knowledge that is worth knowing, and how students play a role in making that decision. It also supports the idea of transforming mathematical learning from an objective experience to a subjective process in forming education.

The influence of feminist theory also introduces how student voice can be utilized when teaching mathematics (Burton, 2012). Taking into account the personal narrative, and connections of the subject matter to student lives, is important to incorporate into teaching the subject matter. Utilizing voice as a form of empowerment comes from a feminist lens where an individual is given the opportunity to be heard. Student voice allows for personal identity to have a place in empowering individuals against oppressive cultural and educational groups (Ellsworth, 2013). Utilizing this approach can help reach levels of critical thinking when trying to form a connection to the epistemic orientation.

In regards to critical race theory, connections between undermined racial groups and students with learning differences can be made. Similar to the epistemic orientation that allows students' experience and voice to be established and heard, for critical race theory scholars, the focus relies on the individual telling the story, the manner in which they are telling the story, the theoretical lens used to explain the story, and the purpose for telling the story itself (Zamudio et al., 2011). Within critical race theory and its study of the inequalities for students from various racial groups, a main focus acknowledges the rejection of student positionality within schooling, where students find themselves performing in a mainstream culture of standardized testing (Zamudio et al., 2011). The position that students of color hold within learning environments can be paralleled to those with learning differences studying mathematics. The application of a theoretical framework that helps to understand social structures that perpetuate inequalities is important. In terms of reform attempts to math curriculum for diverse learners, there are similarities with helping students of color achieve roles in society as they take part in our educational system.

Utilizing both feminist and critical race theory to incorporate the positionality of students includes making student identity as a part of the learning experience. Continuing standardization and assessment-based structures will further produce an unequal society. Providing learning opportunities for students in minority groups, however, can help break down the structures that have been put in place. In order to understand these structures and help create opportunities for marginalized groups, it is important to apply intersectionality and its influence in theorizing curriculum. The intersection of race, gender, and class can help to understand the various perspectives that are held by members of society. As we apply this mindset to teaching, we may utilize each student's identity in formulating the overall educational experience, including the learning of mathematics. Taking into account the various positions that are held by our students, and the intersectionality of these positions, helps to reframe the goals of teaching. Reflecting on practice and curriculum should lead to communicating the purpose of teaching mathematics to students with learning differences. In utilizing critical social theory, Zamudio et al. (2011) suggests that critical reflection should consistently occur for educators and scholars, especially in regards to the underlying ideologies that guide thinking. The theoretical lens that can be used towards teaching curriculum to our students can help to create positive change in society, and provide modes of equity to our marginalized students: that is the potential of curriculum theorizing.

Normative Practices in Mathematics

The dynamics and structure of society plays an important role in developing unequal relationships (Bernstein, 2011). Forming representations of people flows into the structures of our world and the construction of performance. When disparities are made between different sides of these representations, there is a group of people that is considered the opposite of what is considered normal. The polarity of various representations creates a connection between the groups, but only to help define which specific sets of behaviors receive credence, also known as *normal* behaviors, and which things are considered common practice, known as the *norms* that are identified and followed by members of society (Bernstein, 2011). In education, we value knowledge that is measured by numbers that supposedly reflect skills that are considered official or legitimate. However, the numbers represent and embody a specific group of people who are considered normal, fitting the expected norms of social structures. As individuals live through the various social structures, they are asked to face the pressures of fitting into what is considered relative normalcy. The result of creating this sense of normalcy leads to the development of *difference*—which is a natural product of the oppression and exclusion when certain individuals do not fit the characteristics of what is considered normal.

When aspects of society such as education are structurally oppressive, the opposition of ideas naturally takes place. As social constructions develop through time, the resistance against the dominant social constructs continuously repositions the meaning of norms. In this process, resistance gives meaning to material that is used as a form of pushing back against the dominant social constructs. The dominant and non-dominant social constructs exist together, and as relationships change, the meaning of material gets repositioned. Throughout their developmental years, individuals are constructing meaning of the world that surrounds them, followed by performance based on their meaning-making process (Bernstein, 2011). Although we can influence the way students are thinking, the process of creating meaning is always occurring. The multiple meanings of performance allow for various ideas to develop. Acknowledging this process is important in thinking about the development of individual identity.

When opposing meaning-making processes take place in defining what is considered normal, meaning for certain groups of people becomes repressed. For this reason, it is important that we push for students to think about the world, and groups of people within the world, differently. It is often through life experiences that individuals come across diverse groups of people and learn that their differences do not equate to non-normative behaviors. Allowing students to construct their knowledge based on experiences in the world can help create pathways to accepting others. The capacity to think differently about what is socially constructed, and therefore normalized, is important in meaning making and the learning process. This requires deconstruction of meaning, which requires us to realize that getting closer to truth, in an epistemological sense, requires us to understand that there are multiple ways to seeing things and therefore, there are multiples ways for people to perform in the world. There is room for acceptance of the different views individuals hold, including their performative behaviors and inclusion of multiple meanings. Deconstruction is not the end goal, but rather a process that allows for multiple perspectives to be heard and accepted.

Culture within Mathematics Curriculum

Culture is the collection of shared meaning that is formed between individuals through common language and dialogue. Shared meaning includes the interpretations and understandings of the world. Culture is formed when a connection is established between individuals experiencing similar or different development of ideas and thoughts (Hall, 2005; Lightfoot et al., 2013). Through time, the shared meanings and understandings turn into shared values and a way of life for a particular group of people. Within the formation of culture, social construction exists. It is not what is in the biology of people and what occurs scientifically, but rather a perceived understanding of what happens in the world – construction of meaning through social interaction and agreed upon understandings. The interactions between people are what lead to the development of cultural practices. The meaning ascribed to physical objects, language, clothing, art, and other aspects of the material world informs vocabulary and language development. But even further, language allows for ideas, philosophies, and theoretical dialogues to take place in the symbolic world (Lightfoot et al., 2013). The cultural construction of meaning leads to an idea of what is considered normal, which is problematic because it defines things that are culturally included and excluded. We should be motivated to use culture to communicate, understand, and accept differences between people. Rather, a discussion of meaning leads to an argument of what is right and wrong – creating difference in thoughts and differences between groups (Hall, 2005). This leads to binary oppositions, where differences are over-simplified and the more powerful ideologies are considered right and dominant. Meaning should not be fixed, but rather fluid based on individual understandings and experiences. Assigning particular meaning can lead to assigning positions within a controlling system (Hall, 2005; Lightfoot et al., 2013).

Developmental years involve the learning of ideals, growth in character and traits, and formation of personality and identity. This involves interactions with various cultural groups to which the individual may subscribe. Both material and symbolic aspects of cultural tools impact development – from the various activities that take place to the environment that surrounds an individual (Lightfoot et al., 2013). Cultural exposure transmits through generations, and accepted meanings are passed on through time. The social processes of how things are accepted within a cultural group continuously influence development.

Ethnomathematics & Critical Mathematical Literacy

The historical study of mathematics in various cultural groups sheds light on the influence that the process of learning the subject matter has on individuals. Various cultural groups around the world give different levels of importance to learning mathematics and present math curriculum differently. This has led to observations of varying values towards learning mathematics, developing associations of particular cultural groups having stronger roles in mathematical fields. Countries differ in their approach to teaching mathematics, some of which have incorporated high expectations for their students compared to the curriculum that is developed and implemented in classrooms across the United States (Bush, 2003). The generations of families who have learned mathematics in other countries have developed funds of knowledge important to the application of mathematical concepts in a real world setting. There is a stark difference when comparing *schooling* in mathematics to the *education* of mathematics, both of which are reflective of various cultural groups and their values towards what it means to think mathematically (Bush, 2003).

The strong correlation between mathematics education and cultural practices has led researchers to develop literature discussing important theories that can be implemented into classrooms. Ethnomathematics, a term originally coined by Ubiratan D'Ambrosio (2007), is used to describe the way in which various cultural groups use mathematics in their developed societies to reason through different issues outside of schooling purposes (Bush, 2003; Frankenstein, 1990). This concept helps connect culture to mathematics in the classroom. It requires educators to give value to the *cultural* capital that is held by members of the class. Unleashing cultural capital allows students to form connections between the experiences from their personal lives with those related to the mathematical concepts in the classroom. As a leader at the forefront of developing research ideas pertaining to ethnomathematics, D'Ambrosio (2007) discusses the lack of value given to teaching mathematics from a critical thinking cultural perspective.

An understanding of ethnomathematics allows the use of cultural experiences that students bring to a classroom, and how these cultural experiences can be incorporated into the teaching and utilization of mathematics content. This multicultural education form of instruction allows students to engage in learning experiences that involve their own cultural backgrounds and for exposure to other students' cultural capital. The cultural experiences that students gain are related to the importance of mathematics, and over time, the formation of a mathematical identity. Multicultural education can be implemented through mathematics, and the exposure that students can receive into a variety of cultural experiences through mathematics can make the experience one that is worthwhile and influential. When developing curriculum for mathematics, educators often do not take into account these important cultural contexts. Utilizing ethnomathematics as a theoretical lens to teach mathematics allows educators to value the experiences individuals bring to the classroom, which has potential to influence the formation of mathematical identity. A multicultural approach to learning mathematics can help use cultural capital to make the content more applicable to the students' personal lives, leading to the development of a mathematical education that is prevalent throughout the students' future role in society.

Examples of how ethnomathematics has provided insight into the connection between culture and mathematics education include practices known to have existed in societies throughout time. The cultural implications of learning mathematics content and the importance that is given to mathematical curriculum influence the development of attitudes and beliefs of learning mathematics that inform identity development. Powell and Frankenstein (1997) discuss various examples in which the pedagogy of mathematics has led to developments in societies throughout time, including the importance of mathematical knowledge as a means of training for the workplace. The importance in studying the various mathematical influences in these cultural groups is the level of value that is given to learning and applying mathematical skills.

Allowing students to bring their cultural experiences to the classroom, and learn how mathematical concepts can be applied towards their future experiences, may help develop a value towards mathematics education. Ethnomathematics has shown the benefits of incorporating cultural background in learning mathematics and how it can lead to an increase in value for the subject matter. Curriculum in classrooms today ask for students to learn content without allowing them to find a way to make the skills applicable in a real world setting. The value towards math education increases as students experience the application of learned content, allowing them to utilize their skills for future roles in society (D'Ambrosio, 2007). Incorporating experiences in the classroom that develop students mathematically and culturally can increase value for mathematics education and instruction.

Marilyn Frankenstein (1990) introduces the concept of critical mathematical literacy in order to frame a manner of thinking when viewing the inequalities that exist in society. This takes into account the concept of ethnomathematics in order to recognize the importance of teaching mathematics to our students, especially those from marginalized groups. The role of this important perspective in teaching mathematics can provide more opportunities for a problem-posing method using statistical data. Critical mathematical literacy leads to the dissection of societal issues with statistical questions and the presentation of data in order to help make positive changes in the perceptions that people hold regarding important issues (Frankenstein, 1990). In understanding the role of politics, and the potential of disrupting the accepted notions of power and control, critical mathematical literacy can provide students with a voice to understand and point out inequalities in the world that surrounds them. It gives individuals a powerful tool to use towards taking informed positions when formulating their views on structures and processes in society. In connecting ethnomathematics to the development of critical mathematical literacy, value for mathematical thinking within marginalized groups of students can be found. Developing curriculum that is more meaningful for all groups of students increases the confidence and value for the subject matter by using real-life data to help discuss open-ended issues with problem solving techniques.

Cultural Group of Different Learners

Taking into account the cultural differences, social practices, and histories of people can help determine the various approaches used to teach individuals who learn differently. An approach to viewing membership to certain cultural groups without applying specific assumptions and approaches to the entire group is crucial. To avoid a one-size-fits-all approach, it is important to regard identity and experiences into the learning and teaching process (Gutierrez & Rogoff, 2003). Although culture involves shared meanings and understandings, the experiences and formation of identity can vary for individuals belonging to the same cultural groups. The true identification that an individual holds based on their experiences is vital. Assumptions of individuals can lead to detrimental effects for their educational experiences. Cultural variation allows educators to include various learner types based on their cultural experiences, foster individual development, and provide individualized attention (Gutierrez & Rogoff, 2003).

The power that comes from cultural development lies in the dominant group understandings. Learning styles that benefit the dominant groups in our society are considered the strongest. Individuals that do not fall under these dominant groups are considered deficient (Eder, 1982; Gutierrez & Rogoff, 2003). The differences are considered sub-par to dominant groups, and assumptions made about different learners may remove important opportunities towards success. In this instance, the concept of cultural capital is important when reflecting on which groups of people do not have the capital to be considered a part of the dominant groups. Learning styles belong to a particular cultural group, and socially constructed viewpoints about which learning styles are considered most effective decrease overall opportunities. Being labeled and placed into specific groups can lead to trajectories that do not allow for fluidity and variation in learning (Gutierrez & Rogoff, 2003).

Membership into the cultural group of individuals with learning disorders is considered a minority group. The labels that occur in this grouping perpetuate the social understanding of what it means to learn and creates a binary understanding of ability versus disability (Eder, 1982). This grouping falls into the issues of power within and between various cultural groups. Systems of oppression come from groupings of individuals with learning disorders, similar to those who belong to minority racial groups or low socioeconomic groups. An understanding of the positionality that takes place for an individual belonging to this cultural group can help understand, and perhaps remove, the power relations that occur for the creation of dominant groups. The social construction of how society must be organized creates segregation between people who learn differently and do not belong to a group that follows the hegemonic social order. The identity development for individuals that face segregation based on their disability – and the social grouping that occurs due to this label – influences the construction of meaning based on the experiences that occur in schooling.

Utilizing an objectivist lens when teaching mathematics creates a sense of philosophy where mathematical ‘truths’ exist and the knowledge surrounding mathematics can be ‘known’. This viewpoint follows a theoretical lens that supports the hegemonic ideologies of society and makes effectively learning mathematics for students with learning disorders, such as developmental dyscalculia, very difficult. By continuing to use labeling processes to place students with learning differences into particular groups based on what is ‘known’ only reproduces and perpetuates the inequalities of society. Given the current state of education, based on accountability measures and standardized curriculum, we must make learning mathematics accessible to all learner types. However, it is not only the accessibility that we can improve. To reduce the inequalities that exist, mathematics curriculum can be transformed to become a tool for equity. We should better prepare our students to utilize mathematics for a greater purpose – for something that can be used as a tool towards creating positive change to negative societal and cultural constructions.

A close focus on the cultural implications of students who learn differently can help to better understand the current hegemonic practices that give specific groups of students a disadvantage and reproduce the social inequalities related to mathematical learning. For students with learning differences, these inequalities remove accessibility to mathematical learning, specifically those diagnosed with developmental dyscalculia at a young age. The mathematical classroom can be transformed into a space of critical thinking, where development of math literacy can help to question and refute the hegemonic practices in education, leading to more positive mathematical identity formation.

Attitude & Value Towards Learning Mathematics

As students take part in learning experiences, they are exposed to various content areas and subject matters. From early years of schooling, students learn about their strengths and weaknesses within specific subject areas. These strengths and weaknesses, however, may be directly influenced by the exposure of certain pedagogical practices. Ongoing learning experiences force students to form their interests and passions and influence a path of study chosen in their educational advancement. By the time students enter secondary schooling, many have been tracked into courses based on these strengths and weaknesses, defining the ability and inability to higher-level thinking proficiencies in specific subject areas.

Students with learning disorders face difficulty in the classroom due to the challenges throughout their schooling experiences. Whether the reason for their existence is nature or nurture, learning disorders create negative views towards overall learning. They lead to the formation of a specific attitude toward the more challenging subject matters. Particularly in the mathematics classroom, the presence of learning disorders can lead to negative experiences that form depreciation of the subject. Potential to help students connect mathematics to their own lives is not reached in our current presentation of mathematics curriculum, which devalues the experience. Students form their attitude towards mathematics based on the failures they may have faced or an ineffectiveness to see the connection between mathematics and their individual lives.

A negative attitude towards the mathematics subject makes it difficult for educators to cultivate a learning environment that is positive and productive. The approach to presenting mathematics content follows a linear path determined by content standards and subject matter concepts. However, the importance of learning these mathematical topics is never fully developed or discussed as teachers are prepared to guide their students. Lesson plan creation focuses on what students will be able to do mathematically rather than forming effective ways to teach mathematical content in a way that allows students to explore the subject matter's contribution to their personal lives.

Even as a mathematics educator approaches the content that is to be presented in their class, the attitude that is formed and used for presenting curriculum is extremely important to establish (Makiguchi, 1936). Japanese philosopher Tsunesaburo Makiguchi (1923) introduces value-creative pedagogy, which may give students an opportunity to connect content knowledge to their important roles in society. To create this experience, the role of an educator must shift from a mere presenter of information to an active participant in student learning. Individuals can gain knowledge and skills through the experiences that they come across by connecting real-life examples of how the content can be applied to their own lives (Gebert & Joffee, 2007; Goulah, 2012).

Makiguchi (1923) also presents the difference between *truth* and *value*. The truths that are experienced by students are in existence based on what we create as citizens of the world.

However, the value that is created for these various instances of experience are greatly influenced by the interactions we have with the people we meet, the places we go, and the things we see and feel in nature. The difference between truth and value is that only values can be created in the experiences we hold, not truths (Makiguchi, 1923). It is the educator's role is to provide the setting in which students may form value through successful experiences in the classroom, without any influence from their own values.

Value-creative pedagogy can involve the use of vocabulary development and discourse surrounding mathematical concepts connected to real world situations (Goulah, 2012). Finding a connection between the mathematics they are learning with a memory of personal experience can lead to development of this value (Gebert & Joffee, 2007). Students are encouraged to talk to their peers about their thinking, which leads to stronger working memory development involved with mathematical learning (Geary, 1993). The idea is to develop a shared philosophy through mathematical communication and use the content area as a means to deal with current issues in our local communities, society, and throughout the world. Through these more positive and applicable experiences, students walk away from the classroom empowered to use the mathematical knowledge that is learned.

Mathematics as a Political Tool

Education and politics are understood separately in society. Formal education drives members of society to work towards a specific goal that benefits them directly. As we question the role of education in society, it is important to think about the role of politics. Political philosophers and theorists argue that the traditional role of politics is to serve the purpose of developing a greater public life. The role of politics is to question and better the lives of all members of society. The subject of mathematics holds potential to provide equity. In today's society, mathematics curriculum feeds into the commodification and financialization of our lives. The standardization and privatization of education is a result of the country's agenda to impose certain qualities of educational experiences that benefit specific groups of people. Alexander Means (2013) explains that the government uses education in order to increase profits. The negative effect of this agenda has widened the gap between groups of people belonging to different backgrounds, such as socioeconomic status. The country has entered an age of austerity looking for ways to make up for overall economic and political decline (Means, 2013). Response to this downfall has led to the privatization of education, and our leaders are constantly finding ways to increase the economic standing of our country.

This ideology is coined as neoliberalism, which describes the transformations that have recently occurred in restructuring our country and social life to fit the demands of globalization and free-market capitalism (Means, 2013). In the interest of governance, neoliberalism has promoted the standardization and privatization of public education, with a shift away from focusing on the social good. Neoliberalism has led to a competitive educational system, and specifically with mathematics, standardization and accountability measures have led the subject matter into becoming selective. This selectivity gives a particular group an advantage when becoming mathematically educated. It is critical to acknowledge the importance of teaching the subject in a way that allows citizens of society to think and communicate mathematically in order to utilize it as a tool to decrease the inequality that exists in our world (Ranciere, 1991).

Our current system of education focuses on producing knowledge that is beneficial for a profits-based industry, teaching specific skills to particular groups of students that will in turn benefit and grow the economy (Apple, 1992). This ideology serves to benefit those who are able to continue control of society. In this viewpoint, mathematical knowledge is a form of cultural capital, gained as an asset for those who use the skills for their personal advancement. The valuation of the subject matter adds to the idea that mathematics is a tool for socioeconomic utility (Apple, 1992). The divide that is created by perpetuating this capital allows specific groups of individuals who have access and exposure to the higher levels of mathematical thinking an unfair advantage, further dividing the gap between various groups of people.

Philosophical thinkers allow us to re-think the potential of teaching mathematics curriculum as a means to provide education that leads to equity. In the world of political philosophy, mathematics has the potential to be the vehicle for developing reason over rationality in order to bring about equity in a form of a democratic society (Ranciere, 1991). The perception that only the intelligent elite can acquire and take part in mathematical thinking is a myth. Jacques Ranciere (1999) attempts to help us think of education out of social order. The role of political philosophy is to help set up an ideal version of social order. However, this requires going against the setup of our current system. We must move away from having the market and economists determine all decisions. Rather than education, politics becomes the assertion of equality. Everything that exists is how it is meant to exist: equality is based on the inequality purposely formed by the people in power (Appelbaum, 2012; Ranciere, 1999).

Various philosophers discuss the collapse of reason and rationality in our current society (Arendt, 1998). Reasoning allows members of society to question and understand the various aspects of the world that feed into the inequalities that exist. As members of society, having differences in opinions allows us to interrupt the police order and question the existence of rationality being used to regulate and control members of society. The dominant knowledge system of rationality has been imposed on politics and the governing of people, further supporting that only certain members are allowed to have arguments. This perspective leads to the problematic control from an elite group. Ranciere (1999) uses Socrates to explain an important distinction between rationality versus reasoning exists, and uses Plato to argue that reasoning through mathematics, geometry, and various mathematical principles can create a source of equity. These philosophers argue that mathematical education can potentially help individuals think through reasoning, rather than rationality.

Oppressive Nature of Learning Mathematics

The epistemological lens in viewing mathematics as a tool for social change can lead to increased participation in the politics of everyday life. We must acknowledge forms of ignorance that are projected by educators: one that perpetuates inequality by creating a relationship where the teacher imparts knowledge onto the students, and a second that mathematics must be taught without the assumption that students do not know or have the knowledge base or skills. Mathematical learning holds a sense of elitism (Freire et al., 1997). We can work against this elitism if we present mathematics as a way to solve problems that surround us.

In *Pedagogy of the Oppressed*, Paulo Freire (2000) introduces the banking approach to education that is currently used in order to provide our students with pieces of knowledge that are considered efficient, following the neoliberal practices of education. Leon Benade (2015) relates Freire's banking approach to current educational practices such as twenty-first century learning through technology. This movement aims to prepare students to be literate for the world's leading industries. Developing citizens into bodies that provide a benefit to those in power only develop individuals that can be utilized as objects. The relationships that are formed in the work force are hierarchical, and this objective approach to educating future members feeds into the hierarchy of materialism. In this approach, we are dehumanizing people through power and control. Freire (2000) presents the idea that education can play an important role in letting go of our fear when we view the people in power who have created our current world. Explication allows us to understand why and how we are oppressed. The problem-posing approach to teaching allows students to question the oppression and performative nature of doing mathematics (Freire, 2000).

Teaching can be considered a system of oppression, where knowledge is narrated from the teacher and students are expected to memorize facts and regurgitate known thoughts and ideas that are given to them. The top-down methods of the banking approach prepare students to answer questions that the teacher creates. Dehumanization is understood as the ideological method for oppression to exist in society, creating the relationship between oppressors and the oppressed (Freire, 2000). It doesn't seem to be in the students' best interests if the methods used in the classroom hold them back from becoming future contributors of society. In order to avoid the oppressive methods of the classroom, it is the teacher's decision to create opportunities for student voice and true learner-centered environments.

Culturally, students enter a classroom with expectations that the teacher has all of the answers (Eder, 1982). A teacher that makes a mistake in their lesson will be looked down upon, further adding to the social construction of an oppressive system between students and their teachers. As each new school year begins, classroom culture can be formed so that teachers are able to remove the oppression that is felt. By liberating the students' feeling of being pressured into learning concepts, topics, and skill sets in order to receive good grades and high scores, we may be able to revolutionize the purpose of education in schools. It is with this mindset and approach where students may be considered liberated from the oppression that exists in what we would like to see as learner-centered classrooms (Freire, 2000).

In the mathematics classroom, many of the skill sets and problem-solving attributes that are learned at a younger age are required to reach the higher-level concepts. To attain the problem-posing educational processes, it seems only appropriate to first give the students the tools they may need in order to reach the potential higher-level thinking concepts. To avoid an impending oppressive teaching model, students must be active participants in the learning process. Methods that may lead to this model would require both teachers and students to simultaneously learn. Other ways to attain this learning process can come from creating opportunities for students to teach each other the different ways they think about the mathematical topics. To help students become beings for themselves so that they are transformed individuals of society, it is important to introduce creative thought processes. Freire (2000) puts this responsibility in teachers' hands. It is in the educator's teaching methods where students can become active participants of their own learning process.

The challenge with this classroom culture is making sure that students understand the methodology behind the ideology. When a learner-centered classroom is developed, students should be prepared to think about the true value for achieving educational experiences. This may require breaking down barriers between different subject matters. Although various skills sets are important, we must ask what a student feels is their responsibility in society and how they believe they can achieve the power and voice to become contributors of society. With an understanding of direction and goals put in place, it is possible to remove the oppressive models currently utilized to teach students.

The specific forms of oppression towards students with learning differences must be acknowledged, as their current status in math classes can be classified as dehumanized beings. The process of an individual being released from their oppression can lead to the humanization of this being (Freire, 2000). An educational system that places students with learning differences in mathematics into specific categories, classes, and groupings creates an oppressive setting. It is important for educators to provide opportunity for students to release themselves from the oppression. Providing appropriate modes of this release can be achieved once an understanding for the oppression and a discussion of its existence in education occurs.

The nation stands to help further the success and power that is attained by certain groups of people. The model of oppression that holds our country in its current state benefits the oppressors. The mindset of the oppressors follows a very materialistic ideology, wanting to utilize money to purchase power in order to possess and withhold control. Oppressors are looking to have more, even at the cost of others having less (Freire, 2000). The only way to remove the oppression is for the oppressed to find ways to free themselves from these forces. For students with learning differences, this comes from avoiding being placed into classes that do not allow for their full potential and growth. The methods of placing students into special education courses based on assessments creates a division between students who are able to learn higher-level mathematics, and those that are given skills-based coursework. An understanding that the memorization behind numeracy and arithmetic for students with neurological differences, such as developmental dyscalculia, may not be possible can then inform ways to accommodate so that these students can be successful in learning higher-level mathematical thinking.

With the right tools and a removal of accountability measures that do not measure true critical thinking, students with learning disorders can be successful. It is the educator's responsibility, then, to provide these students with the opportunities to develop the right types of tools. The use of dialogue can help students build on their knowledge and cognition of ideas, which can lead to liberation. Giving students the opportunity to learn through experience leads to creation of meaning. The curriculum often followed by teachers, however, is ideologically intended to perpetuate the oppression. What is unfortunate in this situation is that dominant elites will not give up their position as the oppressors. A problem-posing approach gives students a chance to find ways to impact the world after understanding that transformations in reality can exist (Freire, 2000). This method of educating students can lead to rich dialogue in the classroom, where the students and teachers work together to create learning experiences. Dialogue involves engagement with critical thinking, allowing an understanding of reality as something that can be transformed – not just something that must be accepted as being true (Freire, 2000). The encouragement for students to think critically while developing experiences for dialogue can be very powerful, especially for students with learning differences. Students with learning differences in mathematics often do not have this opportunity to dialogue – to problem solve, to have their thoughts and ideas heard, and to gain experience in formulating knowledge based on experience. This right to speak is what Freire (2000) urges to reclaim in order to discontinue the dehumanizing practices that hold back students with learning differences from having their place in our world. The inequalities that exist for these students can be deconstructed with the power of using dialogic methods. Based on the action these students make, reflection can occur once true critical thinking is achieved, even in mathematics.

Accountability by Assessment within Mathematics

Current mathematics pedagogy plays into the neoliberalism of our country. In the neoliberal age, politics is deemed as a form of power. The market is meant to rule all aspects of our lives, leading to the financialization of members of society. The commercialization of education comes from the standardization of curriculum and evaluations of teachers based on these standards (Baines & Goolsby, 2013; McDermott, 2013). The efficiency in further standardizing and commodifying all aspects of the systems that are put in place is most important. The testing culture of schooling has taken away from other dire needs of education – to inform future citizens of knowledge that can be influential in making a better world to live in. In developing a capitalistic society, competition becomes a forefront of developing products and people. With neoliberalism, we become mass consumer citizens, rather than political citizens. As consumer citizens, we become willing to give up democracy as a means to have our voices heard. The role of mathematics education in this neoliberal age is to provide technological advances that feed into the efficiency and accumulation of profit. We give into the surrendering of politics in its role to interrupt police order.

The assessment and accountability measures that are used to serve a nationalistic agenda are taking away opportunities for students who learn differently. In many special education programs, students are placed in levels of mathematics that are watered down. Academic expectations, learning opportunities, and knowledge outcomes are lowered with special education students (Cooc, 2017). Students with developmental dyscalculia have the ability to reach high levels of critical thinking even with their challenges related to traditional mathematical assessments. Tests of basic numeracy that are pushed in early years of schooling hold students back from applying mathematical thinking in greater ways. Although there has been an increase in the use of technology, many assessment practices still require students to use rote-memorization to learn mathematical skills. Schools utilize textbooks that are created based on the standards given importance by specific leaders in education – many of which do not take into account different learner types. Appreciation for learning and utilization of the skills can be acquired if students are able to make a connection of the mathematical way of thinking to their own interests and future roles in society as well as applicable issues in the real world.

The competitive culture that is developed throughout the process of traditional learning methods leads to negative experiences for the students who have difficulty with memorization and quick thinking. This manner of learning mathematics adds to the formation of social inequalities. Individuals facing numeracy issues are held back from developing competency in mathematics, which is very important for future roles in society. The mind is ever changing, and learning allows for this change to occur (Goodlad et al., 2004). We must use different experiences and pedagogical methods to help students with neurological differences to learn mathematics effectively. The critical thinking that occurs for students who are able to learn mathematics in the traditional ways it is presented should be accessible for students with learning differences.

Unfortunately, the requirements that are brought on by standardized tests determine how classes are taught. The authenticity of lesson planning and the overall teacher expertise have been removed due to the pressure that is created by testing. Teaching to the test has become a reality of school cultures. Teachers find themselves worrying more about the results of tests and the data that is put together from the tests, rather than the actual learning that takes place for students. The results of these experiences put students in a difficult position, leading them to question schooling, create a challenge to find value in education, and develop passion for learning more about their interests. The transformation in pedagogical practices in the math classroom has caused educators to increasingly depend on teaching number calculations, decreasing the unique, innovative, and application-based approach to teaching mathematics (Taubman, 2009). Creative lesson planning and assessment of skills have decreased in classrooms, further adding to the low acquisition of mathematical skill development, especially for students who learn differently. Students often become disinterested around lesson plans that lead to test preparation. The potential of providing rich educational experiences has transformed in schools. The hegemonic assessment constructions of accountability, standardization, and testing in schools have led to destructive experiences for our students.

Accountability describes methods we use to hold teachers responsible for learning in the classroom. Standardization encompasses the one-size-fits-all approach that is used in order to make sure students are receiving the skills deemed necessary. Testing is the tool that is used to assess if students are learning the standards that are put in place. The learning process that takes place in the classroom combining these three practices has transformed into a culture of measurement and statistical data, forcing schools to make important curricular decisions based on accountability, standardization, and testing. In mathematics classrooms across the country, teachers have been negatively affected by the required procedural methods, communicated through standards created by governmental groups. The Common Core standards were created by the National Governors Association and the Council of Chief State School Officers and are widely used throughout the country. Benchmarks have been set up at each step of a student's mathematics educational progression (Baines & Goolsby, 2013; Taubman, 2009). Rather than questioning the dominant discourse that exists, however, teachers and students are forced to use these guides to assess learning in the classroom.

Accountability, standardization, and testing have led our public schools to become a pressurized system. School administrators are constantly worried about their doors closing from their scores not being good enough (Bower & Thomas, 2013; McDermott, 2013; Taubman, 2009). Based on the Common Core standards and criteria set by the government, schools are provided a report card, holding them directly accountable for the data that is pulled from students. Funding is provided to schools that grade well, while schools that score below certain thresholds are required to defend why their grades are so low. With this system in place, student test scores equate to the quality of education and the teachers' quality of instruction. Applying the same standard to all schools regardless of the level of resources, community support, and educational opportunities for students is unfair. With the standardized tests that are used in these methods, we ask students to complete the same tasks, even though their experiences and ways of learning may be different. Pursuing particular interests related to mathematics is held back due to the hegemonic impact of accountability, standardization, and testing on an individual's future path (Baines & Goolsby, 2013).

The mindset that assessment should measure an individual's thinking and processing can help to formulate practices that incorporate how people use mathematics in society and how we can teach our students to use their skills in a way that benefits the world around them (Kilpatrick, 1993). In regards to current reform-based practices, the National Council of Teachers of Mathematics (NCTM) has published various guides such as the *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), *Assessment Standards for School Mathematics* (1995), and *Principles and Standards for School Mathematics* (2000) to help educators create evaluative techniques that are inclusive of all learner types (Hopkins, 1999). These suggestions have been used in the twenty-first century, particularly the concept of constructivist models of teaching and learning. A conceptual understanding of mathematics can be assessed using this ideology. Reform-based assessments that improve achievement for students can influence their overall understanding of mathematics (Wallace & White, 2015).

Michael Apple (1992) took the opportunity to criticize the guides produced by the NCTM. He points out the inequalities that still exist in teaching mathematics. The standards that are provided by NCTM give students opportunity for various forms of assessment, but it is important to note that they further divide groups of students based on their ability to learn the 'truths' of mathematics. Apple (1992) introduces a conservative agenda for mathematics education that perpetuates inequalities in schools based on how the subject is taught. Accountability follows the standards that are used to control the curriculum. Funding for programs that further advantage specific groups of people is determined by the same people who create control through these standards.

There are many variables in learning mathematics. Individuals hold various strengths and weaknesses, differing in learning styles and an overall academic understanding of the subject area. When we expect the same set of standards to be met by all students in the same manner, we are setting predetermined levels of achievement for all individuals (Hopkins, 1999). The ideology of constructivism has played an important role in guiding teachers to present opportunities for students to construct meaning of mathematical concepts so that they are able to engage with the content on a personal level. In order for students to display their constructed knowledge, the concept of using authentic assessments would allow students to assume responsibility for their learning. Examples of authentic assessments may include exhibitions, portfolios, journals, and overall reflective descriptions of problem solving (Hopkins, 1999).

As a combination of the various ideas presented is put together, instructors are able to break out of the mold that is created by current accountability, standardization, and testing procedures. The utilization of assessment methods in the classroom is very important. In the end, a student should feel control over their learning processes. The hegemonic ideologies of accountability, standardization, and testing can have little influence if students are given the tools necessary to take control of their learning. The feedback that comes from assessment procedures should help individuals judge whether they have learned, and it should provide reflection to help set future goals in the process of learning. Assessments should allow students to be in charge of their education, with space for a self-evaluation process (Bolton & Elmore, 2013; Bower & Thomas, 2013).

Historical Hegemonic Decisions Forming Today's Mathematics Curriculum

An analysis of the historical decisions made in the last century helps to determine the current position of mathematics curriculum and what has led to our current state of implementing the assessment procedures of accountability, standardization, and testing (Bower & Thomas, 2013). Dominant ideological perspectives throughout time have put math education through revision and reform processes. The current presentation of mathematics does not allow for students to connect the skills that are learned to their personal lives, leading to little interest in the subject matter. Assessment practices in mathematics classrooms tend to require students to learn arithmetic, memorize formulas, and learn how to find a final answer to each problem. Tests are given at the end of each unit in order to cover the standards and skill sets that are set by agencies such as Common Core. In our current changing world, with an increase of technological use, students are often not prepared to apply mathematical thinking skills. Problem solving and logical skill development are removed from teaching mathematics, and rather a focus on teaching standards has influenced the curricular decisions made by instructors. Current reformers that are improving mathematics pedagogy, such as NCTM, have developed strategies that are different from traditional methods of accountability, standardization, and testing. Although the standards encompass an exposure to many mathematical skills, the current policies of education do not allow teachers to creatively present curriculum to students. They take away from the development of critical thinking skills with specific modes of assessment.

The historical decisions that have been made throughout the twentieth century show how educators used methods that were appropriate for the status of education in our nation's state. However, reform-based pedagogy has not been developed to use mathematical skills that are more appropriate for our current students. The reforms that have been made towards improving mathematics curriculum have not fully considered what is best for students, educators, and society (Stanic & Kilpatrick, 2004). Reform-based practices are not new to the field of education, especially when it comes to mathematics. The reform movements throughout history include an application to dominant ideologies at each time frame, connecting mathematics to the issues that were present in society. At each stage, the reforms in mathematics education helped specific people, causing inequalities to form within the practices that were used and the fulfillment of a hidden agenda. The development of math education has systematic implications as well, giving a powerful role to the learning of mathematics in the creation of policies. Understanding the role of mathematics in society and how this role has changed throughout time gives insight into how the value towards receiving a mathematics education has decreased (Bush, 2003). A closer look at history suggests that the subject of mathematics has affected areas of society that are not related to schooling, but education in general to further technological advancements and industrialization, as well as the government's military, economic, and political agendas (D'Ambrosio, 2007).

In the history of our world, various modes of communicating mathematical knowledge have occurred. Mathematical ideas and theories have been shared between various cultural groups, leading to ideas that are still prevalent within our world today. Further investigation of the historical context of mathematics education suggests that communication within cultural groups was developed through important skills such as measurements, quantities, inferences, and abstract thinking (D'Ambrosio, 2007). Based on cultural backgrounds, the role of mathematics in developing high-level thinking was given value. However, the value of these same concepts and thought processes has changed in American history and curriculum. Many major mathematics movements have been made in the last century, which parallel the struggles that we have faced in general American curriculum development. The numerous reform movements have influenced the value of the subject matter itself and the ways in which it is presented to our students in schools today. The dominant ideologies at each time period have led to changes that attempted to quickly amend the issues in mathematics education. However, the revisions that have taken place have benefited specific groups of people, leaving inequalities within the teaching and learning of mathematics.

Early in the 1900s, the progressive movement took into account the events at the turn of the new century. The unified and applied mathematics education movement in the early 1900s attempted to shift the focus from teaching utilitarian skills that had limited academic content. The educational reformers provided mathematical skills that were beneficial for students to use outside of the classroom, however, this included particular groups of students who were thought to be successful in courses that incorporated higher-levels of mathematical skills. This skills-based approach to learning mathematics slowed down student-centered and discovery based teaching. Progressive ideas tried to help students have more control over their learning experiences (Ellis & Berry, 2005). Although progressive advancements were made in terms of introducing mathematics, the actual amount of content that was presented to students had decreased. Policy makers pushed for having students connect mathematics to other subject areas, but very little change from skills and memorization occurred in teaching mathematics. The assumptions made in presenting the content led to inequalities in teaching and learning mathematics to specific groups of students, especially in communities that were considered unable to learn the higher-level content. The social efficiency progressives argued that mathematics curriculum for all students was unnecessary (Ellis & Berry, 2005). Progressive leaders in education took to forming mathematics curriculum that would help students utilize skills outside of the classroom, including Columbia University professor William Kilpatrick, who helped to determine topics in mathematics that were most important to learn, along with deciding which students were most likely to succeed in higher-level coursework (Ellis & Berry, 2005).

In order to create an even lesser skills-based curriculum, the Life Adjustment Movement was introduced in the mid-1940s. Changes to curriculum were made as a response to schools having too much of an academic curriculum. The introduction of tracking students' level of understanding in mathematics dates back to this era, with its main purpose being a force to push students into the mathematical courses that developed vocational, consumer, and industrial skills (Ellis & Berry, 2005). The hope was that the learning of mathematics would directly influence future roles in society. Leaders of education feared the high percentage of individuals who lacked the capability of pursuing college degrees or occupations, while also failing to gain important skills for everyday living (Klein, 2003). Students were enrolled in math courses that focused on being able to deal with problems such as consumer expenses, taxes, insurance payments, and budgeting rather than learning the traditional mathematical subject areas of algebra and geometry. In effect, the students who were enrolled in these courses were only prepared to operate their role in society as service-based laborers, and these decisions perpetuated the inequalities that existed based on math education presented to students from different groups. There was a harsh decline in the number of students taking formal algebra in high school in comparison to the first half of the century. The implications of this decline led to an unfair advantage, and learning specific mathematical topics that were important for the future drastically changed. The development of cognitive abilities in mathematics lessened, closing groups of students off to attaining higher education and professional degrees (Ellis & Berry, 2005).

The modern mathematics movement in the 1950s and 1960s, known as the “New Math” progression, was created as a response to the pedagogical practices that prepared students for specific roles in society. Developing a rigorous curriculum for specific groups of students became a priority. Finally, mathematicians who understood the reasoning behind learning various topics were involved in developing mathematics curriculum for schools (Klein, 2003). The goal became to give practical explanations to mathematical procedures, with a focus and emphasis on the logical explanations. With Russia’s launch of Sputnik in 1957, the government used funds from the National Science Foundation (NSF) towards creating the School Mathematics Study Group (SMSG). The role of the SMSG was to create and distribute textbooks to schools nationwide in order to rectify the slow progression of math education for its elite students, a specific effort made for privileged folk (Ellis & Berry, 2005). The goal was to support students who were viewed as becoming the most successful in our society. The effort was not successful, especially for low-achieving students, and ultimately led to a return of basic skills education (Stanic & Kilpatrick, 2004). There were certain groups who benefited, creating a hegemonic movement in education. Deprivation of an effective mathematics education left others without tools necessary for success in career fields. The modern mathematics movement did not have its intended effect on education. At this point in time, curriculum was not being viewed as a means to make moral and ethical decisions: the question of the purpose of education, along with the purpose of learning mathematics, was not answered (Stanic & Kilpatrick, 2004). Those in power and control of educational decisions benefited from the decisions that were made, leaving the rest of citizens with a deprived mathematical education and setting up a stage for unsuccessful mathematical experiences.

Throughout the 1990s, there was a hierarchical movement of learning math curriculum. This led to courses introducing content that was highly dependent on assumed skills that were supposedly learned in previous math courses. Mathematicians supported this understanding of building math knowledge, however, the importance of teaching mathematics turned into a constant look at filling gaps of knowledge that students had when enrolled in high school math courses. The assessment strategies that were being used followed closely to traditional methods. Reform-based assessments still incorporated a skills-based approach. The Math Wars occurred as a result of introducing textbooks with diminished content and the absence of reviewing basic skills. Curriculum was severely criticized by organized rebellions consisting of parents, mathematicians, and educators (Klein, 2003). To move away from the textbook-dependent teaching methods, liberal math programs stopped using books to teach, and relied on having students discover various mathematical concepts through applicable activities that helped make connections to the real world. Connections of mathematical concepts to real world situations helped students perceive the value in learning mathematics. Although it was difficult for educators to make curricular and assessment decisions, the beginning of the new millennium forced leaders in education to think about the importance of mathematics and its connection to the real world. Once again, the events taking place in the outside world determined practices in the classroom. As was seen in past reform movements, however, these curricular decisions only benefited specific groups and led right into more accountability, standardization, and testing in assessing student knowledge (Baines & Goolsby, 2013; Ellis & Berry, 2005).

Even with these major reform movements in place, the structure of mathematics curriculum followed skills-based education – whether it was for lower-level students or to fulfill specific roles in society. The effect of this watered-down programming pushed leaders in the mathematics education community to rejuvenate curriculum. The passive role of teachers and students along with a failure to have professionals in the field to be a part of the decision-making process made it difficult for changes that benefited all people to occur. Support towards students who were viewed as college-capable limited access to students from various backgrounds, ultimately creating inequalities within the realm of mathematics education. Although we have faced various modes of reform towards math education, it is quite obvious that the success has only shown *revisions* of methods already in existence. As is supported by many theorists in the field of education, the reform movements have always looked for a common ground or quick-fix answer to the questions that involved teaching mathematics. However, schools must operate under the structural constraints of education, which puts limitations on the possibilities as to what they can accomplish.

The Hidden Agenda and its Effects on Students

Apple's (2004) ideas about how to interrupt current social inequalities rely on understanding the ideologies of a hegemonic society. Many social and cultural ideologies that develop over time are used as instruments of hegemony throughout curriculum development. These aspects of culture and society lead to the development of educator ideologies that are used in the classroom. As educators continue to use current practices in the classroom for students with learning disorders, they are perpetuating a labeling process of putting specific students in categories – creating inequalities that continue to exist. The true reasoning behind current curricular decisions serve very specific groups of people, further dividing the oppressed groups that may not have the same opportunity for power and access (Apple, 2004). The knowledge taught in schools does not allow students to understand their positionality in regards to culture or the economy. The division of particular groups, where specific people are benefiters while the others fall on the wayside, gives meaning to the relationships amongst these groups and shows how society is organized. The oppressors create the division of people (Apple, 2004). The reproduction of the labor force and division of labor forces in society can be avoided if we allow disadvantaged groups, such as students with learning differences, exposure to opportunities that can lead to not just access, but also control over their futures in learning mathematics.

The current systems of assessment-based pedagogy and a focus on standardized curriculum also create social inequalities. We have students who are being taught in a way that does not work for them, and then we have their failures being utilized as modes of grouping and placements in the spectrum of society. The position they hold similarly models oppression. The label itself puts *students who learn differently* into the oppressed category – making their peers, who may not need the accommodations, and the teachers, who must teach them the strategies given their weaknesses, the oppressors. This relationship adds to the continued development of social inequalities.

The conservative agenda asks for control of curriculum, putting the blame on schools and teachers for any failures that students may face. However, the standardized curriculum that is produced by people in power aims to keep control over the funding for schools (Apple, 1992; Baines & Goolsby, 2013). The accountability measures have decreased support for public schools, and in effect taking away funding that is able to help maintain strong programming for students with learning disorders. The aid we provide to our students should not be reactionary, but rather proactive in diminishing the inequalities. Current constructions of problems surrounding differences in gender, class, and race lead to issues of power and actions based on self-interest. When thinking about students who learn differently, Apple (1992) discusses the issue in labeling measures. The various methods of determining achievement levels are socially constructed and add to the identity development of individuals. These labels guide the use of curriculum, tracking, and the use of resources in the classroom. Dominant institutions impact the intersection of gender, class, and race, along with achievement levels and learning styles.

The hidden agenda of governmental control through knowledge plays a role in developing curriculum for students who can in return benefit the country. A focus on the knowledge that is important, that is, knowledge that leads to profit and control, forms the competitiveness of our economic society. We live in a capitalistic system that perpetuates the production of knowledge that is needed for businesses and profitable industry to sustain its control in society. The top-down approach used to formulate the content that is taught to specific groups of students adds to and grows the economy that we have (Apple, 1992). With this ideology in mind, knowledge is considered a form of cultural capital. Meritocracy drives motivation and knowledge becomes a valuable asset for people who attain it. Specifically, mathematical knowledge provides benefits to those who are exposed to the strengths in learning how to use it for personal gain. It is in this valuation of the subject matter that propagates the socioeconomic utility of mathematics as a subject area, rather than its practical characteristics in the natural world (Apple, 1992). The capital that is increased for certain students, and the lack of exposure for others to this form of critical thinking, creates further divides amongst groups of people.

In thinking of ways to deconstruct the inequalities and utilize mathematics as a means for change for all students, it is important for educators to help students develop mathematical literacy. However, mathematical literacy should be developed not to serve the political purposes regulating and controlling society, but rather to critique and positively transform society (Apple, 1992). It should be regarded as critical literacy, as explained earlier, leading to the development of language that can be used to connect the subject matter to student experiences that are of personal importance. Educators should create experiences for analyzing and refuting the social inequalities that exist through mathematics. As various topics of equity are discussed, teachers must make an effort to include all perspectives and issues of society. The conservative agenda that holds true for the specific groups in leadership will choose to include issues that will in fact keep inequalities in existence. True social issues are kept out of the standard-based documents produced for curriculum. Standardized curriculum, an increase in control over what is taught in classrooms, and an expectation to utilize the resources that are provided by our government are all forms of controlling our teachers. Federally supported privatized companies produce these resources and they profit from creating this curriculum for all students.

The question educators should be asking themselves is *which* social issues should be considered as valuable to mathematical education. In curricular history, the social problems that are discussed often perpetuate the inequalities that already exist. Critical mathematical literacy development towards social issues such as lowering of pay, concerns over job losses, cutbacks in payments for welfare, and financial aid can be used as a strong and effective tool in connecting mathematics to giving the oppressed people in increased level of cultural capital. Problem-centered math curriculum can be better integrated into students' daily lives (Apple, 1992). The goal is to provide mathematical experiences for students with learning disorders in order to take advantage of its potential purpose in helping achieve social equity. Transforming mathematics curriculum so that it is accessible for different learners gives them access to bringing about change to social, political, historical, and cultural issues.

As we move towards making gains in educational improvements, we should raise questions about the beliefs that have determined the current presentation of mathematics curriculum. It is important to change our thinking as we teach and learn mathematics in our current world. The exhausted idea that mathematics is learned through the repetition of practice problems does not allow students to realize the importance of mathematical thinking in problem-solving situations; and the perspective that learning mathematics is not promising for certain students based on their backgrounds fails to acknowledge the importance of using mathematical knowledge as a tool for equity.

The benefit of having students develop their cognitive abilities leads to learning how to use the facts and skills to make conclusions, form arguments, and use logic to solve future problems. It is important to give students an opportunity to apply the learned ideas and the gained knowledge to take on social roles that are beneficial for society. Through this framework, students would find the role in the world in which they live. The implications of developing a student-centered education leads to the future development of a society where members are able to contribute not only by using skills and fulfilling specific roles, but also by being a part of a world in which they can do good. Through the educational experiences educators provide for students, members of society can be prepared to take on the issues that exist and use their developed selves to positively contribute. However, our current state of education has been formed through time with specific perspectives deciding what is important. Curricular issues may not be completely solved or agreed upon by all members of society, but an understanding that a student-centered approach to teaching and learning may lead to more positive contributions from its members. All members of society – including all learner types and people who can contribute – should have access to an effective education. Current curricular policies and practices focus on things such as standardized testing and holding educators accountable for not reaching set standards. These practices result in the reproduction of social inequalities. Curriculum provides the necessary tools for social and political reform, but can also perpetuate class structures and reproduce social inequalities (Kliebard, 1987). Through various instances in the course of history, education has played a major role in providing resources to our students, while taking away an ability to use knowledge for true development. As we move forward in making decisions and presenting curriculum, it is imperative that a student-centered approach is utilized – for both the student identity development and for our shared society.

Goals of Research

The research presented in this dissertation study aims to answer important questions related to experiences of students with specific learning disorders, such as developmental dyscalculia, that affect overall interest in learning mathematics. This includes the experiences that have led to a negative identity formation in relation to math achievement, implications of elementary school experiences on overall interest in mathematics during high school, and fields of interest even with the particular diagnosed learning disorders. Through a quantitative analysis of questionnaire responses and a document analysis of journals, the purpose of this research project was to look at the associations that are created for students with learning disorders in the formation of their mathematical identity, and how these associations have played a role in forming their mathematical identity. What connections can be bridged between confidence in learning mathematics, career interest in mathematics, motivation in mathematics, and anxiety in mathematics? This includes the individuals' interests in utilizing the subject of mathematics in their future, including college major choices and career field interests.

The researcher presents data analysis that educators can use to understand the aspects of identity formation implemented into teaching practices to help students form positive identities of acceptance when learning mathematics. The goal is to help students not be dissuaded from their fields of interest that may involve learning mathematical procedures and problem solving. Educators must address the depleted mathematical identities of students, especially at the secondary level.

Conclusion

Students have experiences in learning mathematics based on memorization and quick calculations. There are specific individuals diagnosed with neurodevelopmental disorders affecting their problem solving and arithmetic processing. However, there is potential to use the subject matter to develop critical thinking skills that can be very important to their future roles. A look at the neurological reasoning for students with learning disorders related to mathematics can lead to sharing effective ways to present high school level mathematics so that these individuals can still be successful. There are specific cultural implications of being a lower mathematics student, which are socially constructed based on test scores and placement exams. Children with numeracy issues are held back from learning the higher-level concepts and are often not given an opportunity to experience learning these topics.

Mathematics has the potential to help all students create strong connections between lived experiences and other subject matters, leading to a development of utilizing mathematics towards future roles in society. Further, the critical thinking involved with mathematical concepts can be applied to authentic experiences that surround equity in society. The historical decisions that have been made related to curriculum have set up cultural expectations for learning mathematics for mere assessment and admission requirements. However, students who learn differently due to their learning disorders are unable to take advantage of applying mathematics to important career fields because of these accountability measures. Refuting the socially constructed views towards students who learn differently can lead to creating opportunities for all students to communicate mathematically and create positive social change.

The socially constructed viewpoints of labeled students who learn mathematics differently is addressed in this research. The oppressive manner of current curriculum and accountability measures do not allow for these students to develop into contributing members of society, given their learning differences. Their ability to take part in a meaningful role in society is stripped away as they are placed in groups that have socially constructed meanings. The dominant ideologies and social constructions of individuals in our current system include those who can be successful in memorization and testing techniques that allow for higher standardized test scores. These scores then play a role in the high-stakes college admissions process (Baines & Goolsby, 2013; McDermott, 2013). Students who are categorized and placed into a group with the label of having learning disorders face difficulty in engaging with personal interests.

The theoretical perspective when conducting research related to this topic takes into account the positionality of students with learning differences, the oppression that is faced as a student who is labeled, and the socially constructed meanings that surround these students as they experience schooling and form their mathematical identity. However, it is important to acknowledge the scientific reasoning for the existence of mathematical learning disorders. This research may give students an opportunity to learn mathematics, providing an important tool to be successful and have the opportunities that are available to their classmates. Tracking systems keep students with learning differences in their place, not giving them full opportunity to be successful in learning higher-level mathematics. These individuals may still be successful in entering a field that requires critical thinking, even with their numeracy issues. The research study that follows may help to deconstruct the placement of students into labeled groups.

In order to compete in a world that is ever-changing with advancements in math and science, an objective approach to teaching mathematics pervades the curriculum that is presented to our students (Ellis & Berry, 2005). This includes a test-preparatory culture, quickly bringing down students who are unable to score high enough to be placed in advanced courses. Students with learning differences are at a disadvantage when their challenges do not allow them an opportunity to express their potential critical thinking skills, and rather are placed into mathematics courses that are watered down and only focused on achieving a skill-based education (Apple, 1992).

Dimensions of social difference and inequality can be embedded in all research because the idea behind conducting a study to make conclusions is to bring about change in opposition to the currently socially constructed views about a certain group of people. In my particular area of inquiry, I believe it is important to discuss this topic because the particular group of individuals deserves the opportunity to be successful like their peers. The reflexivity involved in this process requires me to consistently ask how I am helping these students and ways we can work to oppose the hegemonic practices that exist. My work can show the success of students with learning differences, and how they can still have a seat at the table of societal roles and influences. The labeling process should not place certain people out of the opportunities that are available. In representing this group, we can then formulate ideas and arguments for all groups that are considered oppressed – such as marginalized groups based on race and gender. It is important to note that the existence of a social problem derives from the possible solutions that can be offered. Understanding the issues of practice, society, and/or culture can lead to action and forming agents of change.

CHAPTER 2:

THE NEUROLOGICAL DIMENSION OF MATHEMATICAL LEARNING

The aim of this literature review is to (a) provide educators with information regarding the formation of identity as a student when experiencing K-12 education, with specific focus on the development of mathematical identity. The review also includes (b) neurological reasoning behind learning disorders (disabilities, differences) and how they impede mathematical achievement, including research studies that have been conducted in order to study the specific ways that the brain is affected by the learning disorders. Finally, the review (c) discusses the importance of mathematics involved in students' post-secondary and career decisions. Providing this collective information can inform the curricular decisions surrounding the teaching of mathematics to students with learning disorders while also helping to positively form a mathematical identity with implications on their future.

Identity Formation

Identity is developed through the collection of an individual's experiences and decisions that are made each day. An individual's experience in school can pave the path for decision-making and ultimately, future life. Various researchers have contributed important developments in research surrounding identity formation, all supporting claims that the navigation through schooling experiences has a large influence on the formation of identity (Allen & Schnell, 2016; Baines, 2014; Darragh, 2013; Flum & Kaplan, 2012; Kroger, 2004; Teng, 2019; Wenger, 1998).

The participation that takes place in engaging with others, collaborating with peers, and dialogue leading to the exchange of knowledge influence the way in which identity is formed (Wenger, 1998). This engagement, however, is important for students to experience in their communities and their surrounding world. Providing knowledge, resources, and literacy to take part in this engagement is an important aspect of education, influencing the formation of identity. Wenger (1998) is a proponent of the concept of social engagement, claiming it is an important aspect in identity formation. Individuals are able to formulate an understanding of the world around them, how they can personally influence the society in which they live, and develop a sense of their individual selves (Allen & Schnell, 2016; Flum & Kaplan, 2012; Kroger, 2004; Teng, 2019; Wenger, 1998). The collection of experiences from the past is synthesized with the experiences of the present and future. Baines (2014) explains that the understanding of self is developed through the sociocultural relations that take place from engagement in everyday actions. Teng (2019) uses a combination of theories related to identity to explain that the value of economic, cultural, and social capital comes across changes as individuals are exposed to various ideologies. This leads to shaping their identity in different ways. It is also the intersectionality of these sources of capital that form different levels of value, forming self-created priorities.

The role of education is important to identity, in that its influences can determine an individual's life stages. As a student, identity development does not come only from the self-perspective and reflection within. Rather, an understanding of one's role in the world structures the decision-making that takes place (Norton, 1995; Teng, 2019). For this reason, it is important to form social environments that help support individual growth and identity development. A common misconception surrounding identity formation is related to self-responsibility. However, identity can be developed and constructed by the influences of the communities and cultures that surround the individual (Jones, 2003). In the end, the ideologies of self are influenced and formed by various experiences throughout schooling and beyond (Benson, 2011; Teng, 2019). For this reason, the educational settings that students come across should allow for opportunities that lead to various experiences, leading individuals to find ways to express their interests and develop their own talents (Kroger, 2004). This can further lead to effective social roles.

Mathematical Identity

Specific to mathematical thinking and learning, students form their personal mathematical identity based on their experiences. Spaces where students are learning provide influential modes of competition and evaluation. The student experiences in classrooms lead to reflection of self in comparison to others (Bishop, 2012; McGee, 2015). Identity in relation to the learning of mathematics should involve individuals learning the subject matter for more than just the memorization of facts or to compete with others based on test scores. Mathematical identity development should focus on the process in which an individual becomes a stronger learner of the subject matter (Darragh, 2013; Lerman, 2009). Embracing the subject matter as a means to identify and problem-solve the issues in the world is an important aspect of learning and using mathematics. An individual's self-confidence drives participation in mathematical experiences. The relationship they form with the subject matter reflects their own mathematical identity (Allen & Schnell, 2016; Cranfield, 2013; Leatham & Hill, 2010). The focus and utilization of mathematics as a subject matter is fixed in our current world, negatively affecting the potential trajectory of students' lives in future pathways (Allen & Schnell, 2016). The theoretical perspective that supports the development of a mathematical identity can be considered developmental and cultural (Cranfield, 2013). Development of self involves relating the subject matter to various roles of life, leading to the individual's development and identity formation. Culturally, an individual reflects on their experiences and interactions with society, including the social norms that surround the learning of mathematics.

The culture of mathematical learning involves the social contexts of being a “good” or “bad” math student, where certain students are at an advantage because of their natural ability of learning mathematics (Cranfield, 2013; Radovic et al., 2017). Students with a lack of the traditionally focused mathematical abilities of speed and accuracy become marginalized and are deemed “bad” math students, which develops self-defeating attitudes about themselves (Allen & Schnell, 2016; Cranfield, 2013; Oslund & Barton, 2017). Boaler et al. (2000) argue that the focus of helping students find their personal connection and interests in mathematics is more important than showing them that they are able to do basic mathematical calculations. Helping individuals become mathematics students within their own identity formation creates value, sense of belonging, and positive disposition within the subject matter (Boaler et al., 2000; Cranfield, 2013; Darragh, 2013; Leatham & Hill, 2010; Oslund & Barton, 2017). The construction of mathematical identity is a process in which importance is given to the social contexts that come from experiences and engagement with others (Bishop, 2012; Darragh, 2013; Jones, 2003). This idea is supported by Wenger’s (1998) ideological explanation of identity formation through an individual’s participation in society. Even as members of the mathematical community, individual contributions should be valued (Allen & Schnell, 2016; Boaler et al., 2000; Darragh, 2013; Leatham & Hill, 2010; Wenger, 1998).

The social context of performative behavior influences the formation of mathematical identity. Students find themselves expressing different levels of confidence in their mathematical abilities in the classroom. Hardy (2007) discusses the importance of helping students find this confidence in doing mathematics, and how seeing themselves as confident and competent learners of mathematical thinking can lead to more positive learning experiences and a stronger mathematical identity. This construction of confident performative behavior influences the way in which a student experiences learning mathematics (Darragh, 2013; Hardy, 2007; West & Zimmerman, 1987). In their research, Leatham and Hill (2010) discuss various words that can be ascribed to mathematical identity, including the terms creative, obedient, and social. These terms may not be considered when describing the typical mathematics student. A shift in perspective to include those who may see themselves as creative, obedient, or social can create an overall more confident outlook and motivation towards building a positive mathematical identity.

The formation of a positive mathematical identity also comes from the culture that is created in the classroom. Identity formation is dependent on both self-reflection and comparisons that are made to others. As students discover their capabilities within thinking mathematically, they are performing their mathematical identities. The mathematical thinking that is involved in doing mathematics may be informally shown through the use of mathematical facts, skill sets, and knowledge. This action of doing mathematics involves the reflection of past experiences in mathematics, and how they affect the current and future experiences in learning the subject matter (Cranfield, 2013). Linking these experiences together can help form a more positive identity that involves reflection and learning from one's challenges. It is a positive approach to help develop an identity that allows an individual to change their perspective on learning mathematics, even after facing these challenges. Discussion-based classrooms allow for expression of mathematical thinking, allowing all students a chance to be heard (Boaler, 2002). Educators should help develop engagement with the challenging work of mathematical thinking, which is a sign of a strong mathematical identity (Bishop, 2012; Oslund & Barton, 2017).

Sociocultural experiences also contribute to formation of identity for students engaging in mathematical thinking. The interactions and contributions that are made to the communities in which the student participates both in and out of school lead to the perspectives and attitudes that individuals have towards the subject matter (Boaler, 2002; Cranfield, 2013). For this reason, providing more positive mathematical experiences is vital to mathematical identity. Without the proper guidance through these processes, a student may face the various barriers and challenges to their learning of mathematics. Unfortunately, it is through these unresolved experiences where doubts regarding the subject matter influence identity development, causing individuals to then avoid mathematical experiences (Boaler, 2002; Cranfield, 2013). The mathematical identity formation, in this perspective, does not only form an attitude towards the specific knowledge and skills that are involved with mathematics, but also a relationship with this knowledge and these skills. The development of this relationship with the mathematical subject matter comes from self-assessing the skills one has learned, along with knowing how to utilize the knowledge (Boaler, 2002; Cranfield, 2013). Mathematical identity allows students to reflect on how they define their position as a learner of mathematics, the goals or aspirations they may have related to the subject, and includes all experiences that impact the relationship they find themselves creating with mathematics.

Understanding the level of engagement with the subject matter has become more important with recent researchers, looking at how mathematical identity can influence the individual's relationship with mathematics (Black et al., 2010). This includes an important inclusive culture involving the individual's sense of self, developmental changes, and the role of understanding mathematics within these changes. Black et al. (2010) detail connections between student conceptions of self with performance of the subject matter. Researchers explain how important it is to consider identity's role in helping students understand the function of mathematics as a social practice, and that each individual has an opportunity to participate (Black et al., 2010; Jones, 2003).

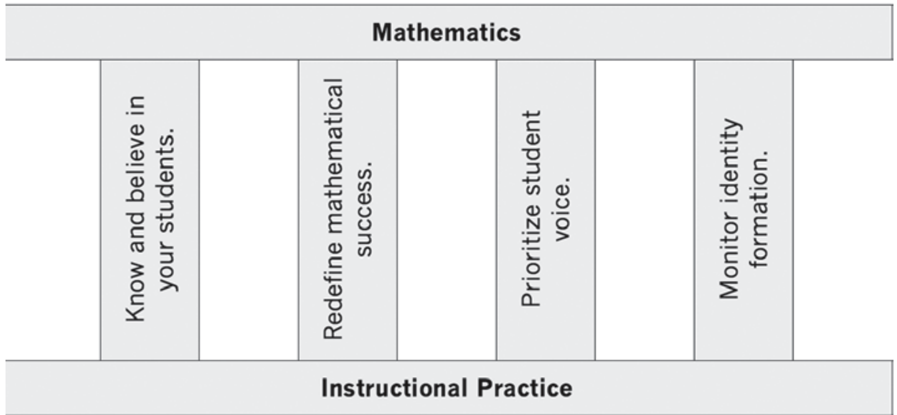
Supporting the Development of a Mathematical Identity

Various theories, strategies, and curricular components have been introduced into research to support the development of a mathematical identity. Carol Dweck (2006) helps educators re-frame the mindset used by students when they are in a learning environment. Differences between a "fixed" versus a "growth" mindset provide explanation as to how students can develop a sense of capability within learning mathematics. A fixed mindset follows the traditional belief that an individual is born with certain traits that cannot be changed. This adds to the thought process that a student is either a good or bad math student. A growth mindset, however, allows individuals to realize that the brain has the ability to continuously create neural connections and become stronger as it is developed (Dweck, 2006). Neurologically, brain malleability allows it to have the ability to grow as it is challenged to problem solve through new modes of thinking. The more practice and exposure an individual receives to a specific learning environment, the less challenging the task becomes (Allen & Schnell, 2016; Dweck, 2006). Applying this mindset in the mathematics classroom can help develop a more positive mathematical identity – where individuals can use scientific reasoning to understand they can increase their potential to learn mathematics. The increase in confidence and motivation towards learning mathematics can lead to a stronger mathematical identity.

Allen & Schnell (2016) provide four important pillars of instructional practice that educators can use to develop a system of support for students' mathematical identities (see Figure 2.1). The pillars include getting to know the students, redefining what success means, prioritizing the students' voices, and continuously monitoring identity formation as critical steps in developing an overall stronger mathematical identity (Allen & Schnell, 2016). Getting to know your students as mathematical learners can frame ways to help them understand their

Figure 2.1

Mathematical Identity Pillars of Instructional Practice



Note. The four pillars of instructional practice are to support the development of mathematical identities (Allen & Schnell, 2016).

personal potential in learning the subject matter. Growth in learning mathematics may look different for each student, but knowing when a student achieves various milestones can make a positive influence to their learning environment (Allen & Schnell, 2016). Allowing students to tell their own stories in mathematical learning can help the educator understand the history of the individual's positive and negative experiences.

In redefining the meaning of success in mathematical thinking, Allen & Schnell (2016) explain that students can benefit from collaborating with their peers and learning how to make contributions surrounding mathematical discussions. The problem solving that involves mathematical thinking should take precedence over memorization techniques and answering questions based on time limits. The focus of mathematical thinking can shift from getting answers right every time to being able to support and communicate mathematically. Some of these talents that can be developed as components for mathematical success can include the development of questioning, being able to restate others' ideas, using diagrams, graphs, pictures, or other visual modes to display their thinking, and even working with a calculator to help lead to important conclusions (Allen & Schnell, 2016). Along with developing these traits, a shift in the mindset for how students receive feedback on their work should also occur. Rather than viewing their mistakes as negative feedback, students should be supported in learning from their errors (Allen & Schnell, 2016). The process of learning in mathematics involves understanding why certain errors occur in the first place. The neurological experience of self-assessing errors and learning from mistakes is an important aspect of the educational process. The social context of making errors in mathematical work should be changed so that students learn to utilize the experience as a reason to learn and grow. The goal should be shifted towards allowing all students to contribute their thinking to a positive learning environment, whether fully correct or not, and using that opportunity of engaging in dialogue with their peers to learn from each other.

In order to shift this social context of learning mathematics, it is important to prioritize the opportunity for students to engage in discussions surrounding the mathematical concepts they learn. Rather than expecting students to independently own their learning, the classroom can become a space of learning allowing students to think out loud and share thoughts that may lead to questioning the challenging aspects of learning mathematics (Leatham & Hill, 2010). As a third pillar in developing a positive mathematical identity, Allen & Schnell (2016) advise teachers to help students make conjectures in the classroom, and then utilize discussion methods to agree with or refute the ideas presented by their peers. The focus of the experience is on how the individuals can collectively understand and express their mathematical thinking, where the sharing of both right and wrong answers is accepted. Radovic et al. (2017) describe the formation of a mathematical identity as a dialectical process. The relationships that are formed from discussions and dialogue in a mathematical setting can add to an individual's mathematical capital. The aspect of mathematical identity that is developed through this process can give access to resources or can play a role in students' positionality within the mathematical world (Radovic et al., 2017). The social interaction that occurs between students plays a part in forming their mathematical role within their relationships with peers. This process adds to the mathematical identity of each individual student, further developing their personal views of how they see themselves when it comes to doing mathematical work. This understanding can help frame the importance of taking into account the marginalization of diverse groups within the population of individuals learning mathematics (Radovic et al., 2017). It further supports the need for practices that can help support various learner types of mathematics.

It is critical for educators to help students learn how to self-assess their learning process. The experiences of mathematical thinking are dependent on how students formulate their questions, articulating what they know and what they need to learn. The concept of mindset and an understanding of forming mathematical identity are important to this process. In developing a strong mathematical identity, students should be viewing the learning of mathematics as a process in which they monitor their understanding so that the subject matter is seen as ever growing and developmental (Allen & Schnell, 2016). As educators, we should aim to understand the diversity of identities that will develop through various mathematical experiences. It is in understanding these various identities where we can increase awareness and positively influence the dispositions our students hold towards mathematics (Leatham & Hill, 2010).

Mathematical Identity within Marginalized Groups

Identity is dependent on an individual's environment through various experiences and is formed based on the social contexts of these experiences. For this reason, being a member of a marginalized or oppressed group forces certain challenges to arise as identity is formed. McGee (2015) explains how individuals must learn to negotiate the various aspects of their identity that can be revealed depending on the social context. This negotiation is an unfortunate product of the social norms that are formed surrounding being a learner of mathematics. Individuals associate themselves with multiple groups, getting exposed to various experiences that form identity – whether that includes race, gender, social class, religion, or cultural aspects such as language, family, residence and academic history (Allen & Schnell, 2016; Jones, 2003). These modes of exposure that help form identity also implicate an individual's positionality in the world. The powerful aspects of these divisions are important to acknowledge when explaining mathematical identity formation for individuals belonging to marginalized groups. These individuals belong to a cultural or social group that does not have the same privileges as individuals considered to be a part of the majority. In regards to mathematical identity formation, these marginalized groups of students have repeatedly heard how they do not fit the mold of a "good" math student, whether this idea stems from their race, gender, or learning style (Cranfield, 2013).

Within various racial groups, researchers have focused on the successes and failures of minority students learning mathematics and the apparent achievement gap that exists within this group (Lubienski, 2002). McGee (2015) presents an issue with the attitude that is held by those who teach mathematics to African American students. There are particular racial disparities that exist within mathematics achievement, and without a deeper look into the lack of African American student representation within above average mathematical students, the racial biases continue to exist. Predicting their assumed failure within the subject matter does not allow the exploration of minority students' successes in the field, and adds to the racialized nature of the experiences African American students face within mathematical learning (McGee, 2015; Tine & Gotlieb, 2013). The trajectories of underrepresented racial groups for both academic and career fields related to mathematics are impacted by the various experiences that add to mathematical identity formation. Researchers suggest that removing racial stereotypes and discrimination can help these marginalized individuals shift the societal narrative away from low mathematics achievement expectations (Lubienski, 2002; McGee, 2015; Tine & Gotlieb, 2013). The practice of grouping and labeling "good" and "bad" math students adds to the assumptions that are made based on societal norms.

Similarly, this binary grouping exists in comparing the female and male genders in their mathematical achievement. The subject matter has been socially accepted as appropriate for male students, leading to a dominated gender gap within fields related to mathematics (Jones, 2003). Bieschke & Lopez (1991) introduce the concept of sex-role identity and informing assumed roles in society, perceptions of societal norms, and how this placement takes place within society based on gender and/or sex roles. Trying to fit females into their feminine roles based on societal pressures leads to an identity development that follows expected norms (Bishop, 2012; Jones, 2003; West & Zimmerman, 1987). The intersection of both gender identity and mathematical identity forces female students to decide how and when to take criticisms regarding their mathematical abilities, leading to circumstantial identity development (Bieschke & Lopez, 1991; Boaler, 2002; Radovic et al., 2017; Solomon, 2007). Females going through this process are unlikely to develop positive self-efficacy towards mathematical abilities, leading to decreased interest or aspirations in careers and occupations related to mathematics and science.

Efforts have been made to make the mathematics and science fields a more viable option for female students. This stems from creating a change towards the conflicted views women have formed towards the subject matter over time, including their relationship with the content, underperformance in the skills related to these subjects, and the social discourse of what it means to be a mathematics student (Darragh, 2013; Radovic et al., 2017). A false perspective has formed with time, claiming certain traits that women inherently possess make them ineffective learners or users of mathematics. This includes and inability to face the competitive nature of calculating, as well as an ineffectiveness regarding the repetition, practice, and rote learning involved with mathematics (Bieschke & Lopez, 1991; Boaler, 2002; Radovic et al., 2017). Having female students understand their position in society as a mathematics student is important to forming a more positive identity. The crucial relationship between the student and the subject matter has an effect on interest level and overall position the individual decides to take within identification with the subject matter (Bieschke & Lopez, 1991; Bishop, 2012; Radovic et al., 2017; Solomon, 2007). It is through a series of conflicts and negotiations of standards that these women find themselves working against the traditional roles and discourses surrounding a male-dominated area of study. Accepting their "bad" performance in mathematical thinking is a normalized discourse in our society (Darragh, 2013; Radovic et al., 2017; Solomon, 2007). The relationship between gender and mathematical identity formation is a work in progress, where the less normalized classrooms are finding ways to create less gendered perspectives for female and male students to pursue their positive identity and interests in mathematical thinking (Torres, 2012; West & Zimmerman, 1987).

Mathematical Identity for Students with Learning Disorders

Students with learning disorders are often overlooked in respect to marginalized populations in society. This specific group of individuals faces the inequalities that exist due to social constructs surrounding their different learning style, however, they must also work through understanding the scientific reasons for their learning disorders. For this reason, this marginalized group is exposed to multiple modes of difficulty when placed in a learning environment. This is not to say, however, that the intersection of race and gender does not play a role. In fact, it is important to note that an individual belonging to the minority race, gender, and learner type groups would face the utmost challenges when learning (Connor, 2006; Gibson, 2006). The large percentage of individuals affected by learning disorders, according to census data, helps realize that individuals from minority groups also facing learning challenges come across the most negative experiences when attempting to be contributing members of society. Historically, a learning challenge was viewed as a medical issue that could only be treated with medicine or surgery (Gibson, 2006). The approach of dealing with learning challenges as an objective issue deemed those individuals as out of the ordinary, having a neurological defect or a loss of normal function. Treating these individuals with a sole scientific and medical approach was viewed as being enough – completely removing the subjectivity that is so important in approaching different learner types (Gibson, 2006). Naturally, these students learn to develop an identity that relies on facing expectations that are constantly unachievable with feelings of inadequacy based on what is considered normal learning. They are forced to believe that their need for support in the learning process equates to incapability of the same successes in the world of learning (Gibson, 2006).

The focus on students with learning disorders is important for educators when creating the various educational experiences that lead to identity formation. There is a specific need for research within the development of mathematical identity for students with learning disorders. Researchers discuss how the development of this identity starts from the labeling process of a student's disability and how educators are able to frame a learning environment, even with the learning challenge. Baines (2014) discusses the importance of the dialogue and relationships that form surrounding individuals with learning disorders. The terms that are used to describe these learners can have a lasting impact. Stigmas surrounding the fact that they are subpar based on normalized student expectations lead to a lowered sense of self in a learning environment (Baines, 2014). In order to work against the social expectations, a transformation within our culture and structures would be required. This change can occur based on the mindset that an educator brings to the classroom – where students with learning disorders are considered important individuals, strong learners, and led by those who hold a positive mindset for their abilities and capabilities. This takes an effort to understand and learn about the experiences and various social interactions that may have taken place to help understand their identity (Baines, 2014; Gibson, 2006; Wenger, 1998). In order to include the ways in which these students learn, we have to question the current system of measuring intelligence and ability. Increasing awareness of different learners with learning disorders can help positively develop their identity, including an approach to viewing the learning disorder as a part of their identity, rather than being the sole identifier of their individuality (Baines, 2014; Gibson, 2006). Using a negative approach towards creating a learning environment for these learners can lead to negative effects – the perceived perceptions that are developed towards students with learning disorders can shift the way certain systems will affect student learning (Baines, 2014).

Gibson (2006), along with other researchers, explains the importance of developing student beliefs, attitudes, and emotions in the classroom. Coined as the *affective domain theory*, the connection between these various aspects is important to the student's learning process and identity development. Not only does affect make an impression on beliefs, attitudes, and emotions, but researchers have also discussed its relation to cognitive development, motivation, mathematics, and problem solving (Cranfield, 2013; Gibson, 2006; Gibson et al., 2012). Understanding the connection of the affective domain theory to cognition leads us to its importance in forming mathematical identity. The stages of identity development for students with learning disorders, according to Gibson (2006), include the following:

- Passive Awareness: students are unable to recognize their disability and what it means for their positionality
- Realization: students recognize their disability and try to reconcile their relationship with members of society
- Acceptance: students begin to view themselves as equal to their peers, embrace their disability identity, and develop a group disability identity

Gibson (2006) presents the Disability Identity Development Model (see Figure 2.2), which categorizes a student based on their perceptions and struggles with learning. Placement within this model is based on the positionality due to their learning disorder and gives the individual clear insight into their identity. With this model, fluidity within identity categorization exists. Even after reaching acceptance, for example, an individual may face experiences that

Figure 2.2

Disability Identity Development Model

STAGE 1 Passive Awareness: First part of life 0-? Can continue into adulthood	STAGE 2 Realization: Often occurs in adolescence or early adulthood	STAGE 3 Acceptance: Adulthood
-No role model of disability -Medical needs are met -Taught to deny social aspects of disability -Disability becomes silent member of family -Co-dependency/" Good-Boy/Good-Girl" -Shy away from attention -Will not associate w/others w/disability	-Begins to see self as having a disability -Self-Hate -Anger: Why me? -Concerned with how others perceive self -Concerned w/appearance -"Superman/woman" Complex	-Shift focus from "being different" in a negative light to embracing self -Begins to view self as relevant; no more no less than others -Begins to incorporate others with disabilities into life -Involves self in disability advocacy and activism -Integrates self into majority (able-bodied) world

Note. Gibson's Disability Identity Development model provides various stages of identity formation as students with learning disorders experience living and learning (Gibson, 2006).

retroactively lead to behaviors in the realization stage (Gibson, 2006; Gibson et al., 2012). Social constructs continuously affect the way an individual faces their disability within this model.

Research-based instruments can be used to measure aspects of the affective domain theory that are also expressed in Gibson's Disability Identity Development model. The distinction between effects of overlapping experiences that fall under attitudes, beliefs, emotions, and values is at times challenging to create (Ren et al., 2016). The presence of math anxiety, for example, can be considered an emotion, attitude, or cognitive issue, making it a challenge to place this aspect of mathematical identity into one category (Ren et al., 2016). The affective domain theory is involved with the confidence, motivation, and levels of anxiety towards mathematics that play a role in forming identity within mathematical learning.

The formation of mathematical identity for students with learning disorders involves the attitudes that are formed towards learning the subject matter. These attitudes, along with levels of self-efficacy, have been researched to investigate their relation to mathematical learning (Bieschke & Lopez, 1991; Ren et al., 2016). The attitudes used in forming what we understand as mathematical identity define achievements within the subject matter. Anxiety leads to lower performance, even with having actual mathematical abilities. This anxiety builds over numerous experiences of feeling failure, creating low self-esteem when compared to others and placement into the passive awareness stage of accepting disabilities (Ren et al., 2016).

Expression of Mathematical Identity through Journaling

In the development of mathematical identity for all students, researchers have expressed the importance of journaling. This pedagogical strategy can lead to providing support for student understanding of mathematics, conversations between students to dialogue about mathematical thinking, and finding ways to explain the connection of mathematics to real world applications

(Allen & Schnell, 2016; Darragh, 2013; Oslund & Barton, 2017). The importance of journaling in mathematics is most crucial in helping students reflect on their positive and negative experiences and leading them to develop a more positive disposition towards the subject matter (Oslund & Barton, 2017). Allen & Schnell (2016) encourage students to develop an autobiography that includes a discussion of their mathematical record and history based on self-evaluative measures. This may include experiences in previous grade levels and a chance to identify and clarify challenges in relation to the subject matter. A math autobiography leads to an important conversation between the student and the teacher, with narratives regarding their mathematical journey developing over time (Allen & Schnell, 2016; Darragh, 2013).

Utilizing a social-emotional lens, the reflections that occur during journaling encourage students to review their own progress, leading to self-awareness and self-management related to their mathematical goals. Teaching individuals to self-assess and communicate their level of understanding can give educators a better idea of their needs. Allen & Schnell (2016) suggest teaching the language of mindset and mathematical identity, so that students are open to a more fluid process of learning mathematics. This helps to avoid the socialized historical development of being a good or bad math student, and allows for a mindset where mathematics allows for change, revisions, and learning from failure (Allen & Schnell, 2016; Oslund & Barton, 2017). This process of monitoring identity formation can be developed with journaling and is important for individuals to be able to express their diverse mathematical abilities. In the end, a journal can serve as a record of student growth and changes in an individual's mathematical identity formation (Allen & Schnell, 2016; Oslund & Barton, 2017).

The construction of identity through dialogue and discourse may reveal similarities and differences between student experiences (Darragh, 2013). In this expression, words that are used to describe experiences are a reflection of the individual's mathematical identity. This discourse could be important insight into how an individual uses their positionality to make sense of the mathematical experiences from their world. The things we say about our experiences lead to who we are as individuals (Darragh, 2013). The process of journaling allows an individual to communicate that mathematical abilities, no matter how different, should be recognized; that individual knowledge, way of thinking, and contribution is important (Oslund & Barton, 2017).

Identity in Relation to Neurological Development

Understanding the connection between identity and neurological development helps to frame the role of cognition in an individual's formation of mathematical identity. The label that has been used historically in schools and by society has challenged an individual's identity by creating the social constructions of what is deemed "normal" development (Baines, 2014). This process has led our educational system to set limitations for individuals, impeding the idea of how success can be achieved. Success is rather defined by the managers of the educational system, and this definition is projected onto our students that are considered different learners (Baines, 2014). The schoolhouse is a place of major stages in identity development, and the experiences that take place in social contexts can define pivotal moments in individuals' lives (Flum & Kaplan, 2012). Especially during adolescence, when cognitive capacities are emerging within formal schooling, students must have opportunities to experiences that cultivate positive self-reflection processes that lead to more positive identity development (Flum & Kaplan, 2012).

The process of schooling should impart skill sets and knowledge and be considered a means for preparing our students towards achievement. The school itself is a place for reflection, meaning making, and development of identity as each year progresses (Flum & Kaplan, 2012). However, Kroger (2004) warns of the ill effects of differentiating our students before the optimal time for readiness. The labeling of a learning disorder gives the student a sense of abandonment in terms of their potential learning levels (Baines, 2014; Kroger, 2004). This feeling can have a detrimental effect on the formation of identity and self-awareness regarding schooling and achievement, and creates a challenge for students to overcome the stigmas attached to the learning-disabled terminology and labels (Baines, 2014). Allowing individuals to self-assess their place in achieving specific skill sets can help to figure out their strengths and weaknesses within math identity development. The labeling process prescribes a structured identity, creating a definition of ability without the experiential process. This leads to discouraging messages regarding students' intelligence based on stigmas (Baines, 2014; Kroger, 2004). Normalized educational practices can negatively impact the development of identity over time, causing lower achievement within the subject matter (Baines, 2014).

A study conducted by Baines (2014) led to important information regarding this issue and how educators can help create a more positive cognitive experience for individuals facing their learning disorders. An important aspect of creating a more accessible environment includes the attitude and terminology that is used to describe cognitive differences. Utilizing "learning difference" in place of "learning disorder" can help lead to a more positive academic identity (Baines, 2014). This is especially important for students with learning disorders since the cognitive difference is a part of their identity and causes separation from normalized groups in society (Allen & Schnell, 2016; Cranfield, 2013). The process of identity development for individuals with learning disorders is different. Knowing how this experience is different comes from understanding how a school treats different learners (Baines, 2014). Students going through the process of learning, given their disabilities, are surrounded by attitudes and labels that force them to believe the differences must be fixed and fit social expectations. In the study conducted by Baines (2014), individuals shared how the perception that others held about learning disorders had an effect on their identity development and overall engagement with others in school. Not only do negative perceptions of a disability impact students' cognitive and academic progress, they also influence the social contexts of experiencing school and forming relationships with other individuals (Baines, 2014).

Learning Disorders and Mathematics

In our current world, an increase in technological use has led to utilization of mathematical skills. However, individuals face difficulty in acquiring and developing skills before entering specific professions (Butterworth et al., 2011). Throughout schooling, a number of individuals face developmental learning disorders that impede their numeracy proficiency. Studies involving the quantitative abilities of adults have concluded that about one in four individuals are functionally innumerate, affecting their mathematical competency when entering career fields (Butterworth et al., 2011; Rosenberg-Lee et al., 2015). An understanding of atypical skill development is important for designing and providing curriculum and instruction that can lead to the rehabilitation of important long-term mathematical skills (Bugden, 2014).

The American Psychiatric Association [APA] (2013) states that up to 6% of all school-aged children are diagnosed with *developmental dyscalculia*. The APA's current edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) places developmental dyscalculia under the category of Specific Learning Disorders, and defines it as a neurodevelopmental disorder leading to difficulty in acquiring arithmetic skills. Dyscalculic students face difficulty in the classroom when implementing problem solving strategies, often take a longer time to complete arithmetic processing, and usually create work that results in errors at a higher rate compared to their peers. This learning disorder has become an issue for students in the mathematics classroom, especially at the secondary level (Geary, 1993; Ranpura et al., 2013). Children who face developmental dyscalculia are unable to successfully develop the ability to apply basic numeracy skills when enrolled in higher-level secondary courses such as Algebra, Geometry, and Calculus (Ranpura et al., 2013; Skagerlund & Träff, 2016). Students demonstrate performance considerably below their same age peers. A significant cognitive impairment causes mathematical challenges to occur, which cannot be attributed to instruction. Current research has focused on other Specific Learning Disorders defined by the APA, including dyslexia and dysgraphia. Although intervention techniques have been developed to help individuals with these disorders involving reading and writing, a wide scope for further research development on the neurodevelopmental disorder involving impairment in mathematics still exists (Bugden, 2014; Price & Ansari, 2013). The dyscalculia that a student experiences throughout schooling may be in conjunction with other learning disorders such as issues in working memory, dyslexia, and attention-related disabilities, specifically attention deficit hyperactivity disorder (ADHD) (Bugden, 2014). These learning challenges negatively impact overall mathematical thinking, achievement, and the development of a mathematical identity.

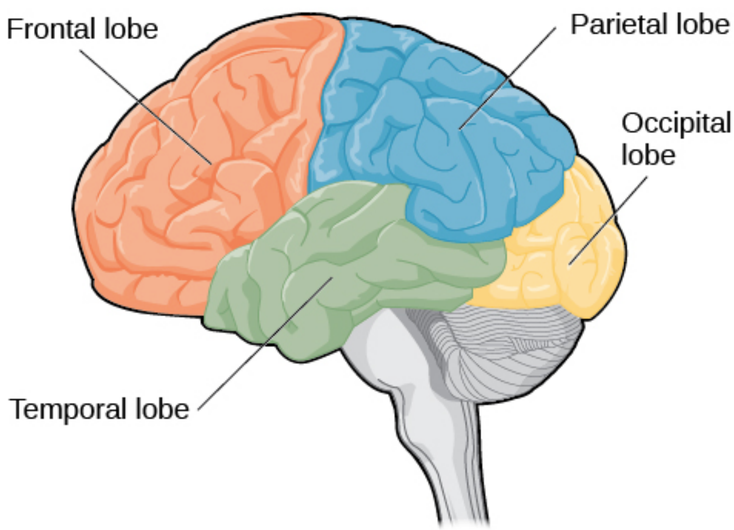
Brain Functionality and Learning Mathematics

Research pertaining to the subject of learning disorders states that the human brain should be able to represent and manipulate quantities when learning formal arithmetic. An impairment in the ability to work with numbers and apply cognitive skills in order to develop basic numeracy leads to difficulty in learning higher-level mathematics (Ansari, 2008; Dehaene, 2011; Geary, 1993; Kauffman, 2008). Brain imaging studies have allowed researchers to learn about students' mathematical thinking (Kaufmann, 2008), leading to a comparison of the differences between students with developmental dyscalculia and those who have normal arithmetic computational thinking (Cohen et al., 2000). These neuroimaging studies are exploratory and provide specific information about the sections of the brain contributing to different types of learning by studying patterns. Parts of the brain that are used for arithmetic have been identified by neuroscientists, and an understanding of these parts offer explanations for why some children may have difficulty learning fundamental math facts and performing basic mathematical calculations (Price & Ansari, 2013; Rosenberg-Lee et al., 2015; Tenison & Anderson, 2016). Neurologists, psychologists, and researchers investigate ways the brain is affected, including the underlying processing in how students with mathematical learning disorders function differently.

The most common and effective tool used to study dyscalculic brains is the *functional magnetic resonance imaging* (fMRI) technique. This process allows scientists to investigate brain functionality by measuring changes in blood flow while individuals are performing tasks (Cohen et al., 2000; Geary, 1993). *Activation* is the response that fMRI picks up when blood flow shows changes in the ratio of oxygenated and deoxygenated blood in specific areas of the brain. Responses to brain activity cause these changes to occur, specifically an increase in the levels of oxygenated blood, when activities are completed. As increased levels of oxygenated blood displace deoxygenated blood, the fMRI signals are activated and measure changes (Ansari, 2008; Butterworth, 2010; Kauffman, 2008). Throughout the course of a task, various images are collected to show changes in this blood flow. The fMRI scans can be used during numerical tasks, and the images that are collected show increases or decreases in the levels of oxygenated blood flow. These images are compared to similar tasks in other brains or activities that require different activation areas. This process helps to understand how an individual's brain may be functioning atypically and possibly affected by developmental dyscalculia (Bugden, 2014; Butterworth, 2010; Cohen et al., 2000; Geary, 1993; Kauffman, 2008).

Figure 2.3

Cerebral Cortex of the Human Brain



Note. The image shows the four main lobes of the cerebral cortex. The *parietal lobe* is where mathematical thinking occurs (APA, 2016)

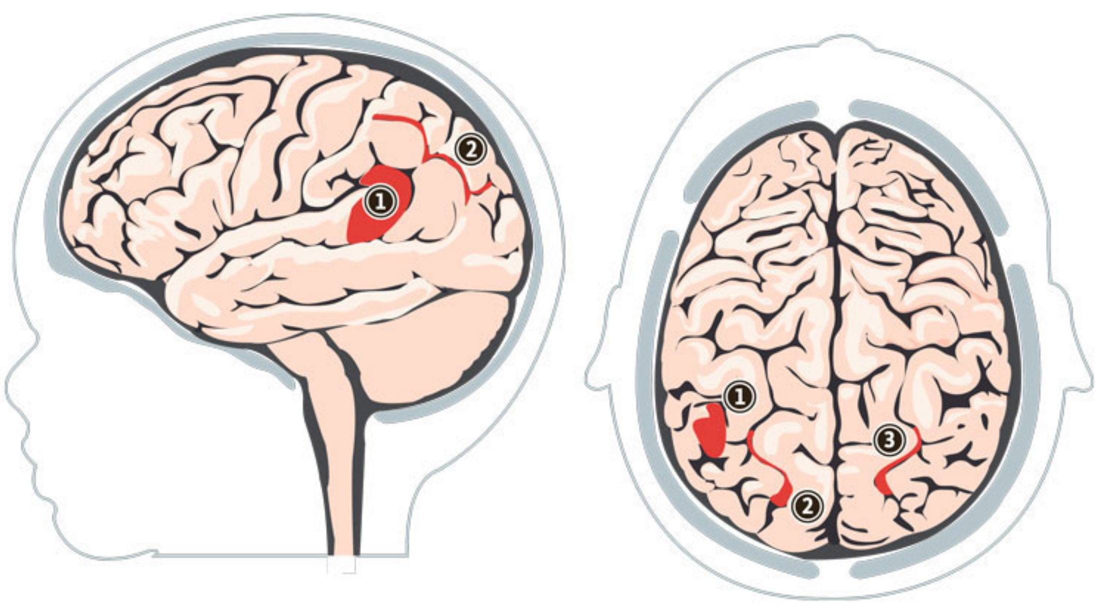
The brain is very complex in nature, which has created limitations for scientists to fully understand how each section is related to controlling bodily functions, emotions, and thinking. The *cerebral cortex* includes the folded outer layers of the brain (Cohen et al., 2000; Yeo & Eickhoff, 2016). Each section is made up of a *sulcus* (groove) and *gyrus* (ridge). The cerebral cortex is divided into lobes (see Figure 2.3), which co ntain the sulci and gyri controlling different functions (Rosenberg-Lee et al., 2015; Yeo & Eickhoff, 2016). Neuroscientists have determined that the two most important parts of the brain that allow for mathematical thinking include the *angular gyrus* (AG) and the *intraparietal sulcus* (IPS) (Cohen et al., 2000; Dehaene et al., 2003), both of which are located in the *parietal lobe* of the brain (Price & Ansari, 2013; Rosenberg-Lee et al., 2015; Tenison & Anderson, 2016). These two parts of the parietal lobe control mathematical thinking (see Figure 2.4):

1. *Left Angular Gyrus (AG)* – Brain tissue located in the left part of the cerebral cortex in the parietal lobe that allows for rapid retrieval of facts. Believed to be involved in relating numerals to quantities.
2. *Left Intraparietal Sulcus (IPS)* – Brain tissue in the left part of the cerebral cortex in the parietal lobe that allows for calculation. Believed to help compare symbols and numbers such as 3 and 8.
3. *Right Intraparietal Sulcus (IPS)* – Brain tissue in the right part of the cerebral cortex in the parietal lobe that is active during calculations and comparing the numbers of groups or collections of physical objects.

Using these definitions helps to understand the function of the brain in learning mathematics. Neuroimaging studies implicate that both left and right parts of the IPS help students learn the foundational level skills for mathematics, known to hold and develop skills related to the

Figure 2.4

Mathematical Thinking Centers of the Parietal Lobe



Note. The specific parts of the *parietal lobe* that have different contributions to mathematical thinking (Ansari, 2008; Cohen et al., 2000) semantic representation of numbers and magnitude in typically-developed brains (Bugden, 2014; Butterworth, 2010; Dehaene et al., 2003). The IPS is also believed to be the location of deficits when studying brain activities of individuals with developmental dyscalculia (Cohen et al., 2000; Dehaene et al., 2003; Price & Ansari, 2013). In general, researchers have found that students with dyscalculia have reduced activity and issues with arithmetic problem solving in the IPS (Cohen et al., 2000; Ranpura et al., 2013; Rosenberg-Lee et al., 2015). Results of these studies are discussed in the review to provide information about how brain activity has correlated to the specific areas of the brain and to help create intervention techniques.

Various hypotheses consider developmental dyscalculia is associated with challenges in processing basic numbers, which is important in learning arithmetic skills. The *access deficit hypothesis* explains that developmental dyscalculia is a result of weaknesses in the processing and access of symbolic numeral representations (Bugden, 2014). According to the *defective number module hypothesis*, dyscalculia is caused by impairment in being able to manipulate and represent numerical quantities that are discrete (Ansari, 2008; Butterworth, 2010; Butterworth et al., 2011). According to the *approximate number system hypothesis*, developmental dyscalculia is caused by deficits in the system that helps to represent the approximation between sets of objects (Dehaene et al., 2003).

An investigation into the development of numerical representations for brains in individuals with developmental dyscalculia, compared to those in typically achieving brains, has relied on symbolic and nonsymbolic numerical discrimination tasks (Ansari, 2008; Bugden, 2014). These tasks have helped researchers find differences in the neural distance effect, which is in reference to students understanding the number system, a basic skill in mathematical thinking (Holloway & Ansari, 2009). Numbers are understood at an early developmental stage, including both positive and negative values and how an increase or decrease in numbers can be related to counting objects. Being able to neurologically process the distance between numbers is an important task in understanding the functionality of the brain (Holloway & Ansari, 2009). The neural distance effect is studied to understand how the activation in brains is different for individuals with dyscalculia – the discrimination tasks that are specific to showing this difference include close distance pairs (numbers that are closer together) versus far distance pairs (numbers that are further away from each other on a number line) (Ansari, 2008; Bugden, 2014; Dehaene, 2011). Neuroimaging studies have confirmed that the typical functioning brain activity for deciphering the distance pairs occurs in the IPS (Ansari, 2008; Bugden, 2014).

Neurological Studies Involving the Dyscalculic Brain

The DSM-V provides diagnostic criteria for identifying students with learning disabilities based on behavioral markers, not brain studies (APA, 2013). Neurological studies have provided insight into why the disorders exist, what areas of learning capabilities they affect, and brain activity that is affected by specific learning disorders. For instance, Brian Butterworth (2010) has developed the *Dyscalculia Screener* to help evaluate whether a student has numeracy issues based on simple tests. Due to the variety of dyscalculic brain differences observed in individuals, an understanding of the neuroscience helps to understand how to intervene based on each student's learning profile (Ranpura et al., 2013). As previously discussed, students' difficulty with mathematical understanding is caused by impairments in the parietal lobe of the brain (Cohen et al., 2000). The following studies looked at specific parts of the parietal lobe and used neuroimaging to compare the differences in the functionality of a brain from an individual with developmental dyscalculia with one that was considered typically developed (Geary, 2000; Rosenberg-Lee et al., 2015; Rotzer et al., 2009).

Psychological Processes

Working memory is defined as the mental capacity of brain processing that allows for storage of information. When learning mathematics, studies have shown a connection between an individual's working memory and its contribution to being able to store mathematical skills, leading to growth of concepts, cognitive understanding of numbers, as well as the procedures used to solve math problems (Bugden, 2014; Geary, 1993; Ranpura et al., 2013). The scientific reasoning for this connection supports the idea that working memory requires both processing and retrieval of incoming information. When solving a problem, individuals remember the story aspect of the problem and figure out the solution as it is understood. However, if students have trouble processing mathematical skills, and are then unable to store the information, they will face difficulty in learning new concepts. This leads students into the difficulty of learning mathematics and is believed to be a major cause of dyscalculia (Rotzer et al., 2009).

David Geary (2000) describes neurological and psychological deficits involved in mathematical thinking, which can help to understand the specific skills sets that may be troubling for students with dyscalculia:

1. Semantic memory: retrieval of arithmetic facts;
2. Procedural memory: understanding and applying of mathematical procedures;
3. Visuospatial representations: understanding spatially represented numerical information such as misalignment of columns, place value errors, or geometry

Individuals with impairments in visuospatial working memory are linked to having developmental dyscalculia (Geary, 2000). Data that was put together in a study by Bugden (2014) provides evidence that the visuospatial reasoning and working memory is important for students to be able to hold numerical representations, specific to understanding and building numerical magnitude representations. Having impairments with working memory can lead to a negative impact on the development of basic arithmetic skills, including numerical calculations and manipulations, and the development of important visuospatial representations at a crucial time in their development (Bugden, 2014; Geary, 2000; Price et al., 2007).

A study conducted by Rotzer et al. (2009) provides additional understanding of the connection between deficits in working memory and developmental dyscalculia by observing the anatomy and functionality of the brain. As previously explained, research indicates that there is weaker brain activation in the IPS and the AG in students with developmental dyscalculia. The study conducted by Rotzer et al. (2009) specifically showed that students with weaker activation in areas of the brain that affected working memory, specifically spatial working memory, also suffered from developmental dyscalculia. The study provided indication for changes in the neural responses of dyscalculic children compared to the normal achieving levels. During a spatial memory task, the activation in the intraparietal areas of the brain was weaker for students with developmental dyscalculia (Dehaene et al., 2003; Rotzer et al., 2009). The task given to children did not involve any obvious arithmetical or numerical content. The right IPS was activated in the brains of typically developed students, however, there were specific differences in the activity that was occurring in the right IPS of the brains of students with developmental dyscalculia. Since the right IPS plays a central role for working memory capacity, arithmetic calculations, and number representations, the study conducted supports correlation between a poor spatial working memory and its contribution to students' developmental dyscalculia (Cohen et al., 2000; Ranpura et al., 2013; Rotzer et al., 2009).

Addition and Subtraction Skill Development

Basic arithmetic issues with addition and subtraction is common amongst students with developmental dyscalculia (Price & Ansari, 2013). A study comparing the brain activation through fMRI scans for typically developed children and those with developmental dyscalculia provided insight into the impairment involved with solving addition and subtraction problems. Rosenberg-Lee et al. (2015) compared brain activation during problem solving. Although hypotheses were made for lower activation in the IPS for both addition and subtraction problems, the study indicated there were differences in the level of brain activity for addition compared to subtraction. The study involved a look at the areas of the brain that were activated during addition and subtraction problems through fMRI imaging tasks. As predicted, the IPS was involved in solving these problems. However, there was greater activation in the IPS for subtraction for both typically developed and dyscalculic brains (Dehaene, 2011; Rosenberg-Lee et al., 2015).

The results presented by Rosenberg-Lee et al. (2015) show that individuals with developmental dyscalculia were less accurate when they completed subtraction problems. Brain imaging devices indicated activation in the IPS, however the processing was slower and more answers were incorrect for subtraction than addition problems. The insight that is provided for this difference is the property of subtraction problem solving techniques (Butterworth et al., 2001). With addition, numbers can be added out of order and a conceptual idea of grouping the two values together always works. However, with subtraction, the commutative property does not apply: the order of the digits plays an important role in solving the answer. There is a disparity between calculating $9 - 5$ versus $5 - 9$, resulting in different answers. This specific property of subtraction was important in showing that the current focus on skills for addition is not enough to help with the deficits and delays in arithmetic development for students with dyscalculia (Butterworth et al., 2001; Rosenberg-Lee et al., 2015).

The most interesting result of this study came from observing hyper-connectivity of the IPS with the AG for students with developmental dyscalculia trying to solve addition and subtraction problems. This finding further supports the neurological differences for dyscalculic students, specifically the organization of the parietal lobe and how it functions during addition and subtraction skill development (Butterworth et al., 2001). Rather than having activation in the region of the IPS that is appropriate for addition and subtraction, students with developmental dyscalculia were activating other parts of the brain that are usually not involved in these specific tasks (Dehaene et al., 2003; Rosenberg-Lee et al., 2015). The *Default Mode Network* (DMN) has been recently observed as the activation of brain functions that are involved when individuals are not engaged in mental tasks (Maillet & Schacter, 2016). For typically developed students in this study, the DMN was deactivated since the students were engaged with the skills required to solve addition and subtraction problems. However, activation of the DMN was observed in dyscalculic brains: incorrect parts of the brain were activated and involved with solving the mathematical problems, causing students to mentally disengage with the mathematical task without any control over this disengagement (Butterworth et al., 2001; Maillet & Schacter, 2016; Rosenberg-Lee et al., 2015).

Dyscalculia and Other Neurological Learning Disorders

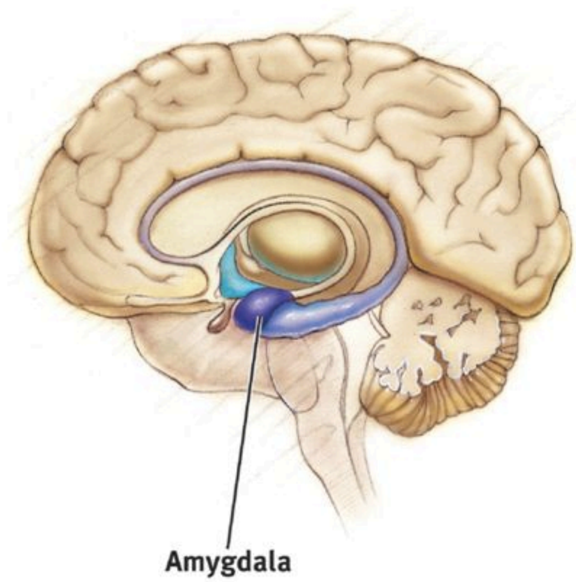
Suggestions have been made that students who face mathematical disorders such as developmental dyscalculia may also have deficits in reading and writing. The correlation between these various learning disorders has led to research methods in understanding the neurological differences causing the deficiencies in mathematics, reading, and writing (Geary, 2000; Price & Ansari, 2013; Rosenberg-Lee et al., 2015; Tenison & Anderson, 2016). Specific Learning Disorders that involved reading and writing impede students from learning vocabulary and concepts in mathematics (APA, 2013; Wadlington & Wadlington, 2008). Language processing disabilities cause deficiencies in abilities, particularly reading and understanding the vocabulary being used in a mathematical question, and then utilizing the correct steps in order to organize and solve the problem. Students having issues with reading may face trouble decoding the instructions that are given for math problems as well. Word problems can be especially challenging due to the nature of the combination of text and numeracy (Wadlington & Wadlington, 2008). The correlation between developmental dyscalculia and other learning disorders adds to the difficulty of diagnosing students and providing them with the appropriate accommodations (Rosenberg-Lee et al., 2015; Rotzer et al., 2009; Yeo & Eickhoff, 2016).

Math Anxiety

With ongoing negative experiences in being unsuccessful in math classrooms, students develop a fearful avoidance of engaging in mathematics, more commonly known as *math anxiety* (Butterworth et al., 2011; Wadlington & Wadlington, 2008; Young et al., 2012). While math anxiety is not considered a disorder, research suggests the stress that is caused by this fear of mathematics can hold back students from learning effectively (Ren et al., 2016; Willis, 2010). Students who face math anxiety release chemicals in the brain caused by stress. The threat that is perceived by mathematics leads to frustration and confusion. Stress chemicals cause hyperactivity and abnormal effective connectivity in the *amygdala* (See Figure 2.5), which is the appropriate part of the brain to control emotion (APA, 2013; Willis, 2010). Information is sent to parts of the brain that react to the stress in ways that are similar to a fight-or-flight situation. A study conducted by Young et al. (2012) found that association of math anxiety with hyperactivity

Figure 2.5

Location of the Amygdala



Note. The *amygdala* allows the brain to react to emotions like fear. Math anxiety causes hyperactivity in the amygdala when students are solving mathematical problems (Willis, 2010)

in the part of the amygdala that are important in processing negative emotions. The fMRI analyses also showed reduced activity in the parietal lobe, which is crucial in mathematical reasoning (Young et al., 2012). This reactionary behavior based solely on emotion, rather than cognition, leads to a development of hopelessness in being successful at mathematics. Emotional responses from the brain can also lead to issues in developing working memory, further supporting the idea that an impediment on memory can deter students from using foundational mathematical knowledge and skills to learn new concepts and solve problems (Cohen et al., 2000; Rotzer et al., 2009; Willis, 2010). Developing ways to reduce math-related stress can lead to deactivation of the amygdala when students are solving mathematical problems.

In relation to the development and progress of an individual's mathematical identity, the level of confidence and ability to self-assess becomes extremely important. Math anxiety takes away from a student being able to increase their confidence and self-efficacy in regards to finding successes in doing mathematics (Leatham & Hill, 2010; Ren et al., 2016). This process is ongoing and is impacted by various pedagogical practices that are brought into the classroom. An understanding of the scientific reasons for math anxiety causing learning issues can help to relieve the negative effects of anxiety during the learning of mathematics, and therefore, the development of a math identity that is detrimental to the individual's success in the subject matter (Leatham & Hill, 2010; Ren et al., 2016). While it is challenging to measure the level and presence of math anxiety, it is important for educators to gain an understanding of its existence so that appropriate responses can be utilized in the classroom.

Teaching Dyscalculic Learners

In order to further help teachers understand different types of mathematical learners, Wadlington and Wadlington (2008) describe two specific learning styles. This understanding can inform pedagogy to improve skill development for learners with developmental dyscalculia:

Quantitative Learning Style

Quantitative learner types develop language skills and concepts. They are able to break problems up into smaller parts, and then reassemble the various pieces together. They can logically work through word problems. These learners are usually able to complete calculations, counting procedures, and identify geometric shapes. Challenges include the principles and concepts for certain topics as well as gaining an overall connection of different mathematical concepts. Step-by-step procedures, when teaching mathematical concepts, are helpful to quantitative learners.

Qualitative Learning Style

Qualitative learner types learn the visual aspects of mathematics, developing more intuitive responses to problems. They are able to notice patterns between concepts, skip certain steps, and still be able to solve problems. They start with the whole problem and then work through various parts. Geometry problems that involve visual figures are easier for these learners. They are able to conceptually understand spatial relationships. They tend to make errors because their work lacks organization, especially with problems that require multiple steps. Inductive reasoning along with pattern recognition and visual-spatial methods are helpful to qualitative learners.

Teaching Practices

When learning mathematics, students often use strict memorization as a way to apply concepts from lessons. However, a full understanding of material can lead to further success when approaching more complex topics. Various aspects of a classroom setup, such as seating arrangement, can be helpful for dyscalculic students (Dehaene, 2011; Price & Ansari, 2013). Students who are seated closer to the focus of instruction are able to follow along in a more effective manner (Wadlington & Wadlington, 2008). When presenting instruction, it is important for students to get a chance to review previous material before being exposed to new concepts. This helps to organize the information they are receiving. The method of instruction should follow a progressive model so that students start with concrete examples, easing their way into the more abstract problems with the use of diagrams (Tenison & Anderson, 2016; Wadlington & Wadlington, 2008). The use of a calculator can be extremely helpful in making up for the lack of basic skills that are required to learn the more complex concepts. Therefore, teaching students how to use a calculator effectively as a tool will help to avoid common errors in arithmetic calculations. A summary of what the students are learning may help to develop vocabulary, explain understanding of concepts, and move forward to learning new concepts the next day. A cyclic method of summary and immediate feedback can help learners assess their understanding of a concept before moving forward (Wadlington & Wadlington, 2008).

Different modes of instruction and diversification of materials used in pedagogy can help make the learning experience more positive. Rather than relying completely on the textbook, teachers can find resources that help learners based on ability level. Using multiple senses, including kinesthetic activities, helps make the abstract concepts more concrete (Wadlington & Wadlington, 2008). Measurement tools and objects can be used to model the real world. The use of objects allows students to access different and multiple senses, creating an experience that is relatable (Price & Ansari, 2013; Tenison & Anderson, 2016; Wadlington & Wadlington, 2008).

Diverse Learning Styles & Assessment Procedures

Taking into account the diverse learners of mathematics and the accommodations they may require can make a difference in their learning experience and development of mathematical identity. As educators, there are ways to notice how students are learning mathematical concepts and provide feedback to those with sub-par levels of work (Allen & Schnell, 2016). In terms of building a stronger identity surrounding the subject matter, it is important to acknowledge the efforts and contribution the individual makes to the conversations involving mathematical thinking. Using multiple modes of showing this thinking can lead to an increase in the student's participation and in effect, contribute to developing a more positive mathematical identity (Allen & Schnell, 2016). Celebrating diverse learners and differences in mathematical thinking can shift the mindset towards labeled students who may approach mathematical thinking differently – whether that involves thinking, writing, or dialoguing to produce a better understanding and make sense of the various ideas and concepts involved with mathematics.

Ongoing formative assessment practices can help teachers learn which techniques, such as those included in this review, are best for their students with developmental dyscalculia. Besides traditional modes such as multiple choice and short answer questions, teachers can utilize project-based assessments that allows for students to explain their understanding of concepts (Tenison & Anderson, 2016; Wadlington & Wadlington, 2008). Oral tasks like presentations and group work allow students to further develop their math literacy and communication skills. Non-traditional methods of assessment also allow students with developmental dyscalculia to avoid errors when they are working under the pressures of high-stakes assessments (McDermott, 2013). Assessments in the classroom should inform students of their level of understanding, and should then advise the teacher on areas that need improvement (Price & Ansari, 2013; Wadlington & Wadlington, 2008). This method of using assessment data allows educators to create intervention techniques that will help each student based on their individual learning style and level of understanding towards a math concept.

Mathematics for Post-Secondary Education and Career

In the crucial period of time when students are making decisions towards college and career paths, students with learning disorders are at a disadvantage. A lack of strong mathematical knowledge is reflected in standardized tests and class grades. Various strengths and levels of intelligence students have that could lead to careers in fields related to mathematics are overlooked by the early failures in the subject matter, which may lead to a decline in motivation to pursue these fields (Apple, 1992; Grotlüschen et al., 2016; Lane & Conlon, 2016; Rivera-Batiz, 1992). Increasing student success in mathematics based on standardized assessments, especially in a competitive world surrounding STEM fields, has become a focus for many schools (Geary, 2011; Rosenberg-Lee et al., 2015). There is inadequate research focusing on students with developmental dyscalculia and other learning differences affecting math achievement, including those in high school level courses (Butterworth et al., 2011; Wadlington & Wadlington, 2008). Current research lacks attention on students with learning disorders forming their mathematical identity, and the implications this process has on the commitment an individual makes towards the field as a career path (Bieschke & Lopez, 1991).

One of the most important skills that a student can develop is to mathematically communicate (Butterworth et al., 2011; Price & Ansari, 2013). Students with developmental dyscalculia have trouble expressing thoughts and answers in their writing (Wadlington & Wadlington, 2008). Journaling in a mathematics classroom can help develop math literacy. As students are learning new concepts, a consistent place to describe mathematical terminology can help become more comfortable with vocabulary to utilize in future roles. Connecting vocabulary terms to concrete examples helps students make a connection between the words that are used and the meaning behind specific skills (Wadlington & Wadlington, 2008). Developing math literacy is important for individuals with dyscalculia, especially when entering a profession that will utilize mathematical thinking (Butterworth et al., 2011; Price & Ansari, 2013).

The importance of developing a quantitative literacy is prevalent in helping individuals find employment and having options when it comes to career choices by providing mathematical skills for everyday life and those used for workplace tasks (Geary, 2011; National Academy of Sciences - National Research Council [NAS-NRC], 1989; Rivera-Batiz, 1992). Developing proficiency in mathematical thinking and communication can lead to better employment in career fields (Geary, 2011; Lane & Conlon, 2016; Rivera-Batiz, 1992). This includes being able to get a job and be successful in keeping the job with skills such as problem solving. A level of confidence in knowing basic calculations helps to perform in an expected manner from employers. The skills that are developed through numeracy proficiency are important for adults learning to perform higher-level tasks (Grotlüschen et al., 2016; Lane & Conlon, 2016). Numeracy can include skills that are important to everyday life such as problem-solving, the concept of reasonability, mathematics within predictability, computational skills, estimation and approximation, geometric thinking, measurement, interpreting and utilizing charts, graphs, and tables as visual aids, and literacy that is related to computers (Galbraith et al., 1992). By providing the development of math literacy, we avoid the disempowerment of this marginalized group of students with learning disorders – we should strive to create opportunities and open doors that lead to various career choices for these individuals (Cranfield, 2013).

The broader scope of K-12 education has potential to include the teaching of mathematical skills that can develop productive members of society. Providing concrete skills to individuals would lead to competencies that are important to living productive lives. Mathematical skills provide access to life skills such as managing money, which allow individuals to engage with financial communities. This access can lead to economic mobility within socioeconomic status. Mathematical skills add to the cultural capital gained by individuals through positive experiences in learning mathematics (Bynner, 1997; Grotlüschen et al., 2016). This capital can help set them apart from competition when pursuing specific jobs. Calculating and computing are important basic skills that are prevalent to individuals finding careers and in gaining employment. However, we create a disadvantage for students with learning disorders when we don’t find ways to present mathematical information that can be learned effectively (Bynner, 1997; Geary, 2011; Lane & Conlon, 2016). Poor math performance leads to limitations when choosing careers in mathematics. Overall poorer skills related to numeracy can lead to lower income and worsened psychological and financial results in adulthood (Ansari, 2008; Bugden, 2014). The subject matter provides an opportunity for individuals to clarify problems, use deduction to make important decisions taking into account various consequences, develop tools, and use mathematical thinking to formulate solutions to problems (NAS-NRC, 1989).

The ongoing negative experiences in mathematics impact the long-term outcome of individuals' interest in the subject matter as a possible career choice. When a lack of interest impacts career choices, it creates inequalities in the accessibility to fields. Students can find success in math-related fields, but there are overall decreased societal outcomes for children and adults who have difficulty with mathematical thinking (Bugden, 2014). Their cognitive strengths must be taken into account so that their learning disorders do not completely close them off to opportunities. Society closes doors to individuals with learning disorders, who can offer strengths within areas of thinking that do not involve computation and rote thinking. Finding ways to effectively help students who learn differently think mathematically can provide access to various fields of study that involve mathematics (Cranfield, 2013). Within the development of math identity and having students reflect on self-efficacy within the subject matter, it important to take into account their age, socio-economic status, gender, sex-role identity, and race to positively influence their perceived ability to perform certain tasks (Bieschke & Lopez, 1991; Ren et al., 2016). These aspects of personal identity, tied in with abilities in mathematical thinking, ability, and anxiety, can form overall interest in pursuing the subject matter for a future role in society. Lower levels of self-efficacy in regards to math achievement have been connected to decreased consideration of math-related careers (Bieschke & Lopez, 1991; Ren et al., 2016). We need to move away from using traditional methods of measuring mathematical learning levels that close off opportunities for members of society (Cranfield, 2013).

Conclusion

Dyscalculia is a Specific Learning Disorder that creates issues in numeracy, arithmetic skills, counting processes, and overall engagement with numbers (APA, 2013; Butterworth, 2010). The normal brain functions allow students to use their intraparietal sulcus and angular gyrus effectively to make mathematical calculations. However, students with dyscalculia are unable to effectively learn mathematics due to their neurological differences (Ranpura et al., 2013). At the secondary level especially, students with dyscalculia are unable to learn higher-level topics in mathematics (Butterworth et al., 2011; Ranpura et al., 2013). Current studies have focused on the students at the elementary age; however, further research on students at the secondary level is necessary to help formulate pedagogical improvements and access for adolescents as they enter the process of choosing career paths. This specific area of research can help inform curricular decisions for all math educators who have students facing difficulty in learning mathematics, leading to the development of strong foundational math knowledge and identity in order to be successful in future career roles related to mathematics.

There is a general importance of mathematics that we should strive to give our students. The accepted beliefs towards the subject matter include the socialized career fields that require "good" math students – fields that students may not be interested in pursuing and therefore find a reason to view mathematical thinking as useless (Leatham & Hill, 2010). However, the process of thinking mathematically includes fields other than sciences or engineering. Perspectives and attitudes towards the subject matter are created during identity formation. Forming a negative view of mathematics solely based on the traditional methods of teaching and learning the subject in the classroom turns students away from the importance of thinking mathematically for various aspects of their lives (Leatham & Hill, 2010). As educators, we should strive to help our students understand that even with learning disorders, they can achieve mathematically. Making this a priority during the crucial experiences our students have in learning mathematics can make a positive difference for our diverse learners.

CHAPTER 3:

TRANSFORMATIVE RESEARCH STUDY METHODOLOGY

In this transformative design study, the researcher aims to learn about the mathematical identity formation for students with learning disorders that impact mathematical thinking. A quantitative analysis of responses to a questionnaire created by the researcher and a document analysis of journal entries written by members of the sampling group, identified as students with learning disorders, are used for this study. The purpose of this study is to find associations that may exist between attributes that are considered pertinent to the formation of mathematical identity. The goal is to understand mathematical identity formation through associations between confidence, motivation, and anxiety with interests in pursuing mathematics as a subject that can be used in college major choices and career fields. In this study, a descriptive quantitative research design was used as a methodology to study the experience from the individual's point of view to gain an understanding of the associations, differences, and frequencies of the variables based on questionnaire responses and journal entries.

Individuals are diagnosed with mathematical deficiencies or neurological disorders that impact mathematical skills. Developmental dyscalculia, issues of working memory, language-based disorders, and processing speed are examples of learning disorders that can inform identity development reflective of these lowered mathematical skills. Confidence and motivation are driven to lowered levels, causing negative self-esteem when engaging in mathematical thinking or pursuing a field related to mathematics. This local-level issue, in the researcher's perspective, is prevalent in classrooms all over the country. In the current representation of research related to students with learning disorders, there is a lack of association being created with aspects of identity development and future career roles related to mathematics. There is no specific questionnaire that exists for students with learning disorders linking confidence, motivation, and anxiety to career interest in mathematics.

The analysis and results of the data presented may help educators better understand how mathematical identity formation occurs. This can influence the teaching practices educators use in order to form more positive mathematical identities, which in turn can help students become more confident and motivated to pursue mathematical college majors and careers. The results of this study may also influence future research that focuses on preparing individuals who are interested in becoming a mathematics teacher, further helping all learner types develop mathematical thinking and positive identities. Curriculum's role in this positive transformation may be influenced with the contribution that this research project makes to the scholarly world. Educators are encouraged to reflect on their training in order to help students with identity development. The impact of this research can help students make progress in subject matters that are related to their career interests, rather than being placed into lower levels of mathematics that impede their ability to take part in career fields related to mathematics.

Background

One in four adults face mathematical incompetency, affecting their utilization of mathematics in their career fields (Butterworth et al., 2011; Rosenberg-Lee et al., 2015). Issues of mathematical incompetency in younger students inform the difficulty they face when enrolled in secondary level math courses (Geary, 2000; Wadlington & Wadlington, 2008). Specifically, students facing a developmental learning disorder involving abilities in mathematical computations are challenged when learning higher levels of mathematics. As stated by the American Psychiatric Association (APA) (2013), about 6% of all school-aged children are diagnosed with a neurodevelopmental disorder involving the acquisition of mathematical skills.

The APA's Diagnostic and Statistical Manual of Mental Disorders (DSM-V) refers to this specific learning disorder as developmental dyscalculia, which has become prominent in both younger students as well has high school students (Ranpura et al., 2013; Wadlington & Wadlington, 2008). Learners with a diagnosis of developmental dyscalculia require more time to process arithmetic calculations, have issues with problem solving, and in comparison to their peers, produce work with increased levels of errors (Geary, 1993). When taking part in high-school level courses, students with developmental dyscalculia are unable to fully retrieve basic arithmetic skills necessary to learn and apply higher-level content (Ranpura et al., 2013; Skagerlund & Träff, 2016). Multiple attempts to practice problems and constant failures throughout assessments create aversion towards the subject of mathematics, causing students to develop a fearful avoidance of mathematical thinking known as math anxiety. This leads students to emerging disinterest in pursuing fields related to mathematics (Wadlington & Wadlington, 2008). It is important to transform this inability into successful mathematical learning so that students with learning disorders are able to pursue career choices that may require mathematics. This study aims to describe the relationships between confidence, motivation, anxiety, and career interest in mathematics within the formation of mathematical identity for students with learning disorders.

In the crucial period of time when students are making decisions towards their college and career paths, students with learning disorders that affect their mathematical thinking are at a disadvantage. A lack of strong mathematical knowledge is reflected in standardized tests and classroom assessments. The various other strengths and levels of intelligence students have, that could lead to careers in fields related to mathematics, are overlooked by the early failures in the subject matter, causing a decline in motivation to pursue these fields (Apple, 1992; Geary, 2011;

Grotlüschen et al., 2016; Lane & Conlon, 2016; Rivera-Batiz, 1992). Increasing student success in mathematics based on standardized assessments, especially in a competitive world surrounding STEM fields, has become a focus for many schools (Geary, 2011; Rosenberg-Lee et al., 2015). However, there is inadequate research focusing on students with learning disorders affecting mathematical ability (Butterworth et al., 2011; Wadlington & Wadlington, 2008).

Theoretical Framework

The transition of schooling from elementary to high school level classes can be challenging for students. The curiosity and questioning of the content taught in schools becomes a part of the daily learning experience. The assessment and accountability measures that are used in our current system of education, however, serve specific people to create an unequal educational experience for students with learning disorders and reduce employment opportunities (Apple, 1992; Geary, 2011; Grotlüschen et al., 2016). Specifically in relation to learning mathematics, memorization and quick facts are used to assess students of their mathematical knowledge rather than an attempt to connect mathematics to areas of interest and applications that are personally important (Bynner, 1997; Lane & Conlon, 2016).

Based on standardized assessment measures, students with learning disorders, such as developmental dyscalculia, are labeled as weaker mathematics students, which leads to negative experiences and an overall disinterest in the subject matter (Apple, 1992; Butterworth et al., 2011; Wadlington & Wadlington, 2008). The numeracy issues that affect both children and adults hold them back from developing a stronger mathematical competency that can be helpful in being successful in career fields related to mathematics, even though these issues are not attributable to overall intelligence (Bynner, 1997; Geary, 2011; Rivera-Batiz, 1992). The history of curriculum and the decisions that have been made in setting up specific assessment expectations for students does not take into account the students who learn differently due to their learning disorders (Ansari, 2008; Apple, 1992).

Rationale

The rationale for taking part in this study is to understand the identity development of students with learning disorders when enrolled in high school level mathematics so that they are able to take advantage of applying mathematics to their career interests. There has been research conducted to help students with learning disorders, such as developmental dyscalculia, when they are in elementary school. However, a variety of neurological issues can cause a brain to functional atypically and the research conducted thus far may not include all individuals based on their personal learning profile. Many neurological studies focus on the brain as it is still developing at an early age, but there is little research on how the numeracy issues affect students who aim to learn higher-level mathematics. The purpose of this study is to understand the relationship between mathematical identity formation with aspirations to pursue the subject matter in future roles. The rationale for studying the formation of mathematical identity is to help educators create positive experiences for students so that they are able to find their strengths in mathematical thinking. The results of this research project can help inform curricular decisions for all math teachers who work with students facing difficulty in the mathematics classroom. The research can be applied to pedagogical decisions that are made to formulate successful experiences for students and increase overall interest towards the subject matter when choosing a career path.

Role of the Researcher

In my own experience of learning mathematics, high scores on standardized tests and strong grades in high school level courses allowed me to openly make decisions regarding career fields that I wanted to pursue. As I was deciding to become a teacher, I found importance in explaining the mathematical concepts that I was able to effectively learn to my fellow peers who needed assistance. This interest developed from the specific way I was able to explain concepts to my peers. I found myself choosing to teach mathematics because of the many students who faced difficulty with this specific subject matter. My experiences in teaching mathematics soon required learning the different ways mathematics curriculum could be presented. I found that standardization did not allow different learner types to be successful in showing their understanding of mathematics.

As a teacher trained for regular-education courses, it is challenging to create opportunities for students with learning differences to make the mathematics they learn personally applicable and valuable. I am approaching this specific study to understand the mathematical identity development for students with learning disorders that affect their mathematical thinking. My perception of the subject is biased in that I am able to understand mathematics relatively easily, and this study allows me to understand perspectives and experiences different from my own. In relationship to the research question, I have observed many students with high levels of potential that are denied opportunities to fields that require minimum scores on standardized mathematics assessments, such as the American College Test (ACT), Graduate Management Admission Test (GMAT), and Graduate Record Examination (GRE). I want to understand the identity development for students who have difficulty in learning mathematics from an early age, and how this affects their overall experience at the high school level. Not only will this allow me to make adjustments to my own practice, but this study will also contribute to a gap in research related to high school students with learning disorders.

Researcher Assumptions

My personal understanding of mathematics as a subject matter focuses on the specific presentation of the concepts. I hold a perspective that all individuals have the potential ability to gain an understanding of the subject matter. Mathematical thinking, in my view, involves the development of problem solving techniques. The problem solving I refer to includes the skills that individuals must use in their chosen career paths. I see potential for students with learning disorders to be successful in career fields that may require mathematical thinking. However, I have observed strong problem solvers be turned off to the idea of pursuing mathematical career choices due to the early onset of negative experiences related to numeracy and arithmetic issues. Given the technological age we have entered in almost every career field, I believe these learners can be strong contributors to the important fields involving mathematics.

Research Setting & Context

The research setting that was utilized for this study is a small midwestern independent school in Chicago that only serves students with learning disorders. The site was carefully chosen because the students have been diagnosed with one or multiple learning disorders, including developmental dyscalculia. This particular group of high school students is able to reflect on their previous experiences learning mathematics and share their perspective on learning the subject with formal learning challenges. Being a college-preparatory school, students are working with the various available resources to reflect and choose colleges based on their career interests. With this common goal and homogenous setting, the variation in student experiences is decreased. A more focused understanding of the mathematical identity development can be discovered through this study with this particular research site.

The goal for students attending this specific high school is to receive an outstanding education that fits their needs and learning styles. The learning disorders that students are facing cause difficulties in performing at their highest potential when mixed into a traditional high school that contains large class sizes. At this school, class sizes typically range from four to twelve students, with an average class size of ten students. This small class size model allows instructors to gain an understanding of the specific challenges each student faces. With the school's specific vision in mind, instructors can benefit from creating a classroom environment that allows students to be successful at their level of understanding and based on their specific methods of learning. The learning process for the majority of these students was a negative experience, bringing failure in multiple instances. This was not caused by student carelessness, but rather disengagement due to a lack of attempt to bring out the best way each student learns.

Research Design

The research design utilized for this study involves a transformative approach where quantitative data from questionnaires inform the document analysis process of qualitative data from journal entries. The journal responses transform into categorical data for quantitative analysis in this process. The cross-sectional data analysis aims to find associations, differences, and frequencies that occur between the categories of confidence, motivation, anxiety, and career interest. Both sources of data are pulled from the exact same sample group, giving two modes of analysis. The information is obtained appropriately, following ethical research guidelines. All aspects of the research study were presented before DePaul University's Institutional Review Board (IRB) to receive input and formal approval (Appendix I) for this research study, which involves collection of data from human subjects. The research design implemented for this dissertation study follows the regulations set forth by the IRB. It does not involve any experimental or control groups, subject randomization, use of deception, non-full disclosure, or manipulations. The research design also does not collect data using audio, photographs, or video recordings and does not involve the collection of biological specimens or materials.

Designing the Instruments of Research

In formulating the questionnaire instrument as a tool for measurement, the researcher used previously conducted research studies related to identity development, attitude, and career interest. The tool was modeled after questionnaires used in studies related to various topics such as mathematics anxiety, confidence in learning mathematics, motivation, and attitude towards success in mathematics. These aspects of the student experiences in learning mathematics are considered important to mathematical identity formation, and used in defining what the identity formation for students would look like for the purpose of this study. The Fennema-Sherman Mathematics Attitudes Scale (FSMAS) is a popular instrument used in studies that are related to student attitudes (Ren et al., 2016). It has been used in our country as well as Canada and Australia. The test was originally created to look at the gender-related differences in the attitudes towards mathematical thinking for high school students (Fennema & Sherman, 1976). The FSMAS includes nine scales that measure domain-specific attitudes related to learning mathematics (Fennema & Sherman, 1976):

- Attitude Toward the Success in Mathematics
- Mathematics as a Male Domain
- Mother (perception of mother’s attitudes toward one as a learner of mathematics)
- Father (perception of father’s attitudes toward one as a learner of mathematics)
- Teacher (perception of teacher’s attitudes toward one as a learner of mathematics)
- Confidence in Learning Mathematics

- Mathematics Anxiety
- Effectance Motivation in Mathematics
- Mathematics Usefulness

Various researchers have utilized the FSMAS, or parts of the instrument, to conduct research related to mathematical identity formation. Out of these nine scales, different researchers have decided to use various combinations. For example, Lim and Chapman (2013) and Dew et al. (1983) used the Mathematics Anxiety scale of the FSMAS, Norton and Rennie (1998) used five of the scales in their study regarding attitudes in single-sex and coeducational schools, and Betz (1978) has used the anxiety scale for college students (Ren et al., 2016). The researcher chose to follow a method similar to Pearn et al. (1996), who selected specific items from the FSMAS, rather than using the full scale, to develop a multidimensional questionnaire that combined aspects of the FSMAS with other instruments to look at the mathematical attitudes of secondary students in Australia with non-English speaking backgrounds (Ren et al., 2016). The instrument has been mostly used for secondary and college level students. The researcher chose to model statements in the questionnaire designed for this study based on those utilized in the FSMAS. Along with the FSMAS, the researcher used aspects of the Career Interest Questionnaire (CIQ) developed by Christensen and Knezek (2017), which provided insight into the mathematical career interests expressed by secondary students. Combining the strengths of these resources allowed the instrument created for this study to include statements that incorporated attitude, confidence, and anxiety from the FSMAS with statements related to career interest from the CIQ.

A 5-point Likert scale was used for this instrument in order to give students a choice of responses from strongly disagree to strongly agree. The statements were re-phrased and grouped by the researcher to include the domains of mathematical identity (confidence, motivation, and anxiety) and their potential associations with career interest. The final product includes multiple statements for these four domains that are similar, a few repetitive, in order to develop reliability and validity of the instrument. The instrument created was the first of its kind in linking together these four aspects of research. This new instrument was created to look at the particular area of research presented in this study, specifically for students with learning disorders (Appendix A).

An additional instrument used for data collection involved a first-day-of-school activity that the researcher utilizes with students at the beginning of each year. The instrument is a Math & Me journal activity that asks students questions about their experience in learning mathematics. The various questions are to guide the thinking for students to help describe their strengths, weaknesses, and various factors that have created the experience of doing mathematics (Appendix B).

Sample Recruitment Procedures

The identification and recruitment of subjects included all students enrolled at the research site. Recruitment materials were approved by the IRB before implementation for this study. The researcher made the initial interaction by e-mail, which included making contact with the potential subjects and their parents/guardians. The subjects were initially provided with the assent/consent forms detailing information about the intentions of collecting data through questionnaires, utilizing the journal entries, and details of voluntary participation. Parents/guardians received a permission form. Both parents/guardians and potential subjects were provided the opportunity to contact the researcher in order to discuss any questions or to learn more about the results of the research study. The e-mail contact was made while protecting each individual's e-mail address using the school's secure e-mail listserv service. The research site sent the e-mail on behalf of the researcher through the protected listserv service. The researcher did not have access to individual e-mail addresses unless subjects or parents/guardians decided to contact the researcher directly.

The private records utilized in this research included the personal e-mail addresses for the parents/guardians permission of the subjects' participation. The students' school e-mails were used to distribute their assent/consent forms. The custodian of these records was the research site and the letter of support from the high school's head of school mentioned providing access to these records for the use of distributing and collecting permission and assent/consent forms to recruit research subjects for this research project only. In this process, the researcher did not gain access to the e-mail addresses. The school distributed the IRB approved recruitment e-mail on behalf of the researcher so that the privacy of the parents and students was not violated. The school used the secure protected listserv service that was already used to contact parents/guardians and students. This service included using the Bcc (blind copy) function and did not list any private e-mail addresses in the To portion of the e-mail. A single e-mail was sent to the parents/guardians, minor subjects, and subjects aged 18 or older. The email was carefully worded to clarify instructions for how parents and students could return permission, consent, and assent forms directly to the researcher.

To minimize the potential perception of coercion or undue influence for students and parents feeling forced into participating in the research, it was made clear through the recruitment e-mails that a decision to participate or against participation in the study would not have any influence on the student at the high school, including impacts on the grades or standing relationship with the school. This clarification was included in the recruitment e-mails, parent/guardian permission form, assent form, and consent form. The information stated that subjects and/or parents/guardians were free to decline participation and were told they could withdraw at any time up until the participation in the questionnaire. A follow-up e-mail was used to remind parents and students four days after the initial e-mail was sent. As permission, consent, and assent forms were returned, the researcher kept record so that only subjects with proper clearance were included in the study. This parent/legal guardian permission occurred alongside the assent process. The subjects aged 18 or older were included on the recruitment e-mails with a copy of the consent content. Based on the final list that was created, the researcher only gave questionnaires and included journal entries for those with permission and assent/consent.

Individuals that are considered children (ages 14-17) were asked to sign and return the appropriate assent form. This form was distributed by e-mail along with the initial contact that was made to parent/legal guardians. A consent form was also shared for any students that were considered adults (ages 18-19), however permission from parents was required only for any student enrolled at the research site that were minors (under the age of 18). The students and parents were asked to return these signed materials directly to the researcher by e-mail, mailed to the school under the attention of the researcher, or brought in person directly to the researcher.

Questionnaire Responses

The main source of data collection involved use of the questionnaire created for the purposes of this research study. The questionnaire was administered to students with various learning disorders to draw connections between student confidence, motivation, anxiety, and career interests related to mathematics. The questionnaire was administered one time in one sitting after confirming that appropriate permission and assent/consent was provided. Each participant was read specific directions for the study, which included a statement that allowed for no participation in the study if the student became upset, uncomfortable, or simply changed their mind. Included in these directions were to make sure the students did not write their names anywhere on the questionnaire. The researcher followed a set schedule to administer the questionnaire to students during a learning resources class that all students are enrolled in throughout the school year. The subjects took the surveys in their regularly scheduled classroom. The questionnaire planned to take about 10-15 minutes, which was communicated to the research subjects, and it was administered with paper and pen. The non-research participants in the class were asked to work independently on regularly scheduled work for their class. This setup of administering questionnaires was discussed and agreed upon with the research site's Head of School. The questionnaire was conducted solely for the purposes of this research.

The researcher asked subjects to place the completed questionnaire into a bin when completed. The process was repeated for all subjects until the research collection time had ended. Since no identifiers were included on the written responses, the researcher was able to take all of the responses and tabulate them digitally in an Excel spreadsheet. As the data was entered into the spreadsheet, the questionnaires were coded with a three-digit number in order to archive responses. This archive was to be accessed to confirm that each response was only included once in data analysis and can be accessed in case the researcher finds a need to view original responses for any reason. The original responses will never be shared with anyone. The data was recorded in a way that allows the researcher to calculate frequencies of responses based on the Likert scale that was used. The responses were to be categorized and presented in the results section. The categories for these responses include Confidence in Learning Mathematics, Career Interest in Mathematics, Motivation in Mathematics, and Anxiety in Mathematics. The 5-point Likert scale used in this questionnaire utilizes frequency of responses ranging from Strongly Disagree to Strongly Agree. The statements for the four categories were mixed so that students are able to respond to all statements without creating connections between them. Re-grouping the responses into the four categories is explained in the results section.

The specific research design and methods for this part of the study involves a quantitative analysis based on the overall data and the responses categorized into the four categories. The data was to cross-reference aspects from multiple categories in order to make conclusions based on any connections that may exist. Dependent on the results of the data, the researcher planned to utilize a comparison of median responses for each statement. Descriptive statistical analysis would lead to any existing correlation of the data. A Chi-square analysis allows for comparison between expected and observed frequencies for particular statements, categories, or based on gender. The Mann-Whitney U test would allow for comparing median values of the responses to the questionnaire statements. All in all, the researcher was to generalize patterns and draw conclusions for the group in order to create associations between the four categories presented.

Journal Entries

The second part of this study involves an analysis of the Math & Me Journal artifacts for students who reflected on their experiences in taking mathematics in the researcher's mathematics class. These journals were completed as a part of the students' normal school activities as assigned and were not done specifically for the research. These journals were completed specifically for the researcher's class as an activity, typically used to learn about students' experiences with mathematics as the school year begins each year. Students who gave assent/consent could have completed this at any time they were enrolled in the researcher's mathematics class.

For the journal entries, the permission and consent/assent form was used to receive permission only from students who have completed this journal activity. This was information that the researcher already had in existence, but only the individuals with proper permission and assent/consent on file were included. The narrative responses to these journals were collected and recorded without any identifiable information. The responses from each journal entry were recorded and marked with gender for data analysis purposes. The reason for recording gender is related solely to the purposes of data analysis for this data set. The researcher did not know yet if patterns existed within this data at the time of data collection, but the research asked to look for patterns in journal responses, and one method of categorizing the data that is analyzed is by gender. This is important in finding differing results, if any, based on gender. The typed responses and scans of any drawings are stored on a digital file with no identifying information. This part of the study required no time being used from the students. It was simply an anonymous analysis of responses the researcher had received from students in class.

The aim is to simply analyze these journal entries for patterns and key vocabulary used in describing experiences. They were used in helping the researcher to generalize and categorize math identity formation. The research design and methods aim to find patterns in the descriptions that students provided in response to the specific questions that were employed on the first day of math class. This involved word analysis and frequency of particular words related to and defined in the dissertation study as related to the topics of the study.

Research Questions & Hypotheses

Research Questions

The research aims to answer the following questions:

1. What connections can be bridged between confidence in learning mathematics, career interest in mathematics, motivation in mathematics, and anxiety in mathematics?

2. What experiences have led to a negative identity formation in relation to math achievement?
3. How do the early elementary school experiences for a student with a specific learning disorder, such as developmental dyscalculia, affect their overall interest in learning mathematics in high school?

Research Hypotheses

Hypothesis 1

- H_A: In the development of mathematical identity for students with specific learning disorders, there are clear associations and differences with how their confidence, motivation, and anxiety in learning mathematics has influenced their career interests in mathematics.
- H_o: In the development of mathematical identity for students with specific learning disorders, there are no clear associations or differences with how their confidence, motivation, and anxiety in learning mathematics has influenced their career interests in mathematics.

Hypothesis 2

- H_A: Specific learning disorders that have negatively impacted mathematical thinking for students has led to disinterest in the subject matter, specifically in how it may play importance in their future.
- H_o: Specific learning disorders that have negatively impacted mathematical thinking for students has no association to interest in the subject matter, specifically in how it may play importance in their future.

Setting, Sample & Population

The population for the research study includes students enrolled at a midwestern independent college-preparatory high school for students with diagnosed learning disorders. The age range includes 14-19 years and the research study includes all students, regardless of gender, race, religious views and/or ethnicity. The researcher aimed to recruit a sample size of at least forty students to include in the research.

Data Collection & Analysis

Quantitative Data Collection and Analysis

- Questionnaire responses from researcher-created instrument
- SPSS data calculation and computation
- Comparison of medians for each statement
- Chi-square analysis for expected versus observed frequencies in responses
- Mann-Whitney U test for comparing median response values between the statements
- Measure of association, differences, and frequencies of responses to statements within each category
- Comparisons based on gender and grade levels, if important

Qualitative Data Transformation and Analysis

- Analysis of journal entries responses to include a coding process into the categories that are presented in questionnaire
- Transformation of qualitative data into quantitative data to test for associations between categories

Proposed Data Analysis

Relevant Descriptive Statistics

Non-experimental testing for association between categorical variables of confidence, motivation, anxiety, and career interest is found using the Chi-square test statistic, comparing observed and expected frequencies for independence.

Proposed Inferential Analysis for Hypothesis Testing

The Mann-Whitney U test is conducted to evaluate whether the median responses of specific categories or statements are significantly different based on gender or grade level, where the independent variable of questionnaire responses based on gender or grade level is related to the dependent variable of median responses.

Statistical Significance

If the results indicate that there is no significant association between the categories that are considered a part of mathematical identity formation with career interest, then we would fail to reject H_o. If, however, there were an association between categories, we would reject H_o.

Conditions and Assumptions

1. The observations are randomly and independently sampled
2. A sample with large size is assumed (a Type II error may occur with small sample size)
3. The observations are assumed to be independent of each other
4. The observations must have the same fundamental distribution
5. The data is presented as frequencies

Graphing

In graphing data, bar charts show the frequencies of responses for each statement, category, and compare expected to observed responses.

Validity Approaches

The questionnaires must have statements that do not show bias based on the researcher's experiences with teaching the sample group of students. Journal entries are sourced data from the researcher's students. The measurements taken from journal entries are used to enhance the study results. Bias should not affect the results of the study when analyzing the journal responses.

Potential Ethical Issues

Some of the individuals that took part in the study have previously been students in the researcher's classes. The researcher made sure that confidentiality was kept for students' responses and that bias did not affect the results of the study. Also, the research involved the participation of minors, K-12 students, who have all been diagnosed with one or more learning disorders. The reason to include these vulnerable subjects is to address the impact of learning disorders on student achievement in mathematics that is directly pertinent to this population. The only way to learn about the issue within the specific population of these students in this manner is through this study, which may help members of this population in the future. Although this population is considered vulnerable, they are fully capable of providing their assent/consent to take part in the study. The students enrolled at the research site are considered intellectually average to high achieving individuals. There is no part of the learning disorder designation that may hold them back from being capable of providing assent/consent or taking part in completing the questionnaire. The rights of the research participants are protected through the conventions of research ethics and the formal IRB process. This was followed before any data collection took place.

The foreseeable risks to students who filled out the questionnaire for this research study are mere possibilities. The students included in this sample are cognizant of their learning differences and are capable of answering the questions that are asked. Students becoming upset or feeling uncomfortable with the questions that are asked about their experience with mathematics, and reflecting on their interests in career fields related to mathematics, are considered common risks related to educational research. A potential breach of confidentiality of the data, should someone outside the research gain access to results, is not an issue since the data was completely de-identified as it was collected.

The journal entry collection is a risk since it involves the collection of personal or sensitive information in private records, initially accessed in an identifiable way. However, the journal data was collected without identifying information, recorded only with gender and marked with a special three-digit code. Once recordings of this data were made (typed responses and scans of any drawings), the entries were stored on a digital file with no identifying information. A potential breach of confidentiality of this data, should someone outside the research gain access to results, is possible during the time period that the data is identifiable and before the identifiers are stripped from the original source of data. This was stated in the IRB approval process.

In both parts of the study, data collection involved recording data using gender. The questionnaire also recorded grade level. The data, however, was coded with no connection to the original participant. The researcher has no way of knowing who filled out which questionnaire. The coding was simply used in case the researcher needed to go back to original questionnaire responses. However, the codes did not link the data to any individual subject.

In order to minimize potential risks, the researcher planned to note any student who felt upset, uncomfortable, or had adverse effects or events by participating in the questionnaire. These students were to be directed to the appropriate resources in the school, including the school psychologist, social worker, or guidance counselor. However, this did not occur throughout the data collection process. The students were also reminded that their participation in the questionnaire could have been stopped even after receiving permission from parents and submitting assent/consent. Students did not face any consequences for choosing not to participate. Students were given the option to skip questions that they did not want to answer. The likelihood of any adverse effects due to the mentioned risks was extremely minimal, as the subjects are fully aware of their capabilities and often take part in reflective activities. The seriousness and anticipated duration of the risks is minimal, but the researcher made sure to appropriately report any risks that subjects could have encountered to the parents through detailed information in the permission documents. The members of the student services team at the research site were to be immediately informed in order to take the appropriate actions in case any individuals were affected by these risks.

Limits and Delimitations

Limitations are weaknesses to the study design that could potentially affect the outcomes. In collecting responses to attitude and interest questionnaires, it is important to acknowledge various factors that may impact student responses. The researcher's decision not to include and link the particular learning disorder for each participant to his or her responses may restrict the scope of this study. A small sample size could limit the results when the final group of participants is divided by gender or grade level. To observe differences between these groups, it would be beneficial to have a larger sample size. Delimitations are parameters intentionally imposed on the research design to limit the scope of the study. The sample used for this particular study serves as a delimitation to conduct research in a single setting to specifically study this population.

Conclusion

Students with developmental dyscalculia experience standardized curriculum and assessments from an early age when learning mathematics. Often, these modes of instruction hold them back from being able to take advantage of higher-level mathematical courses because they are placed into lower levels. Rather than learning strategies to work around the negative effects of their learning disorders, these individuals find themselves averted from career fields related to mathematics by the time they are enrolled in high school level mathematics courses. The purpose of this transformative design study is to explore the formation of mathematical identity for students with learning disorders, in regards to confidence, motivation, and anxiety, and this identity's implications on overall interest in pursuing a career field related to mathematics. School leaders, educators, parents, and students can benefit from the results of this study.

CHAPTER 4:

DATA ANALYSIS FOR MATHEMATICAL IDENTITY

In order to make contributions to research related to curricular studies, it is the researcher's goal to investigate the important questions that have been supported with literature. The purpose of this transformative design study was to analyze the data that was collected in order to explore research surrounding the mathematical identity formation for students with learning disorders. The report focuses on questionnaire responses that allow for quantitative analysis of four categories including Confidence, Career Interest, Motivation, and Anxiety related to mathematical achievement. Individual identity formation impacts overall interest towards post-secondary education and careers related to mathematics. The analysis of this data contributes to conversations related to the current curricular issues with mathematical education in our system. The following summarized results and emergent conclusions give insight into the problems and questions that were posed as a goal of this dissertation research study. This chapter specifically serves to organize and report the transformative study's main findings related to both quantitative and qualitative data.

The data analysis consists of an explanation of how the questionnaire responses and journal entries were synthesized into quantitative data and then analyzed using statistical testing. The study presents two analyses: first with the questionnaire responses, which give an objective summary of data collected from the sample of students with learning disorders and second with the journal entries, which were transformed into quantitative data using a subjective, narrative analysis approach. The analyses of this data aims to answer the following research question: What associations can be bridged between confidence, career interest, motivation, and anxiety in learning mathematics? The data also developed sub-questions important to acknowledge and discuss: What aspects of early school experiences for a student with a specific learning disorder, such as developmental dyscalculia, affect their overall interest in learning mathematics in high school? How does gender and grade level at the high school level play a role in analyzing the confidence, career interest, motivation, and anxiety related to mathematical identity formation?

Defining the Categories of Analysis

The experiences an individual faces throughout their schooling mark the numerous aspects of identity. Specifically, the schooling experiences play a large role in the identity formation, as described in the review of literature (Allen & Schnell, 2016; Baines, 2014; Darragh, 2013; Flum & Kaplan, 2012; Kroger, 2004; Teng, 2019; Wenger, 1998;). Various experiences that require interactions with others, such as social engagement (Wenger, 1998), sociocultural relations (Baines, 2014), and intersectionality of different capitals (Teng, 2019), contribute to identity formation. The key areas of identity formation specific to mathematical thinking that hold focus in this study include levels of confidence, motivation, and anxiety. Although these areas have been previously studied together, this study aims to bring in career interest as well as focus on the identity formation for students with learning disorders. These four areas are defined below in order to build a framework and provide a lens to understand and approach the findings of this study:

Confidence: the ability to see oneself as capable of taking part in the learning of mathematics, with an acceptance that the subject can be learned effectively and well

Career Interest: mathematical goals and aspirations in the future, including post-secondary education or career fields that may involve the utilization of mathematics

Motivation: viewing the subject area as enjoyable, with perseverance and putting forth effort and work in order to complete mathematical thinking and attain mathematical skills

Anxiety: fearful avoidance of doing math and being challenged, which may be a direct or indirect result of prior negative experiences involving mathematical thinking

Mathematical identity can influence the learning of mathematical concepts and understanding the various aspects of this influence is important. Self-perception may be related to abilities and participation in mathematics while the social context of being a certain type of mathematics student may influence how each individual identifies within their confidence, career interest, motivation, and anxiety related to mathematics (Allen & Schnell, 2016; Cranfield, 2013; Leatham & Hill, 2010).

The questionnaire responses are considered a reflection of these four areas and how each individual performs within their educational environment. The analysis should therefore represent an understanding of how these individuals view themselves within the context of their mathematical identity. Within this understanding is the attitude that is held by this specific sample of students with learning disorders attending a high school that is set out to service their specific learning disorders. The journal entries were an opportunity for individuals to use a narrative approach to explain a self-understanding of their mathematical identity.

Profiling Levels of Identity Categories

In order to utilize the data for both the questionnaire responses and journal entries, an approach was designed by the researcher to create profiles for each individual. The concept of profiling in research, as used for this research study, pertains to information retrieval based on the methods of information science as historically introduced by researchers such as Paul Otlet (Rayward, 1997). Documentation procedures to summarize data have been an important aspect of data analysis methods throughout history. The importance of forming profiles for the individuals involved in this research plays a large role in conducting the analysis of data, helping to answer the research questions that are of focus. The process of documentation for research purposes helps to understand answers we are seeking in the field of research (Rayward, 1997).

Correlation in Research

In statistical research and analysis, correlation allows the understanding of association between variables that are being studied. The term association specifically refers to the relatedness of two events, which helps to understand how they vary with one another. The presence of two variables can co-exist and increase together, for example, causing them to co-vary and associate as they increase (Abbott, 2011; Tanner, 2012). Correlation in this study allowed for the exploration of the relationships that may exist among variables that I believed to be important to the research questions regarding mathematical identity formation for students with learning disorders. When two measures co-vary in a non-random manner, it is possible to predict the value of one measure from the value of the other (Tanner, 2012). In future research, the goal is to utilize the witnessed correlation to help predict outcomes based on the related variables (Abbott, 2011).

Since the data used in this study is ordinal, Spearman's rho statistical test was utilized to measure correlation. In educational research, the rank-ordered data can be used as well in order to find correlations, which was utilized for the analysis of the questionnaire responses. The results of this test range from -1 to $+1$. With the Spearman's rho calculation, hypothesis testing allows to see if the value is significant (Abbott, 2011). A relationship between the two variables is thought to emerge from the data when correlation is statistically significant (Tanner, 2012).

Contingency Analysis in Research

As data analysis progressed, the need for a goodness-of-fit Chi-square test of independence emerged to find whether the category data was influenced by the variables of gender and grade level (Abbott, 2011; Tanner, 2012). Each of the four areas of research related to mathematical identity formation was analyzed. The test was able to show if the frequencies observed were influential within gender groups or within grade levels. Both expected and observed frequencies are compared in a Chi-square analysis to look for differences in these two frequency counts and to measure the "goodness" of how the sample conforms to the values that are expected (Tanner, 2012). The test analyzes how well the resulting observed data fits with what is expected from the data.

Questionnaire Response Analysis

For the questionnaire responses, it was important to summarize the data in different ways. To start the data analysis process, the Questionnaire Key (Appendix A) was used to rearrange the responses by grouping the statements into the four categories that were to be studied. This included Confidence, Career Interest, Motivation, and Anxiety. The original Likert-scale response for each statement was kept for each respondent, but the grouping of statements helped to see how the individuals were responding to statements that belonged to the same category.

At first, I looked at the median responses for each statement. The range of responses corresponded to a Likert-scale from 1 through 5, where a score of 1 was assigned to a response of "Strongly Disagree", 2 as "Disagree", 3 as "Neutral", 4 as "Agree", and 5 as "Strongly Agree". In doing so, it was important to realize that the Neutral median response did not tell enough information about the responses as a whole. Next, I created three groupings to summarize the percentage of respondents for each statement. The three groupings included overall Disagreement (response scores of 1 and 2), Neutral (response score of 3), and Agreement (response scores of 4 and 5). The data was reported as percentages of individuals that were either in Disagreement, Neutral, or Agreement with each statement. This helped to see the data in more detail for each questionnaire statement and where the majority of students responded for each statement.

The next calculations were performed to help create a profile for each of the fifty-five respondents by creating three distinct levels for each category that was studied. The respondents were profiled by being placed into a Low, Mid, or High level of the four categories. For example, student questionnaire form number 101 was placed under a High level of Confidence, High level of Career Interest, High level of Motivation, and Low level of Anxiety based on their questionnaire responses.

In order to create these profiles, I first read through each statement of the questionnaire and transformed statements into the reverse or negative statement in order to appropriately fit the Low, Mid, or High levels of each category (Appendix C). This also caused the response value to change into its reverse. For example, under the Confidence category, the statement, "I'm not good at math" with a response of 5 would show that the respondent Strongly Agrees that they are not good at math, showing a Low level of Confidence. Writing the reverse of this statement into, "I'm good at math" and changing the response value to a 1 would express that the respondent Strongly Disagrees with the idea that they are good at math. This lower point value of 1 would be included into the student's total profile score, and corresponding to a Low level of Confidence. All categories required some statements to be changed into the reverse or negative statement, and the response scores were also changed appropriately. This allowed me to then use sums of the response values to create profiles in each category for each respondent.

To create the score ranges for the Low, Mid, and High levels in each category, I used a response range of 1 through 2.5 for the Low level, greater than 2.5 to less than 3.5 for the Mid level, and greater than 3.5 through 5 for the High level. Next, the actual score range for each level was calculated by multiplying the total number of questions per category by these values. For example, to calculate the ranges for the Motivation category, the following calculations were used: (1 x 14 questions) and (2.5 x 14 questions) gives a Low level range of 14 to 35; (3.5 x 14 questions) and (5 x 14 questions) gives a High level range of 49 to 70. This leaves sums of 36 to 48 for the Mid level range.

Once the reverse statements were created and scores were transformed to match the reverse statements, the sum of the responses to questions within each category helped to code each respondent into the four categories. This helped to form their profile based on the Low, Mid, or High levels for Confidence, Career Interest, Motivation, and Anxiety (Appendix D). In performing data calculations, the scores from this process were used in different ways. Based on the statistical test used, the raw scores for each respondent, the ranked raw scores for each respondent, or the profile formed under a Low, Mid, or High level of each category was used.

Strength and Direction of Association Between Ordinal Variables

Correlation between the four categories that were utilized for this study was calculated through a Spearman-rho analysis (Laerd Statistics, 2018). The Spearman rank-order correlation was used to measure the strength and direction of the association between ordinal variables for the initial quantitative analysis of this study, with the following hypotheses:

- Confidence & Career Interest
  - H_o: There is no association between Confidence and Career Interest.
  - H_A: There is an association between Confidence and Career Interest.
- Confidence & Motivation
  - H_o: There is no association between Confidence and Motivation.
  - H_A: There is an association between Confidence and Motivation.

- Confidence & Anxiety
    - H_o: There is no association between Confidence and Anxiety.
    - H_A: There is an association between Confidence and Anxiety.
- Motivation & Career Interest
    - H_o: There is no association between Motivation and Career Interest.
    - H_A: There is an association between Motivation and Career Interest.
- Motivation & Anxiety
    - H_o: There is no association between Motivation and Anxiety.
    - H_A: There is an association between Motivation and Anxiety.
- Anxiety & Career Interest
    - H_o: There is no association between Anxiety and Career Interest.
    - H_A: There is an association between Anxiety and Career Interest.

Assumptions are met to use this statistical test. The responses to the questionnaire categories would be considered ordinal data since a Likert scale was used for respondents to answer the statements, and then the respondents were placed into ordered levels of Confidence, Career Interest, Motivation, and Anxiety (Low, Mid, and High). The variables that were used are paired observations for single participants, where each of the four categories were matched with each other.

A Spearman's rank-order correlation was run to assess the relationship between the various categories listed in the hypotheses for students with learning disorders. Fifty-five participants were included in this study. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. The respondents' total score within each category was ranked. This ranked data was utilized to run statistical analysis. The Spearman correlation was used to determine if there is a relationship between any two categories, given the following correlation coefficients:

Table 4.1

Questionnaire Response Spearman rho Correlation

	Confidence Level	*Career Interest Level*	*Motivation Level*	*Anxiety Level*
Confidence Level	1.000	.519**	.782**	-.835**
Career Interest Level	.519**	1.000	.564**	-.516**
Motivation Level	.782**	.564**	1.000	-.760**
Anxiety Level	-.835**	-.516**	-.760**	1.000

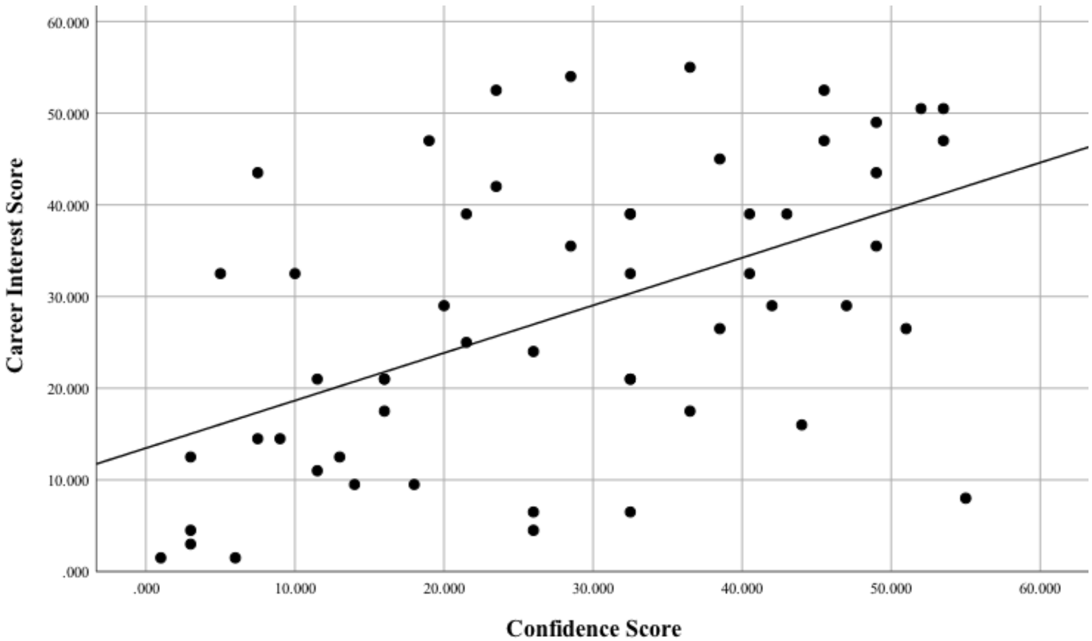
** $p < 0.01$, two-tailed

The correlation coefficient indicates the strength of the relationship between the variables and the degree to which the variables co-vary. Based on the statistical measurements in Table 4.1, the following analyses were made:

Confidence & Career Interest: There was a statistically significant, moderate positive correlation between level of Confidence and level of Career Interest, $r_s(53) = .519, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.1

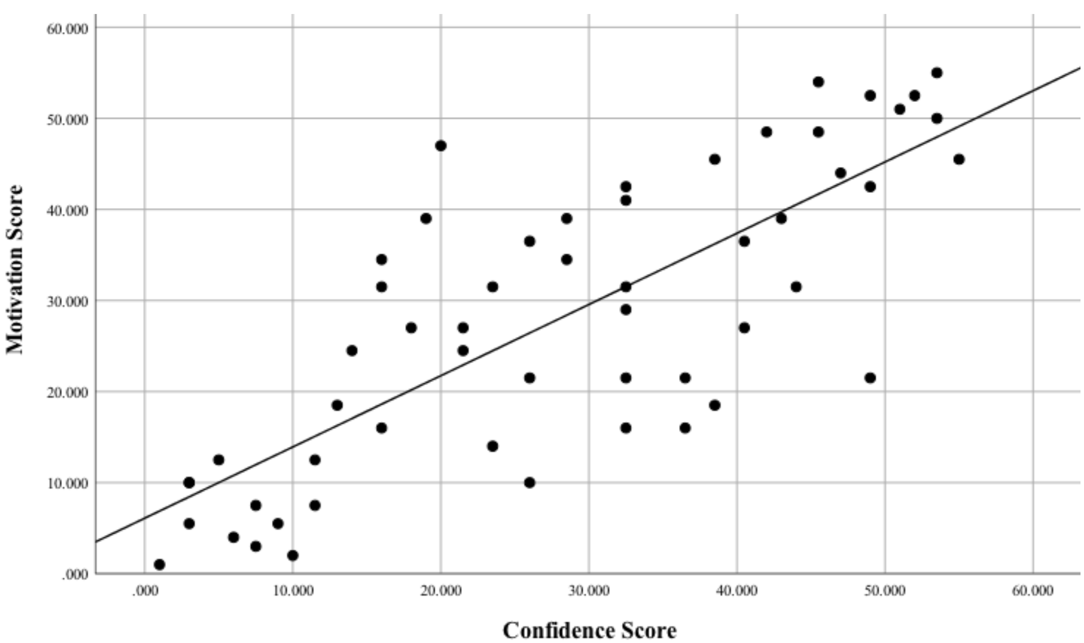
Questionnaire Correlation of Confidence and Career Interest



Confidence & Motivation: There was a statistically significant, strong positive correlation between level of Confidence and level of Motivation, $r_s(53) = .782, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.2

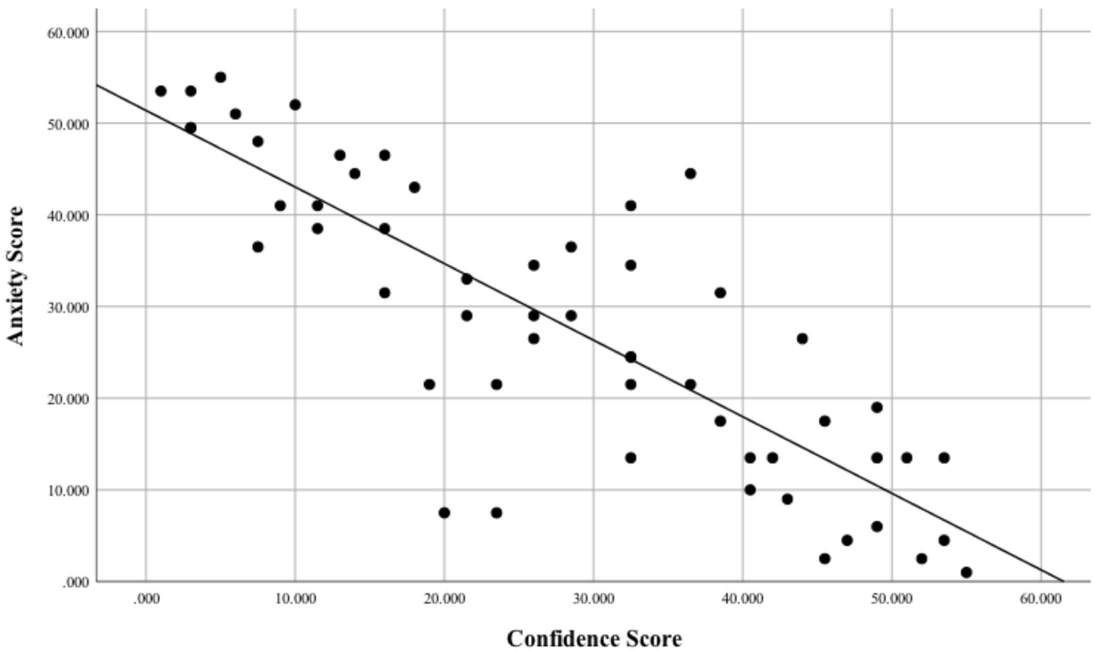
Questionnaire Correlation of Confidence and Motivation



Confidence & Anxiety: There was a statistically significant, strong negative correlation between level of Confidence and level of Anxiety, $r_s(53) = -.835, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.3

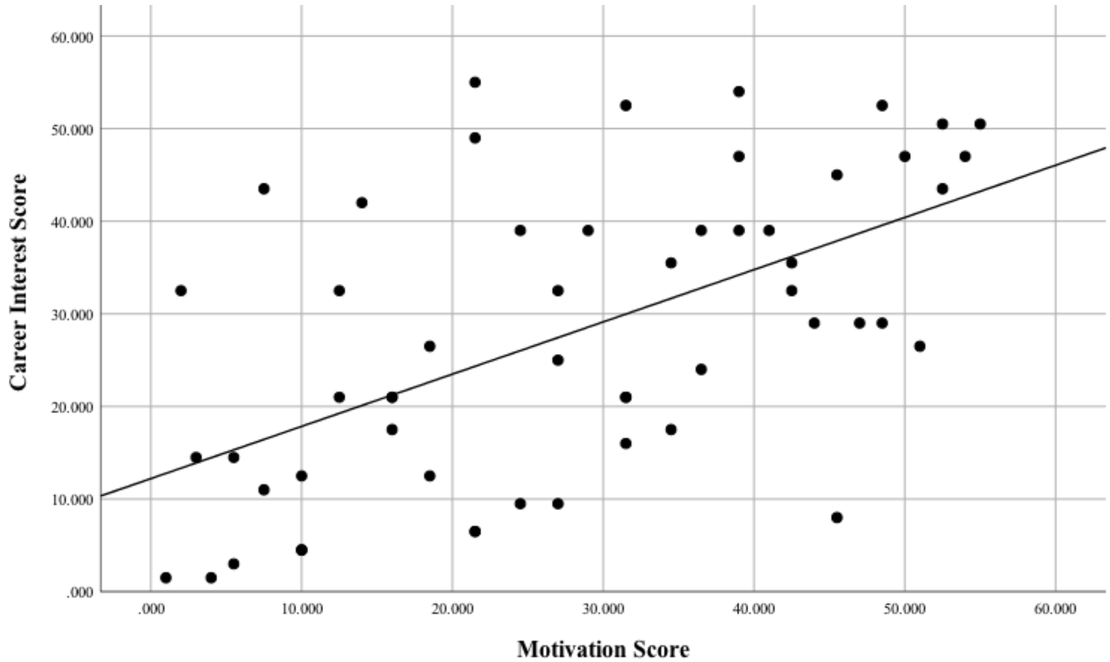
Questionnaire Correlation of Confidence and Anxiety



Motivation & Career Interest: There was a statistically significant, moderate positive correlation between level of Motivation and level of Career Interest, $r_s(53) = .564, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.4

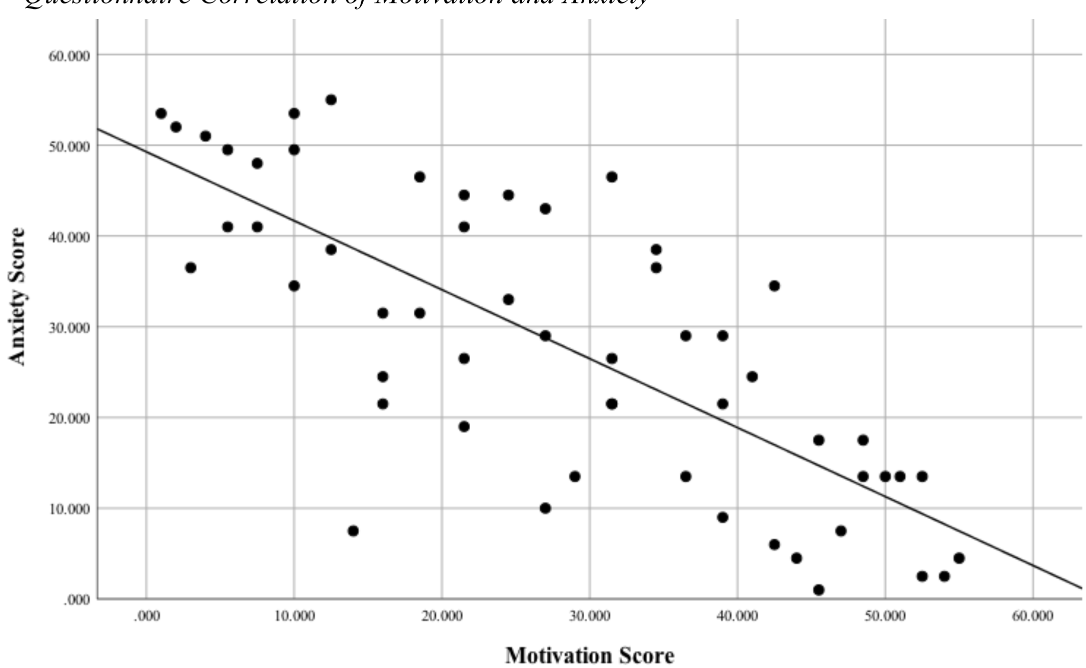
Questionnaire Correlation of Motivation and Career Interest



Motivation & Anxiety: There was a statistically significant, strong negative correlation between level of Motivation and level of Anxiety, $r_s(53) = -.760, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.5

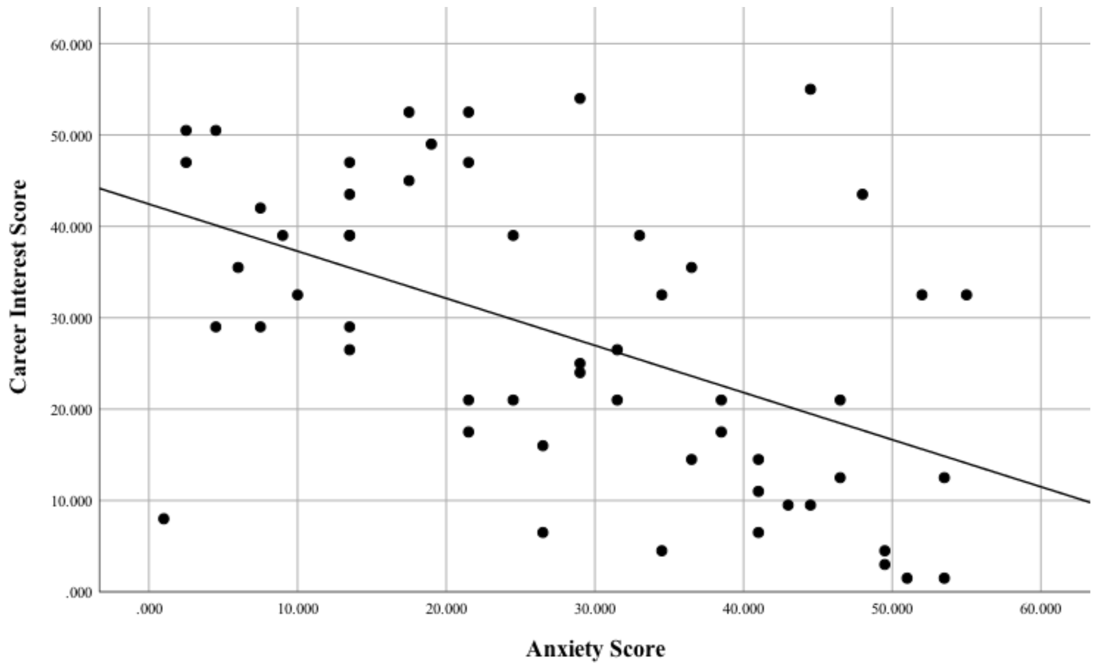
Questionnaire Correlation of Motivation and Anxiety



Anxiety & Career Interest: There was a statistically significant, moderate negative correlation between level of Anxiety and level of Career Interest, $r_s(53) = -.516, p < 0.001$. Therefore, we can reject the null hypothesis and accept the alternative hypothesis.

Figure 4.6

Questionnaire Correlation of Anxiety and Career Interest



Contingency Tables for Gender and Grade Level

The contingency tables utilized in this data analysis help to summarize the frequency distribution of Low, Mid, and High levels of the Confidence, Career Interest, Motivation, and Anxiety categories for comparing Gender groups and Grade Level groups. This data allows the researcher to dig deeper into the analysis that was conducted for this study. A Chi-square analysis helped the formation of contingency tables (Laerd Statistics, 2016). This statistical test for association determines if there is an association between two variables. The observed frequencies for Low, Mid, and High levels are compared to the expected frequencies if no such association existed between the variables, which are being compared between gender groups and grade level groups. The expected frequencies are calculated and based on there being no association between the variables. For this reason, the greater the association between variables, the greater we would anticipate the observed frequencies to differ from the expected frequencies. The less the two variables are associated, the closer the observed and expected frequencies would be to each other in value. Therefore, the Chi-square test produces a test statistic based on the magnitude of difference between the expected and observed frequencies based on the data results of the questionnaire responses. The further the observed frequencies are from the expected frequencies, the larger the test statistic. This would lead to making a conclusion that the association would be greater, and the more likely the result is statistically significant.

The assumptions made for the Chi-square test are that the data set includes two variables measured at the categorical level (Gender of Female or Male with Low, Mid, or High levels of Confidence, Career Interest, Motivation, and Anxiety) and that the observations are independent for each group. The following table summarizes the Chi-square results for Gender groups within the various levels of the different categories studied for mathematical identity:

Table 4.2

Questionnaire Chi-square Associations for Category Levels by Gender

	Value	*df*	*Asymptotic Significance (2-sided)*
Confidence	8.768	2	.012
Career Interest	5.076	2	.079
Motivation	5.393	2	.067
Anxiety	11.715	2	.003

Note. Data is reported for all $N = 55$ cases

The detailed frequencies and percentages, along with bar charts, are presented in Appendix E. Based on the statistical measurements in Table 4.2, the following conclusions can be made:

Confidence Level by Gender: A Chi-square test for association was conducted between Gender and Confidence Level. There was a statistically significant association between gender and confidence level, $\chi^2(2) = 8.768$, $p = .012$.

Career Interest Level by Gender: A Chi-square test for association was conducted between Gender and Career Interest Level. There was not a statistically significant association between gender and career interest level, $\chi^2(2) = 5.076$, $p = .079$.

Motivation Level by Gender: A Chi-square test for association was conducted between Gender and Motivation Level. There was not a statistically significant association between gender and motivation level, $\chi^2(2) = 5.393$, $p = .067$.

Anxiety Level by Gender: A Chi-square test for association was conducted between Gender and Anxiety Level. There was a statistically significant association between gender and anxiety level, $\chi^2(2) = 11.715$, $p = .003$.

The data calculated for associations within grade level groupings were not found to be statistically significant. Using a Chi-square test, an association for Low, Mid, and High levels of Confidence, Career Interest, Motivation, and Anxiety by Grade Level was not found.

Emergent Patterns & Themes within Questionnaires

The data presented in this study verifies the correlation between the four categories that were studied through the questionnaire responses. Correlation in statistical analysis, however, does not equate to causation. Rather, there is significant evidence that the correlation of the various categories that are considered attributes of mathematical identity exist. This is important in confirming how Confidence, Motivation, and Anxiety are crucial to the mathematical identity formation, and that the association with Career Interest between all three of these categories does exist for students with learning disorders that impact mathematical thinking. This important information contributes to research and gives reason to take part in further investigation.

Furthermore, a positive correlation between Confidence with Motivation introduce a relationship with the self-efficacy model that students with learning disorders utilize in their assessment of mathematical achievement. A negative correlation between Confidence with Anxiety and Motivation with Anxiety helps to understand that the identity attributes that pertain to self-efficacy share a relationship with the level of anxiety an individual feels when doing mathematical work. The negative relationship in both of these correlation calculations advise that higher levels of both Confidence and Motivation are related to the lower levels of Anxiety and that lower levels of Confidence and Motivation are related to higher levels of Anxiety.

The meaning that is created from this statistical analysis is related to the information that Confidence, Motivation, and Anxiety can provide when preparing students with learning disorders to think about their future plans related to mathematical Career Interest, including college majors and career choices. The patterns and themes from these findings allow the designed questionnaire to be used as a significant tool to profile students in the four categories. This information would be helpful in the guidance of student decisions related to futures that involve mathematical experiences.

Further, there was a difference in the observed and expected frequencies for Low, Mid and High levels for Confidence and Anxiety with relation to gender groups. The identified Male and Female gender groups had statistically different levels of Confidence and Anxiety based on the questionnaire responses. In issues of opportunities for females to achieve post-secondary college and career mathematical choices, this data helps to understand the key areas of research and work that still needs to be done.

Journal Entry Analysis

The journal entries that were utilized for this research study are considered archival data. The existing, relevant, and contextual information from these journals are to be used to further the contribution of research in the area of discussing the development of mathematical identity. The existing documents, in this case, are providing context and history to help triangulate data that was pulled from the quantitative aspect of this study (Ravitch & Carl, 2016). The purpose for this archival data is to supplement the data that was collected through the questionnaires. Specifically, the archival data used in this study would be considered personal documents, as explained by Bogdan and Biklen (1998), where students were asked to describe their experiences with mathematics as a method of reflection when they filled out a Math & Me journal entry (Creswell & Poth, 2018; Ravitch & Carl, 2016).

The journal entries were de-identified and marked only with gender and a 3-digit code unrelated to the codes used for the questionnaires. Each journal entry was transferred into text so that no connection to handwriting could be made (Appendix F). Spelling errors were not corrected when the journal responses were typed to avoid changing the original voice of the student. The typed journal responses were then coded for Low, Mid, or High levels of the four categories that were used for the questionnaires. Some of these journals had inconclusive information about the categories. For example, although the prompt asked students about their career interests in fields related to mathematics, some of the journal entries did not have any information to help profile the respondent of the journal entry within this category.

Since the journal entries are considered narrative responses to specific open-ended questions, a qualitative lens is used to analyze the responses. Utilizing the data in a way that influences this research project involves coding, or categorizing, and approaching the data with a narrative analysis lens (Ravitch & Carl, 2016). In qualitative analysis, coding involves assigning a phrase or word that captures the essence of the qualities produced by the text. The process of analyzing this data assumes that subjectivity is embedded into the data, along with how the data is interpreted (Creswell & Poth, 2018; Ravitch & Carl, 2016). The goal was to represent each journal entry with an accurate level of Confidence, Career Interest, Motivation, and Anxiety, which connected the data to the quantitative aspect of this study. These four aspects of mathematical identity were used as key components in creating profiles for each respondent involved in the study. Employing the lens of mathematical identity formation in relation to Confidence, Career Interest, Motivation, and Anxiety helps to code the text for each journal entry. This process allowed for findings based on data from the journal entries to contribute to the dialogue that is initiated in the quantitative analysis for this study (Ravitch & Carl, 2016).

As each journal entry was coded according to the four categories, I was able to create a profile for each of the forty-five journal authors, similar to the questionnaire respondent profiles. This process continued the use of the three levels for each category that was studied and transformed qualitative data collection into quantitative measures. The journal authors were profiled by being placed into a Low, Mid, or High level of the four categories. For example, journal entry number 201 was placed under a Low level of Confidence, Low level of Career Interest, Mid level of Motivation, and High level of Anxiety. In order to create these profiles, I read through each journal entry and highlighted statements or fragments that fit the Low, Mid, or High levels of each category. A color-coding system was utilized for each of the four categories.

The levels from each journal entry were summarized and displayed in a table (Appendix G). Assigning the Low, Mid, and High levels for each category depended on the defined aspects of this study including Confidence, Career Interest, Motivation, and Anxiety.

The following journal entry statements are examples of the three levels within each category:

- Confidence
    - Low – "No matter how hard I tried I am not able to comprehend what I should be doing to solve whatever math problem it is."
    - Mid – "I think I'm ok in math."
    - High – "I'm usually able to understand most of the material in math class and when it doesn't make sense, I'm able to understand it quickly."
- Career Interest
    - Low – "I am not interested in a career field in math."
    - Mid – "I…don't want a career in mathematics, however I wouldn't mind a career that involved mathematics."
    - High – "I know math is used for every job and so I will end up using it in every job perfesion."
- Motivation
    - Low – "Why do we need to learn stuff we don't need in the future?"
    - Mid – "I don't like math. I hope to learn more in general."
    - High – "I hope to build my confidence this year in math and improve my skills as a learner."

- Anxiety
  - Low – No statements were coded as an example of Low Anxiety
  - Mid – “It was almost an emotional thing.”
  - High – “Nothing triggers my frustration more than math.”

I did not attempt to make full interpretations of what was said in student journal entries, but rather, things we can consider as teachers of students who have learned mathematics differently. It is important to take into account the various statements that are made, as these students have gone through years of schooling that have influenced their mathematical identity formation.

Strength and Direction of Association Between Ordinal Variables

Correlation between the four categories that were utilized for this study was calculated through a Spearman-rho analysis. The Spearman correlation was used to measure the strength and direction of the association between ordinal variables for the secondary quantitative analysis of journal entries as a part of this study. There are assumptions that are met to be able to use this statistical test. Through the coding process, the journal entry authors were placed into ordered levels of Confidence, Career Interest, Motivation, and Anxiety (Low, Mid, and High), which created ordinal data. The variables that were used, where the four categories were matched with each other, are paired observations for single participants.

A Spearman's correlation was run to assess the relationship between the various categories for students with learning disorders (Laerd Statistics, 2018). Forty-five journal entry authors were included in this study. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. The level for each category in this study was utilized to run statistical analysis. The Spearman correlation was used to determine if there is a relationship between any two categories, given the following correlation coefficients:

Table 4.3

Journal Entry Spearman rho Correlation

	Confidence Level	*Career Interest Level*	*Motivation Level*	*Anxiety Level*
Confidence Level	1.000	.518**	.172	-.611**
Career Interest Level	.518**	1.000	.357	-.275
Motivation Level	.172	.357	1.000	-.229
Anxiety Level	-.611**	-.275	-.229	1.000

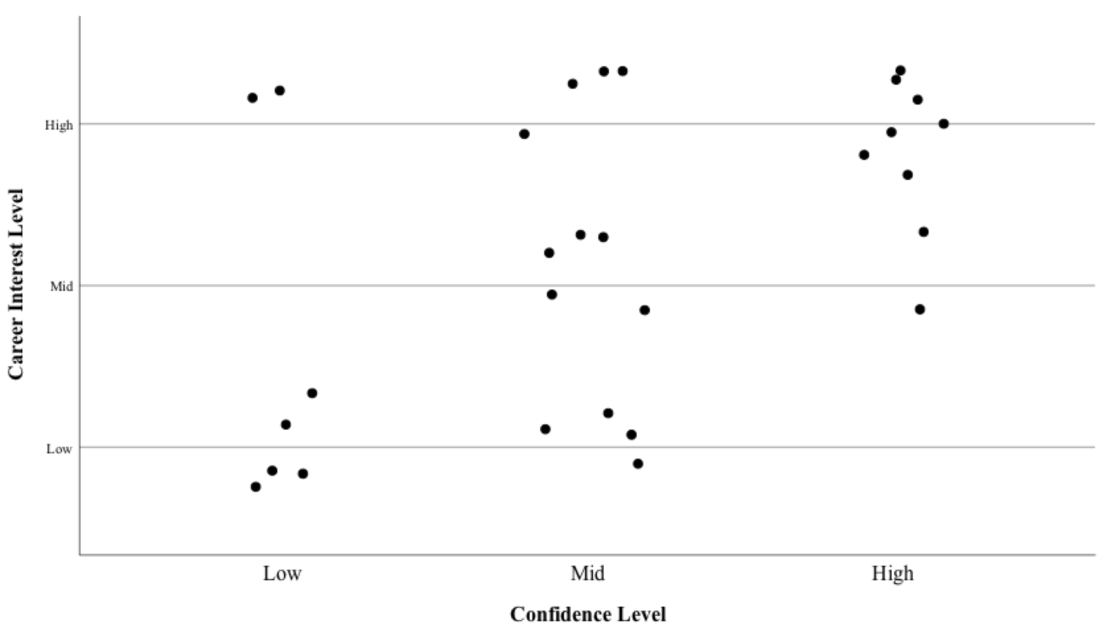
** $p < 0.01$, two-tailed

Based on the statistical measurements in Table 4.3, the following conclusions can be made:

Confidence & Career Interest: There was a statistically significant, moderate positive correlation between level of Confidence and level of Career Interest, $r_s(43) = .518, p < 0.001$.

Figure 4.7

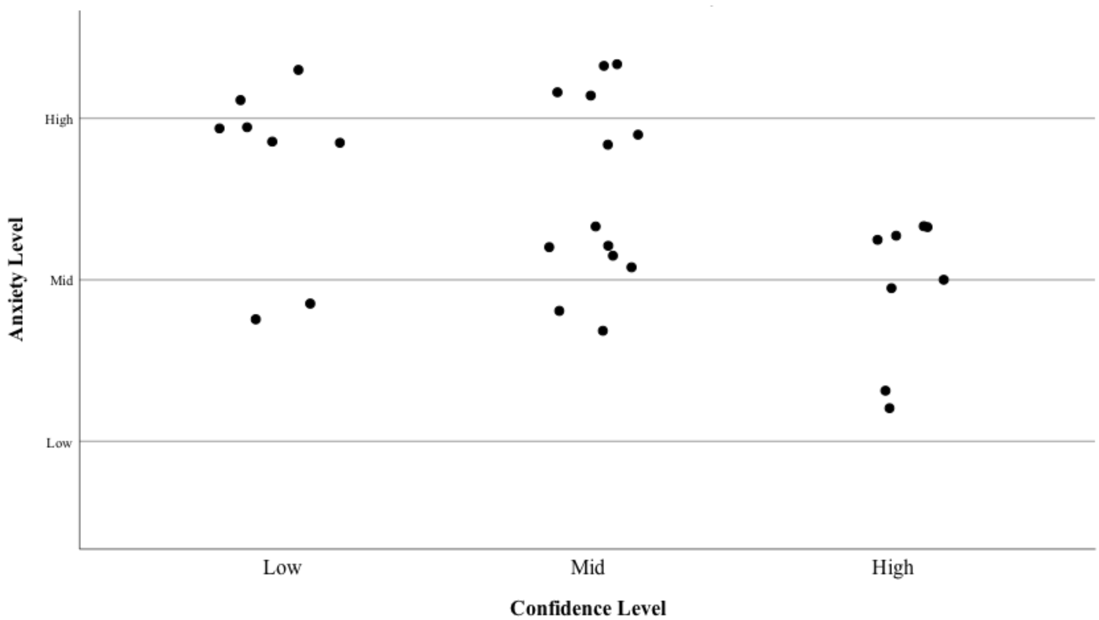
Journal Entry Correlation of Confidence and Career Interest



Confidence & Anxiety: There was a statistically significant, strong negative correlation between level of Confidence and level of Anxiety, $r_s(43) = -.611, p < 0.001$.

Figure 4.8

Journal Entry Correlation of Confidence and Anxiety



Contingency Tables for Gender and Grade Level

A Chi-square analysis helped the formation of contingency tables (Laerd Statistics, 2016). This statistical test for association helps to determine if there is an association between two variables. The Chi-square test produces a test statistic based on the magnitude of difference between the expected and observed frequencies based on the data results of coding the journal entries. The assumptions made for the Chi-square test are that the data set includes two variables measured at the categorical level (Gender of Female or Male with Low, Mid, or High levels of Confidence, Career Interest, Motivation, and Anxiety) and that the observations are independent for each group. The following table summarizes the Chi-square results for Gender groups within the various levels of the different categories studied for mathematical identity:

Table 4.4

Journal Entry Chi-square Associations for Category Levels by Gender

	Value	*df*	*Asymptotic Significance (2-sided)*	*N*
Confidence	.444	2	.801	44
Career Interest	.559	2	.756	30
Motivation	2.940	2	.230	45
Anxiety	.281	2	.869	30

The detailed frequencies and percentages are presented in Appendix H. According to the statistical measurements in Table 4.4, it is apparent that there is no statistically significant association between gender and level of confidence, career interest, motivation, or anxiety based on the coded data from the journal entries. An association for Low, Mid, and High levels of Confidence, Career Interest, Motivation, and Anxiety by Gender was not found using a Chi-square test for association.

Emergent Patterns & Themes within Journal Entries

The data presented in this study verifies the correlation between a few of the categories that were studied through the journal entries. Correlation, as a reminder, does not equate to causation. In regards to the journal entry analysis, there is significant evidence that the correlation of Confidence with Career Interest and Confidence with Anxiety exists. This information is important to framing mathematical identity formation for students with learning disorders. A positive correlation between Confidence with Career Interest relates self-efficacy to the potential that students with learning disorders may have in fields related to mathematics. A negative correlation between Confidence with Anxiety helps to understand that the self-efficacy attribute of confidence shares a relationship with the level of anxiety an individual faces when doing mathematical work. The negative relationship in this correlation calculation further confirms the evidence that was seen with the questionnaire responses, advising that higher levels of Confidence are related to the lower levels of Anxiety and that lower levels of Confidence are related to higher levels of Anxiety. Finally, the category frequencies of Low, Mid and High levels based on Gender were not statistically significant for the journal entry profiles.

The coding process for the journal entries revealed other themes outside of the four categories in this study that students ascribe to their identity formation and the experience of learning mathematics with a learning disorder. First, a number of students made a point to mention how their positive and negative experiences were related to, and dependent on, the math teacher that they had in previous years. Next, students were self-aware of the negative effects of their learning disorders and general challenges and were able to point out what pedagogical strategies or curricular adjustments were helpful in their experiences with mathematical learning. Finally, individuals expressed having a positive change in the experiences they had in learning mathematics at the research site. These are important themes that have emerged from the narrative thematic analysis of the journal entries, and contribute to making suggestions for future research.

In completing the qualitative data analysis for the purpose of this research study, it is important to address the power differentials involved with analyzing the data, and considering this power as an ethical and methodological concern (Ravitch & Carl, 2016). The interpretive power comes from analyzing someone else’s sense of reality and the story they have told. This may influence the biases that come from the thematic analysis that takes place. Also, in making conclusions based on this data, it is important to consider that the data does not include all voices represented by the population and that the individuals responding to the journal template were students in the researcher's class. However, when submitting their responses to the journal activity, it was for an activity on the first days of the school year, not as a response to the researcher's project or for the purposes of a study. As the researcher, I made interpretations and inferences in the process of coding the data that is provided in these journal entries and avoided making subjective biases as best as possible.

Summary of Results

Understanding the development of a mathematical identity for students with learning disorders depends on the levels of Confidence, Motivation, and Anxiety that are expressed. The analysis of data that was conducted for this study revealed important information that students expressed through their self-assessments of these categories. The study aimed to relate Career Interest to the attributes that add to mathematical identity.

A combination of Spearman's rho correlation and Chi-square association helped to understand important features of this study's sample of students with learning disorders. The initial plan to utilize the Mann-Whitney U test was non-conclusive for these data sets. The data from questionnaire responses and journal entries informed important conclusions that could be made based on the analyses. Correlation between the four categories exists. Association based on gender groups was less prominent, but a focus on the areas in which this data was statistically significant helps to prioritize future research efforts.

Factors that play a role in the mathematical identity formation are correlated to each other, in that there exists relatedness between Confidence, Career Interest, Motivation, and Anxiety. The areas of identity formation are present when observing levels of post-secondary education and careers related to mathematics. Research has supported the importance of supporting students' self-efficacy when it comes to finding successes and the drive to take part in mathematical thinking. Based on the results of this study, it is important to acknowledge the contribution to this research based on the specific sample of students with learning disorders used for this study.

The limitations of this study come from the number of students that are used from a very specific population. Also, it would be statistically important to incorporate a larger representation of students in each gender, as the significance in observing differences between gender groups could have been based on chance. A larger sample size could also reveal pertinent information based on grade level. The implications of the findings offer information that is important to both theory and practice in the field of education related to mathematics. As curriculum is developed, it is important to find opportunities to develop aspects of mathematical identity. Relating these experiences to career opportunities can lead to an even greater level of interest in the fields that involve mathematical thinking.

The research presented through this study contributes to the importance of shifting focus towards creating more equitable opportunities within the learning of mathematics. The group of students with learning disorders has lesser representation in important fields that lead to success. It is imperative that changes are made to practice, but also from a theoretical standpoint in order to include this group of individuals. Further, the data contributes to the importance of helping female individuals with learning disorders develop their mathematical identities as it pertains to an increase in confidence and decrease in anxiety, compared to male students with learning disorders. The findings of this study should be transferred to research that has been conducted in support of creating opportunities for marginalized groups of students, especially in the field of mathematics.

CHAPTER 5:

SUMMARY & DISCUSSION OF STUDY GOALS

The subject area of mathematics oftentimes does not receive the same attention that other subject matters do within our current educational system. However, it can be argued that mathematics is one of the most integral subject matters for students to gain a strong knowledge base. The benefits of increasing skills in this subject matter can lead to opportunities beyond schooling. Mathematics as a subject matter is important for all student learners. In accepting this notion, it is important to discuss the various ways our current educational system does not allow for all students access to learning this subject area effectively. In making decisions towards future roles, such as college and career choices, students with learning disorders can benefit from stronger mathematical identity formation. There are lost opportunities for this specific group of students. A connection to identity comes from finding ways to make the learning of mathematics relative, important, and valuable. Successful development in these areas can help to develop the overall confidence and motivation in learning mathematics, and decrease levels of anxiety that are created with ongoing negative learning experiences.

Current Problem of Practice

Educational opportunity is integral to giving students access to a curriculum that is balanced. Current practices, however, have created inequalities that are apparent for certain groups of people, particularly students with specific learning disorders that impact mathematical thinking (Apple, 1992; Ravitch, 2013). The purpose of education, and helping members of society gain skills, may lead to overall civic responsibility. Opportunities for students with learning disorders, however, have been diminished. An individual as a product of the current school system may enter the workforce with certain disadvantages, especially when deemed as a student with learning disorders.

The current structure of mathematics curriculum disconnects its importance from other subject areas. Mathematics can be utilized as an important tool in all content areas, as long as educators are effectively presenting connections between materials. Furthermore, as a response to the inequitable position of education for students from diverse backgrounds, a new form of mathematics education can be presented as a means to strengthen equity within these marginalized groups. However, with the narrow curriculum measures put in place, teachers are often constrained when trying to make innovative curricular decisions. Although the government has moved towards using Science, Technology, Engineering, and Mathematics (STEM) education to help our students compete with others worldwide, the funds and support go towards particular groups of students (Geary, 2011; Gutstein & Peterson, 2006; Rosenberg-Lee et al., 2015).

The misconceptions of mathematics education being important for only certain groups of students can be detrimental. Rather, we should acknowledge that mathematics should be learned in order to better shape our world by all learner types (Gutstein & Peterson, 2006). Our students should learn enough mathematics so that they are able to remove the inequalities that exist. The connection between mathematics and social justice, for example, can help lead students to find themselves in a world that contains more equity and justice for all members of society. There are apparent issues of democracy and equity – students who belong to marginalized groups based on race, gender, lower income areas, or deficient learning abilities do not have the same opportunity to achieve gains in mathematics courses. This holds back these groups of individuals from being able to take part in career fields that require math to lead to career success.

Examining the historical changes that have occurred in the field of education provide insight into the curricular decisions that have been made for teaching mathematics. Teachers have attempted to enforce socio-cultural connections to teaching mathematics in order to make it relevant for students, especially those with learning disorders. However, the dominant pedagogical practices still follow a routine-based approach to teaching the subject matter. This impedes teachers from being able to present curriculum creatively, and students with learning disorders from being able to make important connections to the mathematics that they learn (Eder, 1982). The standardization and accountability measures that have led to the creation of current curriculum hinder students who are not able to learn mathematics curriculum in its current presentation. There are numerous opportunities for education to shift the role of mathematics into a powerful tool that can be used by all students to attain success in their futures and overall equity in society.

Purpose of Research Study

Personal engagement with theory and research related to the inequalities in education led to an interest in helping students learn from curriculum based on individualistic attributes. In experiencing teaching high-school level mathematics to students with learning disorders at a small independent school in Chicago, it was important to think about the importance of mathematical identity and its influence in preparing these students for post-secondary education and careers. With the school being the only one of its kind in the area, the students who attend come from various backgrounds and experiences. At this research site, students were previously placed into lower-ability groups, mostly based on a formal diagnosis of a learning disorder. This created a mixture of previously learned school cultures based on the areas from which students are attending. The experiences that students have faced within their traditional education schools have formed practices, both positive and negative, which affect the attitude students bring to this high school environment. The students have experienced different methods of learning, have received different levels of accommodations based on their learning disorders, and have come from various social environments based on the locations of their previous schools. The suburban students have not faced situations where the safety of a peer is in question. The urban students have not experienced the wide array of technological educational resources and privileges. These collective aspects of the student population have contributed to the overall development of identity.

An acknowledgement of students' learning disorders is a starting point to help communicate the importance of offering equality within education. These learning differences do not hold students back from being high-level thinkers, and do not translate to student capabilities being lower than others. It is important that we develop a society where these differences can be acknowledged as *strengths*. Nel Noddings (2013) mentions equal opportunity being attained by recognizing differences in student talents and interests. However, this recognition should not stop at the passions that students may have. It is important to acknowledge the differences that members of society may possess – this may include class, religion, race, or gender. Specific to education, it is important that we include the learning experiences of all students and the knowledge and skills they may have to offer based on their experiences. The current curriculum does not allow teachers to create a learning environment where collaboration is used to acknowledge student differences. An important shift in developing curriculum that works for students' strengths and weaknesses can be made if we move towards a society that does not translate learning challenges as a disabling quality. Rather, it is important to move towards curriculum development that takes into account the aspects of democracy: all learner types and students have a meaningful role in learning environments.

This research study aimed to look at the identity development for students with learning disorders, and how in the development of this identity, the individuals are successful in gaining mathematical skills that can be utilized as a means for attaining equal opportunities. In teaching mathematics, a connection to personal lives, experiences, and positions allows for potential of using the subject matter in a positive and powerful manner. Inclusive mathematics curriculum can lead to a transformative impact on the way mathematics equity is developed for all students (Spielman, 2012). The various issues that affect our students can be used as a platform to create positive changes to society. Specifically for students with learning differences, we must find ways to provide the appropriate skill sets in order to help them approach problem solving and critical thinking effectively.

Creating experiences for students with learning disorders such as developmental dyscalculia to be successful in understanding and learning math – without the inequalities being reproduced – can help them be able to communicate mathematically. Mathematical literacy helps to develop mathematical thinkers who are able to communicate using problem solving techniques. Connecting the concepts to experiences that are personally important for the students allows developing the epistemological viewpoints they have. This can lead to moving past the standardized curriculum and agenda of producing citizens that are benefiting people in power. It is important to form connections between mathematics curriculum and pedagogy with the problems that exist in students' daily lives. A suggestion from Apple (1992) related to mathematical literacy suggests including examples that are related to the loss of jobs, lowering of job wages and benefits, and cutbacks to welfare payments by the government, which will help to connect mathematics to the world. This suggestion particularly serves to create a more positive approach of utilizing mathematics to help marginalized groups find their strength in creating a place for themselves in society, including students with learning disorders who may be on a trajectory to challenging experiences in creating a future in the world.

As student experience is given importance in the learning of mathematics, students who learn mathematics differently can be developed into contributing members of society. The neoliberal agenda serves groups of students who perpetuate the inequalities that exist. Students who may learn mathematics differently can still have potential in thinking critically about the issues that we face as a nation and world. Holding back these students from gaining particular mathematical knowledge does not allow their influence to reach its potential. Mathematics has the ability to provide all learners with important tools for the real world and can provide necessary skill sets for success. Learning the relevance and utilization of mathematics can help produce educated citizens that are able to take advantage of the various opportunities (Spielman, 2012).

Understanding the various injustices around the world is the next step in allowing students with learning disorders to effectively think mathematically. Current systems of standardization and accountability measures do not allow individuals to be mathematically educated in ways that can help rid social inequalities. In utilizing theory to rethink of curriculum’s role in creating these opportunities, it is important to cultivate connections between feminist theory and critical race theory to issues that affect groups of people that are socially constructed as *different*. Students with learning differences are marginalized, similar to other groups of people based on race, gender, and class. It is important to bring about change in order to oppose the advancement of only specific groups of people and allow all groups equal opportunity to achieve in fields related to mathematics and even more important, create positive change.

In developing curriculum that helps students be prepared to be effective citizens in society, especially by using mathematics to achieve equity, there must be a redefining moment of curriculum's purpose. The structure of current society assumes that equality amongst various groups does exist, and that economic influence serves to keep this assumed equality in place. However, the reality is that many social inequalities still exist – and the mobility of oppressed groups has not found a way to flourish in order to lead society into a truly revolutionized and equal status. Through current curricular formats, a culture of exclusion in mathematics education has been formed. The dominant aspects of culture and society help to perpetuate the characterization of mathematics education for particular groups of people. Rather than trying to teach our students things like basic arithmetic and numeracy, we should allow mathematical thinking to reach levels of increasing critical thinking. Educators can create a culture around developing lessons that are important and fitting for their particular students. Especially for students with learning disorders related to mathematics, this approach can help to be successful even with the given challenges. Current inequalities in education lead to issues of equity. As our students prepare for their future roles in society, it is important that the skills we teach allow them to use their strengths in order to attain equal opportunity. Learning mathematics leads to the advancement of skills that can be helpful in developing a stronger society based on equal and just lives.

Research Questions

The research presented through this dissertation study aimed to collect data and learn information that could potentially help answer the following questions:

1. What connections can be bridged between confidence in learning mathematics, career interest in mathematics, motivation in mathematics, and anxiety in mathematics?
2. What experiences have led to a negative identity formation in relation to math achievement?
3. How do the early elementary school experiences for a student with a specific learning disorder, such as developmental dyscalculia, affect their overall interest in learning mathematics in high school?

Assertions Based on Findings

Given the findings from the calculations and data analysis procedures, we can conclude that the mathematical identity development depends on the confidence, motivation, and anxiety related to the subject area. These areas correlated to career interest as well, paving the way to new exploration for the specific population that was included in this research. The study was conducted in a way that collected both quantitative and qualitative data. Both sources of data were integral in understanding and prioritizing areas of future research that could help educators contribute positively to the formation of mathematical identity for students with learning disorders. Based on the questionnaires that were designed and employed for this study, positive correlation occurred between the confidence that individuals hold with the career interest they have related to mathematical fields and motivation in regards to doing mathematics. Motivation and career interest also held positive correlation, contributing to the notion of how motivation is important in developing individuals' interest in mathematics-related career fields. Negative correlation occurred between anxiety and the confidence, career interest, and motivation students hold within learning mathematics. This important data helps to understand the importance in decreasing the levels of anxiety that students develop as they engage in mathematical experiences. Journal entries helped to further show that a relationship between confidence with career interest and levels of anxiety does in fact exist. The statements that are made in student journals give context for future studies related to mathematical identity, learning disorders affecting mathematical thinking, and creating spaces that allow for these students to pursue math-related career fields.

These conclusive statements provide a summary of what was learned through this dissertation research, which has added to the literature already researched regarding this topic throughout the process. Interpreting these results leads to other important areas of research that could help educators make important curricular decisions. Confidence, motivation, and anxiety are in fact integral to the mathematical identity development for students with learning disorders. Based on further research, there are curricular changes that can be made in order to focus on developing higher levels of confidence, higher levels of motivation, and lower levels of anxiety in relation to having students engage in mathematical thinking. Due to correlational relationships to career interest, a focus on these areas can help students see their potential in taking part in various mathematical college majors and career choices. The initial step in helping students with learning disorders achieve this goal relies on the development of curricular changes that lead to more confidence and motivation and less anxiety. In conducting further analysis, it was found that experiences differed based on gender. The social norms surrounding the learning of mathematics and a detailed look into the differed experiences for females help to understand how opportunities are removed for this specific gender group.

Recommendations for Future Research

The next steps require a focus and closer examination into creating access to math-related fields for students with learning disorders, as well as the gender roles that take place within mathematical thinking. Data analysis informed concerning issues in relation to the stark differences in levels of confidence and anxiety for females and males. Female participants expressed much lower levels of confidence with mathematical thinking and high levels of anxiety compared to their male peers. The social context and implications of this varying data inform educators about the culture that is created for females participating in mathematical thinking. A shift in cultural expectations must be made to help females increase their confidence and lower their levels of anxiety. Positive mathematical identity development is especially critical for the intersection of female students with learning disorders.

Statements from the journal entries help support different factors that have informed mathematical identity development. For example, students expressed the following sentiments in journal entries, which suggest themes and give context for future research:

- "One of the hardest things for me in math is when I failed one of my tests; that really hurt because I don't like to fail and it was hard to see me fail" (Journal 208, Male).
- "Addition was great, subtraction was alright, multiplication and division made me wish I wasn't 'slow'. I guess you can say my math has improved? Or maybe my memory and listening skills improved and I still suck at math. Either way, I know that I'll have to get better or modern technology will replace me" (Journal 213, Female).
- "Throughout most of my school career, math had been my greatest challenge. It was dense and complicated and with my learning difference, I really struggled with it. However, once I came to ---*school name omitted*---, I learned how to ask questions and advocate for myself when it came to mathematics, and suddenly I found myself understanding it and getting A's. It was almost an emotional thing, regarding how the

subject used to be for me…but I would still never consider a career in it. That I will say" (Journal 214, Female).

- "Teachers that have worked well with me in the past have been open, honest, and believed in me and said so even through difficulty" (Journal 218, Male).
- "I would like to be good at math because I enjoy chemistry and that requires a lot of math. I like math, I just wish I was better at it" (Journal 223, Male).
- "I hope to be a computer engineer. I'm not sure if it involves math, but I am willing to be challenged to be in that career. I feel very nervous that I will be made fun of for my ability in math. My dyscalculia is something I cannot simply control. And I fear that I will be judged" (Journal 227, Male).
- "But when I went to ---*school name omitted*--- and started Algebra I it was really hard at first I still didn't understand it. But my teacher told me to stay after school one day so we can have a one on one talk with math. Slowly but surely I was starting to get it, I started getting the equations and learned something new every day" (Journal 235, Male).
- "I will have a lot of questions and try my hardest even if it doesn't look like it. Dyscalculia causes this but I want to do better in math" (Journal 239, Male).
- "I have always struggled with math. My past years in math have been difficult for me. Last year in geometry I had a lot of trouble with remembering steps to a problem. I don't always pick up on the concept right away. Having extra support has helped me a lot" (Journal 243, Female).

The conclusions that are made through this research can be applied to curricular shifts for teaching mathematics to students with learning disorders. Creating an environment for students so that they feel confident in finding ways to learn mathematics differently can help them to pursue varied career choices. This scholarly work has initiated more questions, opening way for further research related to the topics related to this dissertation study. Specific statements that were analyzed in the Math & Me journal entries allowed for reflection towards the various contributing factors of forming students' mathematical identities. Specifically, this includes important themes that students with learning disorders that affect mathematical thinking ascribe to their identity formation, as well as important themes surrounding the experience itself – of learning mathematics with a learning disorder. Many students clearly pointed out that the positive and negative experiences in learning mathematics were related to, and dependent on, the math teacher that they had in previous years. Individuals also expressed their self-awareness related to the negative effects and challenges of their learning disorders, as well as the pedagogical practices that were helpful in their experiences with mathematical learning. Students expressed the research site itself being a location that allowed for positive changes in their mathematical learning experiences. The important themes that emerged from the narrative thematic analysis of the journal entries contribute to making suggestions for future research.

Additional research questions that were developed as a result of this study include:

- Are the depleted identities of students with learning disorders being addressed? How is the intersection with gender being implemented in these efforts?
- What aspects of research-based positive identity formation techniques can be implemented into teaching practices to help students form identities of acceptance – so that they are not dissuaded from their fields of interest that may involve learning mathematical procedures and problem solving?

- Are regular education mathematics teachers equipped or trained sufficiently in their teacher-education programs to build mathematical skill and identity through curriculum and delivery for students who learn differently? If not, why?
- Is appropriate training provided to regular and special education teachers in order to identify identity deficits, address them, and help positively build identities?

Implications for Practice, Policy, & Theory

Current instructional methods follow standards, leading to learning experiences that rely on students' ability to remember facts, rather than an aptitude to make connections to real world applications. When lessons are created, a strict timeline is followed without an opportunity for students to create an understanding of mathematics as an important subject for cognitive development and its role in critical thinking. Many of the rote memorization techniques that are used in teaching mathematics cause repetitive class sessions that turn students off to learning the subject matter. Rather, teaching students based on their strengths can lead to creating value for the subject. A combination of successful learning and a connection to personal lives can lead to appreciation and utilization of mathematics. Connection to real world applications while teaching individuals according to their strengths may create experiences that allow them to use mathematics even past their years in schooling.

Throughout history, groups that developed and used mathematical knowledge were able to cultivate functional societies. The value for the subject matter transferred into both homes and workplaces (Powell & Frankenstein, 1997). As researchers use ethnomathematics to critique current curriculum development, various methods of instruction are suggested. Creating opportunities for our students to understand and value the power of a mathematical knowledge can lead to social changes (Boero, 1995). Providing knowledge related to purchases, sales, and other aspects that use financial literacy are important for students to understand. Reasoning skills can be developed with geometric thinking through proofs, allowing students to become more comfortable with justifying their claims with proper reasons. This skill development transfers to when the students become vocal members of society. In general, the experiences in the math classroom that are related to situations outside of school can be valuable and helpful in developing democratic members. The contexts in which mathematical skills can be used should be incorporated into curriculum, and the delivery of the content can allow students to experience first-hand the different ways in which mathematical education can be utilized (Boero, 1995). Class activities that incorporate problem-solving skills, and the use of content skills in order to resolve a problem situation, would be beneficial in increasing the participation students show in learning mathematics and overall value towards the subject area.

Learning Communities

As the collection of students with various socialization experiences are put into classrooms, educators come across the challenge of producing instruction that can be applicable to any student, regardless of their early school experiences. Rather than questioning the validity of past experiences, educators can take advantage of learning why students behave and learn in their specific ways. This process allows for a classroom environment to grow, allowing students to learn various ways of schooling from their peers. This process also allows educators to differentiate based on mixed experiences. In general, an effort to understand the community that supports student learning is important to the educational experience. This becomes especially important for students with learning disorders and formation of the mathematical identity. The parents, teachers, and other essential members of a school community can help determine the most important aspects of the students' educational experiences. Various communities have different needs. Teachers play an integral role in preparing members of the community for the world around them (Eder, 1982). A more collaborative approach to preparing curriculum can lead to true assessment of what can be defined as success by the key players in the community.

Adolescents face many realities when they enter their high school years. Besides the social implications of making new friends and being involved with extracurricular activities, the educational environment sets forth the level of education each student receives. As a teacher at the research site utilized in this study, proficiency and expertise are used to provide learning experiences that are best for the students. Although the school still incorporates standardized testing preparation, the overall learning environment that is provided for the students is determined based on their necessities. The general notion is that all students who attend this school have specific needs; the culture that is created between the students is of acceptance for each other’s differences. Rather than facing their challenges in a larger school setting, students are facing their challenges together. This creates a safe area of acceptance for the students with their specific learning challenges.

Ideas of parents, teachers, and even the students are included in order to formulate learning that will help students flourish as they leave K-12 schooling and venture out to where their strengths and interests exist. Students with learning differences have specific needs and community members have an expertise and connection to the research that is best for the students that are served. Forming committees of key community members is integral in helping to put together the best form of education for the particular group of students, which can lead to equal educational opportunity in the future.

Cultivating a Safe Space for Mathematics

The educational experiences that students face can be very different based on the approach that is used by the educator. The most important aspect of creating this experience comes from the form of guidance that is provided to learners. Approaching students with learning disorders to learn content requires a different aspect of care and guidance, something that needs to be well established and solidified by the educator. The notion of guidance can only be accomplished with a clear view of the goals that are set for learners in the classroom. The learning environment is essential for all students, where an educator serves as a caretaker. With close planning and consideration of student needs, educators are able to provide experiences in the class that are best for learners. The mindset that educators have towards working with students to help them achieve an understanding of the content that is taught can help determine the value that students are able to gain towards that content. The attitude that an educator brings to the learning environment should help support the cultivation of student experiences and in distinguishing between the cognition and evaluation of these learning experiences. This attitude is helpful in making the pedagogical decisions required to foster growth for students, leading to not just an understanding of concepts, but a follow-through of applying learned content in lifelong experiences.

Creating Value for Mathematics

For educators to foster an educational environment that leads to positive experiences, an attempt to create value for the subject is imperative. When students learn mathematics, it is often difficult to find a connection or give value to the concepts they are learning, especially for those facing challenges in learning the subject. Math educators are constantly asking how to make learning mathematics engaging through creative experiences so that students form value for what they are learning. It is possible for educators to use other modes of classroom engagement in order to help students create value for concepts that they are learning (Goulah & Ito, 2012). This approach, however, would need to be implemented from an early age so that students are able to develop the value of learning foundational levels of mathematics. A pedagogical approach to increase the value of learning math should implement the use of relatable problems and issues outside of school, where mathematical knowledge is an important tool in understanding the problems at hand (Boero, 1995; Goulah, 2012). There are various ways to incorporate mathematical contexts into curriculum, allowing students with learning disorders to experience the different ways in which the mathematical content that they are learning is utilized in real-life situations. This makes learning mathematics applicable to their lives, increasing value for the learning of skills that are taught by their instructors. Problem-solving activities that involve the topics directly can help students make connections between the core content taught in a mathematics class and how these skills are necessary to resolve real world issues. This experience of applying learned knowledge increases value towards math education. It also allows students to reflect on which future roles they can fulfill in society, where mathematics can play an important part in helping students achieve their goals.

Dialogue in the Math Classroom

Communication between students leads to informal learning experiences that add to the overall knowledge and skill set within a subject matter. In order to create a classroom culture that allows teachers to utilize student experiences as a part of the learning experience, it is important to establish specific procedures that incorporate dialogue. Dialogue is a process in which shared meaning is attained through discourse. The dialogue between peers allows students to share and learn ideas from each other (Goulah, 2012; Goulah & Ito, 2012). There is an important place for dialogue in a mathematics classroom, and it is through this dialogue that students can create value towards the subject matter and shared meaning towards mathematical topics. As individuals use metacognition to reflect on their own thinking and understanding of ideas, the insight can be shared with peers to develop a meaning of concepts and its importance in the surrounding world.

As students discuss finding mathematical solutions, the importance of vocabulary and math literacy is understood. Having students talk about the various mathematical experiences outside of the classroom helps to create a shared insight. Having students share their experiences and ideas can lead to engagement surrounding the subject matter and can add to the acceptance of various ideas from classmates. An important aspect of using a dialogic approach in the mathematics classroom comes from helping students feel comfortable and confident about sharing their ideas. This can be established through the efforts of a teacher to help cultivate a culture of using dialogue in the classroom, where students are more confidently able to connect the content to their own lives. The use of personal experiences and memories from student lives can help create connections to the mathematics content that is being taught and help develop an individual's mathematical identity. The theory of value creation through dialogue can be supported in the mathematics classroom (Goulah, 2012). This experience in the mathematics classroom can lead the development of self-identity and an appreciation for mathematical thinking as it pertains to real life experiences.

Mathematical Literacy through Interdisciplinary Curriculum

In relation to dialogue using mathematical terms, it is important for students to develop vocabulary so that they are able to discuss mathematical experiences and relate knowledge to evaluated situations outside the classroom. With a shift towards developing mathematical literacy through dialogue in the classroom, students are able to develop communication skills and vocabulary to discuss their experiences with mathematics. The skill sets that students can gain through a development of mathematical literacy can lead to access and equity, especially for students with learning disorders. Connecting vocabulary terms to concrete examples can help students make a connection between the words that are used and the meaning behind specific mathematical skills. Developing proficiency in communication using quantitative skills can also lead to improved performance in job places (Bishop, 1988). The daily tasks that take place in most work places involve mathematical thinking, especially general problem solving and routine tasks that require a sense of numeracy. There is a general productivity and advancement that individuals can make with quantitative literacy.

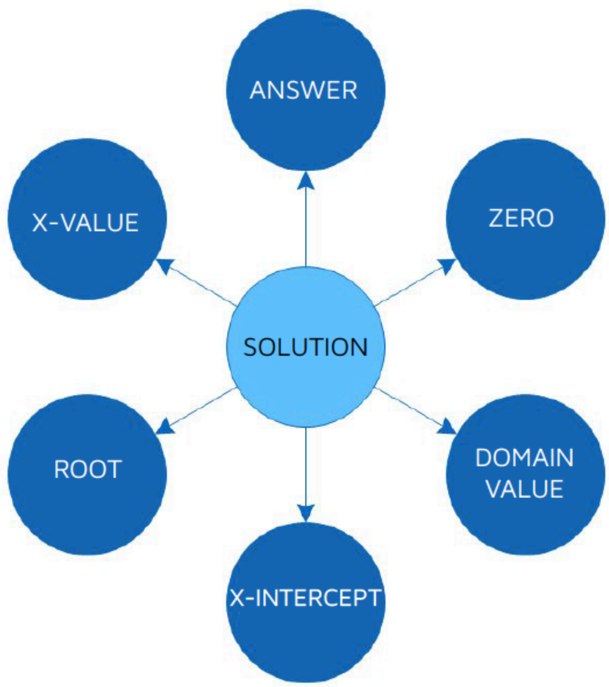
As mathematical literacy is developed, it is important to acknowledge the various opportunities that can be provided to students with learning disorders, and the ways they may use mathematical thinking. For students learning at different levels of mathematics, its application should not be reserved for specific career fields and elite levels of education. Even at a vocational level, mathematical thinking and skill sets are important. We should be open to helping students, especially those with learning disorders, learn skills that are directly applicable to their future roles in society. Countries around the world use this approach to teaching mathematical skills, and students are able to directly connect the content they learn to fields of interest (Symonds et al., 2011). Working with students who may be personally interested in various career fields that require knowledge of mathematics should inform the fact that access to gaining skills within the subject area is important for most. Assisting individuals in the process of thinking about their futures involves a reflection of the role that mathematics plays in this future. It is crucial to help students reflect on a plan that includes a program of study and degree programs, as well as work-linked and career objectives (Symonds et al., 2011).

This approach to teaching the content area can be integrated into current teacher education programs, giving educators in all subject areas the necessary tools in order to make mathematical connections to their own subject areas. The integration of mathematics in various subjects can help develop students' capabilities, giving them instrumental knowledge in becoming more active participants in the world they live. Knowledge of how income and wealth can be attained, managed, and grown, for example, is possible through mathematics curriculum that incorporates real world situations and economic connections. Discussion and application of these topics in a mathematics class, as well as other subject areas, may lead to the development of important mathematical vocabulary and literacy (Gutstein & Peterson, 2006).

Experiences within interdisciplinary work can further develop a sense of mathematical literacy. Linking mathematical terms to teaching science can increase the frequency of applicable terminology that is used and understood. Collaboration with English and reading teachers can help to implement the teaching of vocabulary in mathematics, sentence structure within mathematical problem solving, and comprehension techniques to pull key information from mathematical problems that involve a connection to real life situations. In relation to language and memory more specifically, students may be supported with opportunities to create word associations. The use of concept maps, word webs, Venn diagrams, and graphic organizers in the mathematics classroom may be beneficial for students with learning disorders to learn the language of mathematics (see Figure 5.1). For students with learning disorders, incorporating art into the learning of STEM subject areas is beneficial. The integration of art allows students with learning disorders to transform abstract concepts into more concrete visual depictions, which allows for a multimodal representation of mathematical concepts. This manipulation of abstract concepts into concrete and pictorial images can remediate cognitive flows within neurological

Figure 5.1

Graphic Organizers for Mathematical Literacy



Note. A word web can help students link together the terms that explain the use of a solution in Algebra.

processes that involve mathematical thinking (Hwang & Taylor, 2016). These examples provide opportunities to help make mathematics more prevalent in all forms of learning, which can in turn increase the overall confidence, motivation, and interest in the subject area.

Assessment Procedures

Authentic assessment methods are necessary in order to measure the level of mathematical understanding for students. The authenticity of assessments is just as important as the genuine methods used to teach students – measuring their understanding should follow this approach. In assessing a student's understanding of a standard, the task becomes so focused and skill-based. This removes opportunity for different learner types to be successful in simply *thinking* mathematically (Hopkins, 1999). Assessing mathematics based on the traditional view that it consists of only arithmetic skills has not allowed for a reform-based perspective that mathematics involves processing, various methods of thinking, logical connections, reasoning skills, and a very important form of communication in our current technologically-advanced world (Herrington et al., 2002). The traditional pen and paper methods that are used to assess the construction of knowledge in mathematics is the dominating discourse for new teachers. However, there are many similarities between potential assessments in mathematics and what is already used in other subject areas. For example, investigative approaches to show mathematical understanding of concepts can be important for authentic assessments. Herrington et al. (2002) provide examples of these investigative practices in math classrooms such as higher-order questioning, structured interviews, oral and written reports, portfolios, investigations, journal writing, and reflective self-questioning practices.

Using reform-based concepts, authentic assessments can be used as a method of formative evaluations that involve a review of teacher instruction and student understanding. A move towards creating more formative assessment practices can help to create a supportive environment for teachers and students and can help provide all learner types with a chance to be successful in dictating their understanding of mathematical concepts. Formative assessments should not focus on the particular strategies but rather the processing and thinking that takes place as students are learning – and this should be guiding instruction (Coffey et al., 2011; Taubman, 2009). Rather than measuring overall achievement through standards-based grading, action that results in further learning through formative assessments is more beneficial for students. There is a need for learning activities that lead to authentic experiences. Allowing students to learn how to apply their mathematical skills will be more influential in future career fields. Relying on single tests that evaluate student skills take away from educators being able to recognize the conceptual understanding of mathematical strategies. Various forms of assessment that involve the presentation of student knowledge can broaden the way educators determine understanding of concepts. The utilization of assessment procedures in a mathematics class can include a summative approach to test the mathematical skills that are taught, a formative approach to test and understand the effectiveness of the teaching process, or a combination of assessment and instruction where constant feedback is used to evaluate the learning process and progress that individual students make based on their learning style (Kesianye, 2015). The latter process includes utilization of authentic assessments, giving students opportunities to use various modes of explaining their thinking and learning. This process also helps to make both teacher and student responsible for the learning.

Lesson Study

Methods in the classroom that allow for mathematical concepts to be learned in a way that makes the subject matter more applicable and accessible is important for students with learning disorders. Pedagogical practices important in attaining accessibility to the subject matter include methods that allow for reflection and collaboration. These aspects of learning can occur by involving both students and educators. The Japanese theoretical method of lesson study allows for critical thinking at different levels, and for educators to become researchers to continuously develop pedagogy that is best for their students' development (Lewis & Perry, 2017). The utilization of lesson study has led to many successes in producing lessons that allow all learner types to be successful (Lewis et al., 2006). Lesson study requires a four-phase cycle involving study, plan, do, and reflect with curriculum and lesson plans. Students are learners along with the teachers. Lesson study can be a powerful way to teach students based on their needs and strengths, rather than a standardized approach. The teachers play an important role in creating research-based lesson plans that are fit for their particular students (Lewis & Perry, 2017). An important aspect of developing curriculum so that students can learn effectively is to place student needs at the core of making decisions (Kliebard, 1987). The lesson study process requires consistent reflection to create pedagogy and curriculum that is appropriately presented based on student needs. As important decisions are made for the curriculum that is presented, the process of learning should support students in their cognitive development and an understanding of self. This process contributes to the overall formation and development of mathematical identity.

Social Justice and Mathematics

There are aspects of society that would be difficult for students to understand without the use of mathematics. For instance, as individuals attempt to learn about the world that surrounds them, they can use mathematical thinking towards understanding national debt or government budgets. More importantly, there are social and cultural issues that can be analyzed mathematically, making the content personally applicable and important for students to apply towards identity development. An example of racial profiling and its specific implications can be understood with a mathematical lens, important for helping individuals learn the vital details of societal issues. Applying the subject to social justice situations may help to understand their own lives and the world around them more clearly. Individuals should learn the basic skills and mathematical knowledge in order to become critical thinkers when questioning and justifying social justice situations. Students with learning disorders can become high-level thinkers in order to discuss the issues in society, and are then able to use their strong mathematical lens to help support the arguments they create towards these issues with development of mathematical identity. This ideological approach helps to provide equity for students from all groups, going against the focus of curricular decisions that have been made throughout history.

Teachers can assist students in developing mathematical thinking that understands and questions the world they live in with a mathematical lens. Broadly speaking, there is an important connection to defining the subject matter's role in understanding what it means to be a citizen of democracy. There are potential positive outcomes of positioning mathematics curriculum in order to develop critical thinking skills and effective citizenship in society (Blades, 2015). Mathematics educators have an opportunity to provide mathematics education in a way that allows students to gain the tools that are necessary to help notice and go against the inequalities that exist in society and utilize it in politics to develop a democratic society. For individuals belonging to marginalized groups, such as those labeled by their learning disorders, this knowledge base is important to their access and equitable opportunities. The corporate capitalism that has negatively changed our form of politics has led to the breaking down of democratic institutions. Mathematics curriculum has the potential to provide members of society with a voice to fight against these inequalities and move back towards a more democratic state with a stronger developed mathematical identity.

Our educational practices have students learning subjects and skills that may not be appropriate for their personal qualities and strengths to flourish. Rather, we provide a one-size-fits-all approach that creates different methodologies used to develop society. A capitalistic approach to governing marginalizes and deprives certain groups within the population, such as racial, religious, ethnic, or gender groups, while a human rights approach provides education as a right and an instrument to develop and attain equity (Nussbaum, 2011). These approaches do not take into account how people who fall under the various disadvantaged smaller groups of society can attain forms of success. Assumptions that happiness and a good life can be obtained by yielding the highest returns of money are made by current members of society (Nussbaum, 2011). Financial improvement is the most important goal, and decisions are made based on how the government and most privileged group of the community benefits.

Many of the issues that exist due to the hierarchical structures in place can be better understood with the development of critical mathematical literacy. The curricular decisions that have been made in order to present mathematics to our students, however, have left out key ideas and theories, including a discussion of where mathematical content originates. Powell and Frankenstein (1997) examine how Eurocentric bias has led to leaving out important historical details in the development of mathematics. There are historical gaps concerning the African, Arab, and Indian influences of cultivating the mathematical content that we teach even today. Kliebard (1987) explains the decision-makers of curriculum development value certain forms of knowledge, and this value drives the decisions that are made for curriculum. Shifting to a multicultural approach to teaching mathematics requires an acknowledgement of the history of mathematics, its origins, and the current social and political values that have shaped mathematics curriculum in our country and world (Nelson, 1993). Similar to languages and social systems, the value of using mathematics varies across cultural groups. An appreciation for all individuals, no matter their learning style, strengths, or weaknesses, can be achieved with a multicultural approach to teaching mathematics (Noddings, 2016). For students from marginalized groups, this idea can be important in building both confidence and a connection to the mathematics content, contributing to mathematical identity formation.

Students with learning disorders may be able to understand the world more clearly with a strong mathematical background, allowing them to participate as citizens and advocate their own positions. Allowing individuals to have this representative participation is important in developing a more democratic society (Blades, 2015). By teaching math differently based on student interests and ability levels, curriculum should help individuals make a connection to the real world. When teachers are not able to provide math problems that integrate issues around the world, there is an injustice that is done to the students. This may lead to inexperienced individuals who may not be able to use mathematics as an important tool to change the unjust situations that they will face as they enter the real world and take part in their societal roles. Integrating student experiences, cultural backgrounds, and identities into curriculum can help with engagement, and it can counteract the disinterest individuals may have with the content, especially those with negative experiences due to their learning differences. An example of how this approach can be used in the classroom includes discussion of area and distance related to community buildings such as fresh produce marketplaces. With the use of math skills, students can compare urban and suburban communities and how much access to these markets members of society have in both locations. Students would quickly see the inequalities that exist in terms of access to fresh produce. A discussion of this activity – which started as a conceptual understanding of area and distance in mathematics – can lead to an educational experience that lends to dialogue concerning the inequalities of society. Students can then discuss how they may choose to rectify this issue of equity.

Empowerment through the teaching of mathematics can occur if access to learning the subject area is given to all student learner types. For students who learn differently, mathematics has the potential to becoming a powerful tool to make positive changes in their communities.

Many opportunities are not given to these students when mathematics education is turned into a basic skills-based subject. However, these students have the potential to learn mathematics with a multicultural approach to help them develop positive identities in learning mathematics (Tan et al., 2012). The connection between mathematics and social justice can help lead students to find themselves in a world that contains more equity and justice for all members of society. The misconceptions of mathematics education being important for only specific groups of students can be detrimental. Even when facing learning disorders, students should learn enough mathematics so that they are able to remove the inequalities that exist. In the future roles students may fill, it is important to have a strong understanding of math concepts. This can help to successfully engage with evaluating data pertaining to global issues or other social issues from the students' own communities. Repetitive procedures that have been used in mathematical classrooms have taken away from students feeling success, especially those facing learning disorders. There are apparent issues of equity for individuals belonging to disadvantaged groups – students who are diagnosed with learning disorders do not have the same opportunity to achieve gains in mathematics learning. This inaccessibility to important knowledge holds back these individuals from being able to take part in career fields that require mathematics, develop positive mathematical identities, and remove the inequalities that exist in their world of being known as the others.

The Work Does Not End

An increased level of education in mathematical skills affects domains of personal life, career, and citizenship. Individuals can be prepared to use math skills for personal financing, the attainment of simple goods, and knowledge of socioeconomic attributes for daily living. For the workplace, mathematical learning helps to develop important qualities such as problem-solving skills (identification, procedures, and operations), utilizing multiple representations to display task results, understanding and applying mathematical modeling, and technological familiarity with data processing systems. Within one's career, individuals may utilize critical thinking skills, the impact of numbers in solving problems, mathematical reasoning skills, and statistical analysis. The Science, Technology, Engineering, and Mathematics (STEM) fields have been given focus since the turn of the century. The U.S. Department of Education (2015) stated that up to 62% of the fastest growing careers require proficient knowledge or skills in STEM-related areas. A list of the top career choices reported by the U.S. World & News Report (2020) includes only fields that involve mathematics (see Table 5.1):

Table 5.1

Top Career Choices: 2020

Rank	Career/Field
1.	Software Developer
2.	Dentist
3.	Physician Assistant
4.	Orthodontist
5.	Nurse Practitioner
6.	Statistician
7.	Physician
8.	Speech-Language Pathologist
9.	Oral and Maxillofacial Surgeon
10.	Veterinarian
11.	Medical and Health Services Manager
12.	IT Manager
13.	Registered Nurse
14.	Mathematician
15.	Physical Therapist

Note. Reported annually by the U.S. News & World Report (usnews.com)

In the end, this dissertation serves as my call to an important topic of research, in which educators, researchers, and other proponents of the field of education can take part. Individuals with specific qualities that do not allow membership into groups that hold power can benefit from an effective mathematical education. Students with learning disorders can be prepared for their future experiences in post-secondary education and careers with a more effective educational experience in learning mathematics. The mathematical identity formation that occurs for students with learning disorders determines the trajectory of the role they play in society. The current objective ideologies that are used to determine the importance of mathematics education do not allow students to learn about and utilize math as a tool towards success. Overall mathematical understanding and application is important for students to become successful and achieve equal opportunities. This understanding relies on the approach that educators take when presenting mathematics curriculum and forming a more positive mathematical identity through an increase in confidence and motivation and a decrease in overall anxiety surrounding the subject area. But most importantly, the learning of mathematics for students with learning disorders allows access to the most important skill sets that can lead to a wider array of future roles. The impact that can be made by individuals should not be obstructed, diminished, or halted by the inequalities that exist in our current system of education. The work does not end with this contribution to scholarship, but rather begins – with additional inquiry to lead the study of curriculum into a better world.

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APPENDIX A

Questionnaire Instrument

Mathematical Identity Formation: Preparing Students with Learning Disorders for Post-Secondary Education and Careers

DO NOT WRITE YOUR NAME ON THIS FORM

Grade Level (circle one): 09 10 11 12

Identified Gender (circle one): Male Female

Respond to each item below. There are a total of 55 statements.
Circle the number that you think best describes your response to each statement. Only choose one number.
The responses range from Strongly Disagree (1) to Strongly Agree (5).

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I can attempt a math problem.	1	2	3	4	5
2. I am challenged by math problems I can't understand immediately.	1	2	3	4	5
3. Math doesn't scare me.	1	2	3	4	5
4. I'm not the type to do well in math.	1	2	3	4	5
5. I see math as something I will use very often when I get out of high school.	1	2	3	4	5
6. I have self-confidence when it comes to math.	1	2	3	4	5
7. I usually worry about being able to solve math problems.	1	2	3	4	5
8. I think I could handle more difficult mathematics.	1	2	3	4	5
9. Math makes me feel uncomfortable, restless, irritable, or impatient.	1	2	3	4	5
10. When I study, I can do well in math.	1	2	3	4	5
11. Having a career related to math would be challenging.	1	2	3	4	5
12. I can think clearly when I am solving a math problem.	1	2	3	4	5
13. Math puzzles are boring.	1	2	3	4	5
14. I can get good grades in math.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
15. Math is just as important as any other subject for jobs.	1	2	3	4	5
16. I do as little work in math as possible.	1	2	3	4	5
17. I study math because I know how useful it is.	1	2	3	4	5
18. If I don't understand a math problem, I keep trying.	1	2	3	4	5
19. It would bother me to have a pop/surprise quiz.	1	2	3	4	5
20. I want to have a college major in an area related to math.	1	2	3	4	5
21. I don't often make mistakes in math.	1	2	3	4	5
22. Mathematics is enjoyable to me.	1	2	3	4	5
23. I will need math to do well in my future career.	1	2	3	4	5
24. When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	1	2	3	4	5
25. In elementary school, math was not hard for me.	1	2	3	4	5
26. I will get a job in a math-related area.	1	2	3	4	5
27. It wouldn't bother me at all to take more math courses.	1	2	3	4	5
28. I'm not good at math.	1	2	3	4	5
29. I like challenging math problems.	1	2	3	4	5
30. Math will be important to me in my life's work.	1	2	3	4	5
31. Math doesn't scare me at all.	1	2	3	4	5
32. Once I start trying to work on a math problem, I find it hard to stop.	1	2	3	4	5
33. Knowing mathematics will help me earn a living.	1	2	3	4	5
34. I would prefer to solve for an answer to a math problem on my own.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
35. Mathematics makes me feel uneasy or confused.	1	2	3	4	5
36. I am sure I could do advanced work in mathematics.	1	2	3	4	5
37. I show all my work in math.	1	2	3	4	5
38. Mathematics usually makes me feel uncomfortable or nervous.	1	2	3	4	5
39. I am sure that I can learn mathematics.	1	2	3	4	5
40. I enjoy going to math class.	1	2	3	4	5
41. For some reason even though I study, math seems unusually hard for me.	1	2	3	4	5
42. I don’t think I could do advanced mathematics.	1	2	3	4	5
43. A math test would scare me.	1	2	3	4	5
44. A career in math would enable me to work with others in meaningful ways.	1	2	3	4	5
45. I do well in math.	1	2	3	4	5
46. Generally, I have felt secure about attempting mathematics.	1	2	3	4	5
47. I like math problems.	1	2	3	4	5
48. I can get good grades in mathematics.	1	2	3	4	5
49. I would enjoy a career that uses math.	1	2	3	4	5
50. The challenge of math problems does not appeal to me.	1	2	3	4	5
51. I almost never get nervous when I take a math test.	1	2	3	4	5
52. Math is my worst subject.	1	2	3	4	5
53. I like math puzzles.	1	2	3	4	5
54. Most subjects I can handle, but I have tendency to do poorly in math.	1	2	3	4	5
55. I would like to have a career in math.	1	2	3	4	5

Questionnaire Coding Key by Category

Confidence in Learning Mathematics	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I do well in math.	1	2	3	4	5
2. I don't often make mistakes in math.	1	2	3	4	5
3. I can attempt a math problem.	1	2	3	4	5
4. In elementary school, math was not hard for me.	1	2	3	4	5
5. I have self-confidence when it comes to math.	1	2	3	4	5
6. I can get good grades in math.	1	2	3	4	5
7. When I study, I can do well in math.	1	2	3	4	5
8. Most subjects I can handle, but I have tendency to do poorly in math.	1	2	3	4	5
9. I don't think I could do advanced mathematics.	1	2	3	4	5
10. I am sure that I can learn mathematics.	1	2	3	4	5
11. I'm not the type to do well in math.	1	2	3	4	5
12. Generally, I have felt secure about attempting mathematics.	1	2	3	4	5
13. Math is my worst subject.	1	2	3	4	5
14. I am sure I could do advanced work in mathematics.	1	2	3	4	5
15. I think I could handle more difficult mathematics.	1	2	3	4	5
16. I'm not good at math.	1	2	3	4	5
17. I can get good grades in mathematics.	1	2	3	4	5
18. For some reason even though I study, math seems unusually hard for me.	1	2	3	4	5

Career Interest in Mathematics	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
19. I see math as something I will use very often when I get out of high school.	1	2	3	4	5
20. Knowing mathematics will help me earn a living.	1	2	3	4	5
21. I study math because I know how useful it is.	1	2	3	4	5
22. I want to have a college major in an area related to math.	1	2	3	4	5
23. I will get a job in a math-related area.	1	2	3	4	5
24. I will need math to do well in my future career.	1	2	3	4	5
25. Math will be important to me in my life's work.	1	2	3	4	5
26. I would like to have a career in math.	1	2	3	4	5
27. I would enjoy a career that uses math.	1	2	3	4	5
28. A career in math would enable me to work with others in meaningful ways.	1	2	3	4	5
29. Having a career related to math would be challenging.	1	2	3	4	5
30. Math is just as important as any other subject for jobs.	1	2	3	4	5

Motivation in Mathematics	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
31. I like math problems.	1	2	3	4	5
32. Mathematics is enjoyable to me.	1	2	3	4	5
33. If I don't understand a math problem, I keep trying.	1	2	3	4	5
34. I like challenging math problems.	1	2	3	4	5
35. I would prefer to solve for an answer to a math problem on my own.	1	2	3	4	5
36. I show all my work in math.	1	2	3	4	5
37. I like math puzzles.	1	2	3	4	5

38. I am challenged by math problems I can't understand immediately.	1	2	3	4	5
39. The challenge of math problems does not appeal to me.	1	2	3	4	5
40. Math puzzles are boring.	1	2	3	4	5
41. Once I start trying to work on a math problem, I find it hard to stop.	1	2	3	4	5
42. When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	1	2	3	4	5
43. I do as little work in math as possible.	1	2	3	4	5
44. I enjoy going to math class.	1	2	3	4	5

Anxiety in Mathematics	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
45. I almost never get nervous when I take a math test.	1	2	3	4	5
46. Math makes me feel uncomfortable, restless, irritable, or impatient.	1	2	3	4	5
47. Math doesn't scare me.	1	2	3	4	5
48. It would bother me to have a pop/surprise quiz.	1	2	3	4	5
49. I can think clearly when I am solving a math problem.	1	2	3	4	5
50. I usually worry about being able to solve math problems.	1	2	3	4	5
51. A math test would scare me.	1	2	3	4	5
52. Mathematics usually makes me feel uncomfortable or nervous.	1	2	3	4	5
53. It wouldn't bother me at all to take more math courses.	1	2	3	4	5
54. Mathematics makes me feel uneasy or confused.	1	2	3	4	5
55. Math doesn't scare me at all.	1	2	3	4	5

APPENDIX B

Math & Me Journal Template

MATH & ME

Tell me about your experience in math class. Share at least one positive and one negative experience. What do you like about math? What do you dislike about math? What do you hope to learn in class this year? What questions do you have about mathematics? Are you interested in a career field that involves mathematics? Reflect on a few of these things and jot down anything that comes to mind (even pictures!):

I look forward to the school year and hope you are excited to be here!
-Mr. Shah

APPENDIX C

Reverse/Negative Statements for Questionnaire Analysis

Confidence in Learning Mathematics	**Re-written Statement for Scoring Purposes**
1. I do well in math.	
2. I don't often make mistakes in math.	
3. I can attempt a math problem.	
4. In elementary school, math was not hard for me.	
5. I have self-confidence when it comes to math.	
6. I can get good grades in math.	
7. When I study, I can do well in math.	
~~8. Most subjects I can handle, but I have tendency to do poorly in math.~~	8. Most subjects I can handle, and I do not have tendency to do poorly in math.
~~9. I don't think I could do advanced mathematics.~~	9. I do think I could do advanced mathematics.
10. I am sure that I can learn mathematics.	
~~11. I'm not the type to do well in math.~~	11. I'm the type to do well in math.
12. Generally, I have felt secure about attempting mathematics.	
~~13. Math is my worst subject.~~	13. Math is not my worst subject.
14. I am sure I could do advanced work in mathematics.	
15. I think I could handle more difficult mathematics.	
~~16. I'm not good at math.~~	16. I'm good at math.
17. I can get good grades in mathematics.	
~~18. For some reason even though I study, math seems unusually hard for me.~~	18. For some reason even though I study, math does not seem unusually hard for me.
Career Interest in Mathematics	
19. I see math as something I will use very often when I get out of high school.	
20. Knowing mathematics will help me earn a living.	
21. I study math because I know how useful it is.	
22. I want to have a college major in an area related	

to math.	
23. I will get a job in a math-related area.	
24. I will need math to do well in my future career.	
25. Math will be important to me in my life's work.	
26. I would like to have a career in math.	
27. I would enjoy a career that uses math.	
28. A career in math would enable me to work with others in meaningful ways.	
~~29. Having a career related to math would be challenging.~~	29. Having a career related to math would not be challenging.
30. Math is just as important as any other subject for jobs.	
Motivation in Mathematics	
31. I like math problems.	
32. Mathematics is enjoyable to me.	
33. If I don't understand a math problem, I keep trying.	
34. I like challenging math problems.	
35. I would prefer to solve for an answer to a math problem on my own.	
36. I show all my work in math.	
37. I like math puzzles.	
~~38. I am challenged by math problems I can't understand immediately.~~	38. I am not challenged by math problems I can't understand immediately.
~~39. The challenge of math problems does not appeal to me.~~	39. The challenge of math problems does appeal to me.
~~40. Math puzzles are boring.~~	40. Math puzzles are not boring.
41. Once I start trying to work on a math problem, I find it hard to stop.	
42. When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	

~~43. I do as little work in math as possible.~~	43. I do not do as little work in math as possible.
44. I enjoy going to math class.	
Anxiety in Mathematics	
~~45. I almost never get nervous when I take a math test.~~	45. I almost always get nervous when I take a math test.
46. Math makes me feel uncomfortable, restless, irritable, or impatient.	
~~47. Math doesn't scare me.~~	47. Math does scare me.
48. It would bother me to have a pop/surprise quiz.	
~~49. I can think clearly when I am solving a math problem.~~	49. I cannot think clearly when I am solving a math problem.
50. I usually worry about being able to solve math problems.	
51. A math test would scare me.	
52. Mathematics usually makes me feel uncomfortable or nervous.	
~~53. It wouldn't bother me at all to take more math courses.~~	53. It would bother me to take more math courses.
54. Mathematics makes me feel uneasy or confused.	
~~55. Math doesn't scare me at all.~~	55. Math does scare me.

APPENDIX D

Questionnaire Response Profiles for Respondents

	Low Level Range	Mid Level Range	High Level Range
Confidence	18-45	46-62	63-90
Career Interest	12-30	31-41	42-60
Motivation	14-35	36-48	49-70
Anxiety	11-28	29-37	38-55

Student Questionnaire Form Number	Grade Level	Gender	Confidence Level	Career Interest Level	Motivation Level	Anxiety Level
101	09	Male	High	High	High	Low
102	09	Male	High	Mid	High	Low
103	09	Male	Mid	High	Mid	Low
104	09	Male	High	Mid	High	Low
105	09	Female	Low	Mid	Low	High
106	09	Female	Mid	Low	Mid	Mid
107	09	Male	High	Low	High	Low
108	09	Male	Mid	Low	Low	High
109	10	Male	Mid	Mid	Mid	Mid
110	10	Male	Mid	Mid	Mid	High
111	10	Male	High	Mid	Mid	Low
112	10	Female	High	High	High	Low
113	10	Male	Mid	Mid	Mid	Mid
114	10	Male	High	Mid	Mid	Low
115	10	Male	High	Mid	Mid	Low
116	10	Male	Low	Low	Low	Mid
117	11	Male	High	Mid	High	Mid
118	11	Female	Low	Low	Low	High
119	11	Male	Mid	Low	Mid	High
120	11	Male	High	High	High	Low
121	11	Female	Mid	Low	Mid	High
122	11	Male	Low	Low	Low	High
123	11	Male	High	High	High	Low
124	11	Male	High	Mid	High	Low
125	11	Female	High	High	Mid	High
126	11	Female	Low	Low	Low	High
127	11	Male	High	Low	Mid	Low
128	11	Female	High	Low	Mid	Mid
129	11	Male	Mid	Mid	High	Low
130	11	Female	High	Mid	High	Low
131	11	Male	Mid	Mid	Mid	Mid
132	11	Male	High	High	High	Low
133	12	Male	Mid	Low	Mid	High
134	12	Male	Mid	Low	Low	Mid

135	12	Male	Mid	High	Mid	Low
136	12	Male	High	Mid	High	Mid
137	12	Male	High	Mid	Mid	Low
138	12	Male	High	High	High	Low
139	12	Male	High	High	High	Low
140	12	Female	Low	Mid	Low	High
141	12	Male	Low	Low	Low	High
142	12	Male	High	Mid	Mid	Mid
143	12	Female	Mid	High	Mid	Low
144	12	Female	Mid	Low	Mid	High
145	12	Male	High	High	Mid	Low
146	12	Male	Mid	Mid	Mid	Mid
147	12	Female	Low	Low	Low	High
148	12	Male	High	High	Mid	Mid
149	12	Male	High	Mid	Mid	Mid
150	12	Female	Low	Low	Low	High
151	12	Female	High	Low	Mid	High
152	12	Male	Mid	Mid	Low	High
153	12	Male	High	Mid	Mid	Low
154	12	Female	High	Mid	Mid	Mid
155	12	Female	Low	High	Low	High

APPENDIX E

Questionnaire Frequency Tables and Bar Charts – Category Levels by Gender

Table E.1

Questionnaire Frequencies – Association of Confidence Levels by Gender

		Confidence Levels			Total
		Low	Mid	High	
Male	Observed	3	13	22	38
	Expected	6.9	11.7	19.3	38.0
	% within Gender	7.9%	34.2%	57.9%	100.0%
	% within Confidence	30.0%	76.5%	78.6%	69.1%
	% of Total	5.5%	23.6%	40.0%	69.1%
Female	Observed	7	4	6	17
	Expected	3.1	5.3	8.7	17.0
	% within Gender	41.2%	23.5%	35.3%	100.0%
	% within Confidence	70.0%	23.5%	21.4%	30.9%
	% of Total	12.7%	7.3%	10.9%	30.9%
Total	Observed	10	17	28	55
	Expected	10.0	17.0	28.0	55.0
	% within Gender	18.2%	30.9%	50.9%	100.0%
	% within Confidence	100.0%	100.0%	100.0%	100.0%
	% of Total	18.2%	30.9%	50.9%	100.0%

Figure E.1

Percent of Confidence Levels within Gender Groups

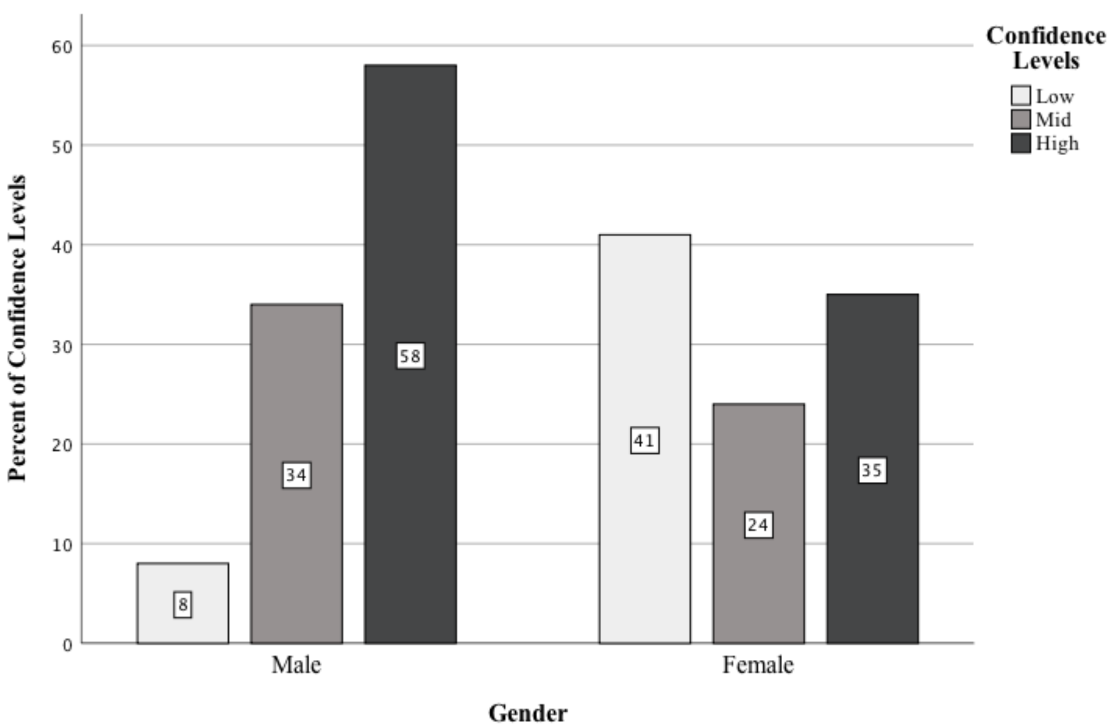


Table E.2

Questionnaire Frequencies – Association of Career Interest Levels by Gender

		Career Interest Levels			Total
		Low	Mid	High	
Male	Observed	9	19	10	38
	Expected	12.4	15.9	9.7	38.0
	% within Gender	23.7%	50.0%	26.3%	100.0%
	% within Career Interest	50.0%	82.6%	71.4%	69.1%
	% of Total	16.4%	34.5%	18.2%	69.1%
Female	Observed	9	4	4	17
	Expected	5.6	7.1	4.3	17.0
	% within Gender	52.9%	23.5%	23.5%	100.0%
	% within Career Interest	50.0%	17.4%	28.6%	30.9%
	% of Total	16.4%	7.3%	7.3%	30.9%
Total	Observed	18	23	14	55
	Expected	18.0	23.0	14.0	55.0
	% within Gender	32.7%	41.8%	25.5%	100.0%
	% within Career Interest	100.0%	100.0%	100.0%	100.0%
	% of Total	32.7%	41.8%	25.5%	100.0%

Figure E.2

Percent of Career Interest Levels within Gender Groups

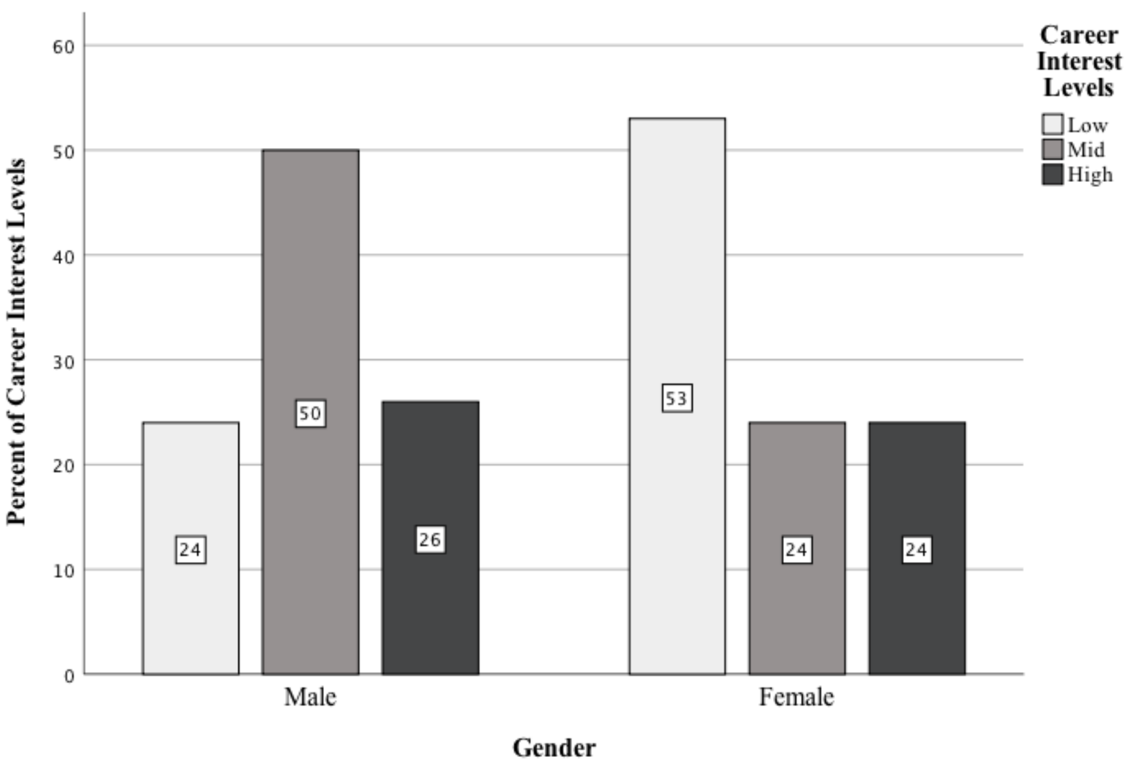


Table E.3

Questionnaire Frequencies – Association of Motivation Levels by Gender

		Motivation Levels			Total
		Low	Mid	High	
Male	Observed	6	19	13	38
	Expected	9.0	18.7	10.4	38.0
	% within Gender	15.8%	50.0%	34.2%	100.0%
	% within Motivation	46.2%	70.4%	86.7%	69.1%
	% of Total	10.9%	34.5%	23.6%	69.1%
Female	Observed	7	8	2	17
	Expected	4.0	8.3	4.6	17.0
	% within Gender	41.2%	47.1%	11.8%	100.0%
	% within Motivation	53.8%	29.6%	13.3%	30.9%
	% of Total	12.7%	14.5%	3.6%	30.9%
Total	Observed	13	27	15	55
	Expected	13.0	27.0	15.0	55.0
	% within Gender	23.6%	49.1%	27.3%	100.0%
	% within Motivation	100.0%	100.0%	100.0%	100.0%
	% of Total	23.6%	49.1%	27.3%	100.0%

Figure E.3

Percent of Motivation Levels within Gender Groups

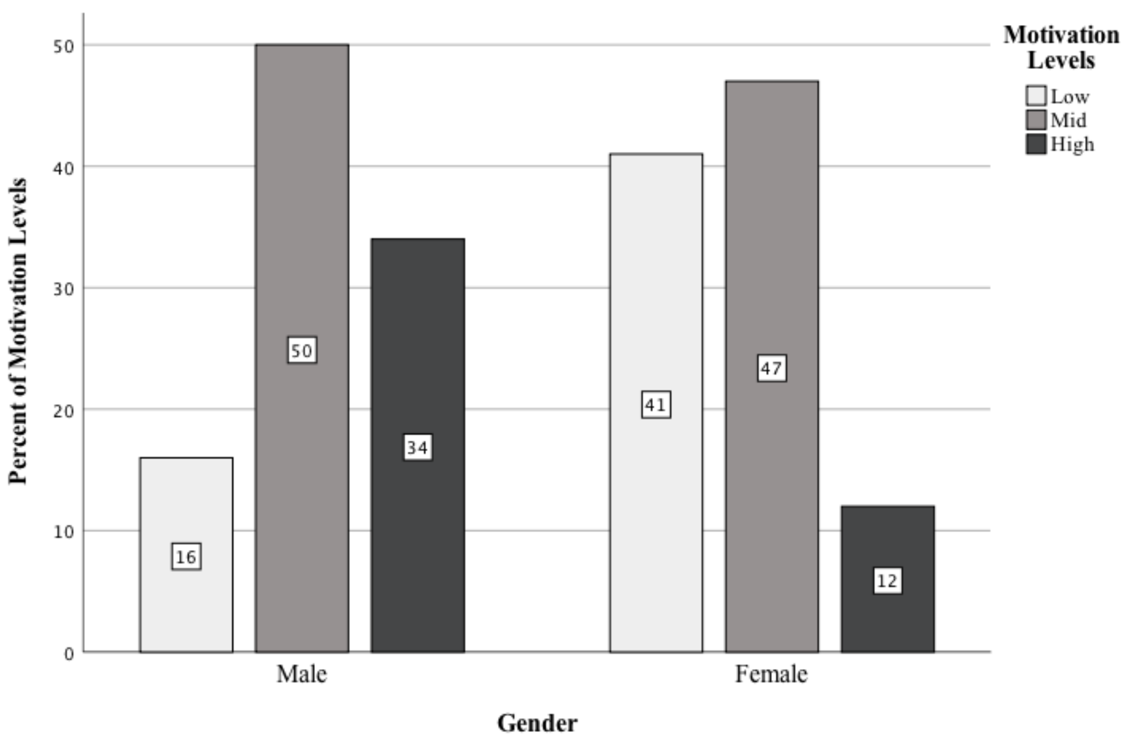


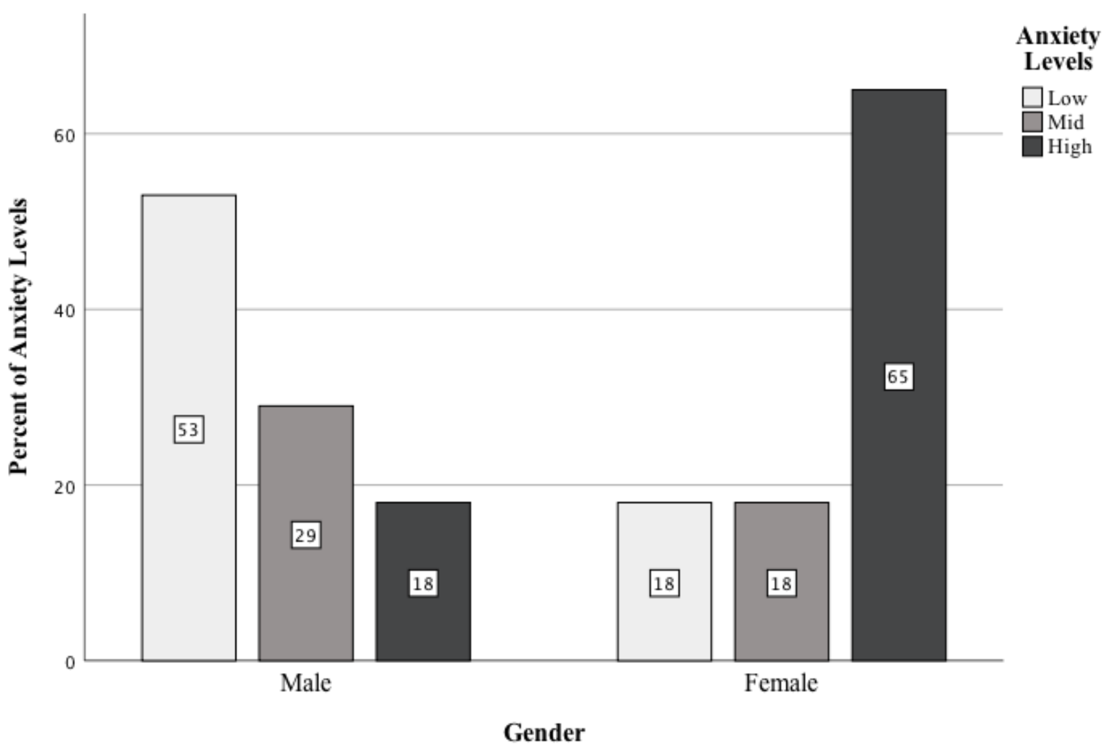
Table E.4

Questionnaire Frequencies – Association of Anxiety Levels by Gender

		Anxiety Levels			Total
		Low	Mid	High	
Male	Observed	20	11	7	38
	Expected	15.9	9.7	12.4	38.0
	% within Gender	52.6%	28.9%	18.4%	100.0%
	% within Anxiety	87.0%	78.6%	38.9%	69.1%
	% of Total	36.4%	20.0%	12.7%	69.1%
Female	Observed	3	3	11	17
	Expected	7.1	4.3	5.6	17.0
	% within Gender	17.6%	17.6%	64.7%	100.0%
	% within Anxiety	13.0%	21.4%	61.1%	30.9%
	% of Total	5.5%	5.5%	20.0%	30.9%
Total	Observed	23	14	18	55
	Expected	23.0	14.0	18.0	55.0
	% within Gender	41.8%	25.5%	32.7%	100.0%
	% within Anxiety	100.0%	100.0%	100.0%	100.0%
	% of Total	41.8%	25.5%	32.7%	100.0%

Figure E.4

Percent of Anxiety Levels within Gender Groups



APPENDIX F

Journal Entries and Coding Process

Journal 201 (Female):
Honestly, math has been a natural enemy since I was younger. I really strived in other subjects but it was always much more difficult in math. I feel that I struggle with understand a lot of the logic behind math. I often find myself in situations where no matter how hard I tried I am not able to comprehend what I should be doing to solve whatever math problem it is. My mind will be blank. Once I get into the flow of things, it goes better, but I sometimes make unconsense errors that stop me from getting the correct answer, or just completely forget about a rule or whatever. Basically, I really hate math, so fair warning, I may get grumpy or angry. But that's because nothing triggers my frustration more than math. There might be times where I need to take mental breaks. Also, I'm the only girl in this class and none of these boy aren't any of the people I usually talk too, so while I'm a very loud and social person, I might not be when I'm in this class. My goal for this year is too feel confident in the matiral we learn by really knowing it well, AND I need to bring my math up for the ACT. Outside of that, when I am in school, I don't want to study a field/profession that's math heavy. I hope this information was beneficial to you and I look forward to discussing it with you, if you would like/feel necessary.

Journal 202 (Male):
I never really thought I would end up in an advanced math class because until ---school name omitted--- I never really did well. With math I know it's not like history or English, I can't make assumptions. I know to be good at math its like a sport. I need to understand every aspect of it as I go along inside and out. I don't have much natural talent when it comes to math so I need to work even harder at drilling and understanding concepts. I am not interested in a career field in math it would do me in.

Journal 203 (Female):
I really enjoy math. In 6th, 7th, and 8th grade my teacher made math very fun for me. We worked very hard and she got me very confident in math. And ever since, I've really enjoyed math. I like geometry and algebra because I feel good at it. But you should know that if I feel like I can't do something or it's too hard or I don't understand it, I will shut down. I know that will happen this year and I will just need extra help one-on-one. I know that this is what works best for me. I hope this year goes good and I learn math =) Thanks for understanding and helping me through junior year! I'm also not a good artist so draw things kinda stresses me out but I will try my best and push myself this year.

Journal 204 (Male):
A negative experience I had with math is when common core was introduced into CPS. The teachers were clueless as to what they were doing almost as much as the kids. A question I have is if I do not get a job that involves math, when will I use it. I hope to fill in some blanks that my freshman year teachers failed to teach.

Journal 205 (Male):
I have always liked math. I am a very independent worker and can do work very fast. When taking a test or when working I like using the huddle room. Math has always been in my top 3 favorite subjects. Math is my strong suit except for word problems. Those are the worst. A job that involves math is pretty much my second option for jobs. I like math because I like patterns, and complex problems.

Journal 206 (Male):
Honestly, I don't remember math class from up to last year well, last year I had ---teacher name omitted--- and it was an awesome class. I like to be done with my hw fast (usually before class is over) and I also like to listen to music. I hope to do as well as I did last year.

Journal 207 (Female):
Math class has been very successful for me at ---school name omitted---. One positive experience was in freshman math class when I always felt like I understood everything and would be able to do the work with little help. A negative experience was last year when I missed 2 weeks of school and practically a whole unit. I

like math because there is usually one answer. This means that you can keep working until you find the correct answer. I dislike that it sometimes involves a lot of different equations and it's hard to remember all of them. I hope to learn more about graphing and the patageron therom and SOH CAH TOA. I want to be a nurse. I know there will be some math involved with this position. I don't really have any questions about math. I like a teacher who can meet me before or after school to review for a test or help me with any questions.

Journal 208 (Male):
I was in all normal math class befor this year. This is my first year in an honers class. I am looking forwed to being a great student. One off the hardest things for me in math is when I faild on of my test that really hurt because I don't like to fail and it was hard to see me fail. I don't like all of the math homework we get. I hope to lern how to be a better math sudent.

Journal 209 (Male):
I think I'm ok in math I was a lot better in Algebra than I was in geometry. I really liked Algebra but I didn't like writed in geometry. I can get a lot better in math. I want to be in business so I need to know math.

Journal 210 (Female):
In math class for me was not that hard. My positive exsperence was proof in geometry. Negtive exsperence was graffing. The one thing that I don't like about is graffing is one thing I am really bad at. I would like to know how get better in Algbrea. How can I get better a graffing and tips for grafing? Maybe teach geometry in high school.

Journal 211 (Male):
My freshman year was a good year in math, I took Algebra I. 7th/8th grade math were both negative experiences. In 7th grade we had 4 teacher switches during the year with different teaching styles. 8th grade, I had trouble with the material. I used to love math before 7th grade, then I hated it for a couople years. Freshman year somewhat brought my love for math back. Then the summer before my sophomore year I took geometry because my parents made me. It was just way too fast for me and about 4 of the 6 weeks in, I had a C, and I convinced my parents to let me drop so I could get a better grade during the school year. I hope this class brings back my love for math, and hopefuly I'll understand the work and get a good grade. Math is a big part of engineering and I wanna go into aerospace engineering. I wanna go to ---university name omitted--- and I hope my Junior and senior year of math at ---school name omitted--- helps to prepare me for whats to come there in mathematics. I'm gonna really work hard this year to learn the curriculum and get a good grade. I'm excited for the year to takeoff. Thank you.

Journal 212 (Male):
I have never had a bad experience with math. I am very excited to learn new material. I wish I could jump to calculus right now and get into advanced physics, but I need to get the stuff in between first. I hope to work with logarithms, graphing trig functions, and the binomial theorem. I am interest in physics and mechanical engeneering, and that's why I love math.

Journal 213 (Female):
I have never been very good in math. It all started when I was in 3rd grade. Our teacher made us do mad Mintutes. Addition was great, subtraction was alright, multiplication and division made me wish I wasn't "slow". I guess you can say my math has improved? Or maybe my memory and listening skills improved and I still suck at math. Either way, I know that I'll have to get better or modern technology will replace me. I know it sounds weird but I want to be a OBGYN and with robots that administer pills, who's to say they won't make robots that deliver babies? Math is something that I have grown to tolerate. I have a love hate connection with it because I can't escape it. I would math + me have a stockholme type love. It has captured me and since I can't be free, I try to be friendly towards it.

Journal 214 (Female):

Throughout most of my school career, math had been my greatest challenge. It was dense and complicated and with my learning difference, I really struggled with it. However, once I came to ---school name omitted---, I learned how to ask questions and advocate for myself when it came to mathematics, and suddenly I found myself understanding it and getting A's. It was almost an emotional thing, regarding how the subject used to be for me. I think that math can either be boring or fun (well, almost fun). It depends on how it is taught to me. If taught right, math can be like a satisfying puzzle. That's what I like about it. But I would still never consider a career in it. That I will say.

Journal 215 (Female):
I like how you teach and your sense of humor. I also like how I feel comfortable in your class + can say when I don't understand something. I don't like the size of this year's class + proofs. I hope to learn Algebra II this year. Maybe if we have time at the end of the year you can perform some show tunes for us! I like solving algebraic math problems because they're like puzzles. I don't like proofs and fractions. One of my dream careers is to become a scientist. I'm not sure what field I want to be in, though.

Journal 216 (Female):
I have had good and bad math years. I loved algebra in my freshman year of high school and did really well. I had a hard time in 8^{th} grade because the teacher moved so fast and never asked me how I was doing. I love plug in equations. That's why I think I did so well in Algebra. I HATE PROFS. I hope to build my confidence this year in math and improve my skills as a learner. I don't really have any questions about math so far but don't worry they will come later. Also I am not interested in a career field involving mathematics. I look forward to another year with you.

Journal 217 (Female):
I always loved math but sometimes numbers get mixed up in my head but I was good anyways. In 8^{th} graded I had a teacher named ---teacher name omitted---. She was one of the best teachers I had. The way she explained was like no other. She would always met with me to help and found was I can do Algebra faster. The day we took the Algebra test I didn't care I did try as hard as I knew I could, I know every teen movies says it "I hung out with the wrong crowed" and I did try. I paid for it 1^{st} year at high school I hated math because I all ready did it, but ---teacher name omitted--- made it fun with his dancing. 2^{nd} year the math class was way to easy and push myself to be in honors (Hello). All I'm trying to say is that I will work hard and love math.

Journal 218 (Male):
My history with math has been mixed. I have had some teachers who worked very well for me, and others who have been a poor match. Overall, I think math is a strong suite for me, but I do not always enjoy it. I really enjoy solving algebraic equations, and do not like graphing. Teachers that have worked well with me in the past have been open, honest, and believed in me and said so even through difficulty. Overall I am very excited for this coming year at ---school name omitted---and I am looking forward to academic success (finally).

Journal 219 (Male):
I enjoy math and find it easy. That's why over the summer I did a geometry course. This year I hope we go more in depth with trigonometry. Later in life I want to work in a career that is in the math/science field. Also, later I hope to take pre-calc over the summer, so I can do calculus for junior year. I want to get a jump start in high school so I am prepared for college.

Journal 220 (Male):
I didn't take any hard math classes until last year. Because of my natural talent for basic algebra being a solid foundation for advanced topics. A good experience I had in math class was freshman year because it was easy and we had barely any homework. I hated 7^{th} grade math because my teacher would only give homework quizzes on days that I didn't do my homework. The quizzes wouldn't be on our understanding of the topics, it would be on our ability to copy down the answers for various problems, question not provided. My goal for this

year is to be a good influence for the sophomores in this class and to get a B+ or better. I have no question and don't want a career in mathematics, however I wouldn't mind a career that involved mathematics.

Journal 221 (Male):
I have had a positive time in math class. I tend to like the topic and solving problems unless they are proofs. This year I hope to keep my positive fealing towards math and be challenged. I suggest that there is no homework all year. I don't know if I would like a career in math yet, but it would be much better than a career in writing. I am exited for math and am ready to learn knew things. The only thing that I don't know how it will turn out is having a lot more kids in the class then last year.

Journal 222 (Male):
I have had mostly positive experiences in math. My biggest consiren is note taking as im not a good writer and have bad hand writing. Also I strugel rembering things and becides that im not woriede. I love everything becides quizzes hw and tests in math.

Journal 223 (Male):
I didn't start like math till last year. In Algebra 1 I had a hard time understanding the material most of my past math classes have be weak points in my learning. Geometry was the first time I had a real understanding of math. I would like to be good at math because I enjoy chemistry and that requires a lot of math. I like math I just wish I was better at it.

Journal 224 (Male):
Math is decent. Its something I have to do as a student. For me to get my major in business I will have to do it, hense why I have to do it. ---Teacher name omitted--- had a great way of teaching it and I wish it was more recognized in this school as example. Last year I never failed or got lower than a 73% and homework was complete most of the year. I except the same help from my teacher this year.

Journal 225 (Female):
In the past I have really struggled with math however last year and the year before I felt like I started to understand math a lot more and I began to like it a lot more. I am very good with shapes and equations I'm not good at doing math in my head. My goal for this year would be to get better at solving equations. The only thing I disliked in math last year was the pace I wanted to work a lot quicker but I'm sure this year it will be a lot more difficult because it is not visual. I am not really interested in a career in math because I am interested in physiology but I am sure you can find a way to connect the two. Cannot wait to be in your class this year!
Thank you, ---student name omitted---

Journal 226 (Male):
I have not had any positive experiences with math. I get very frustrated with myself and my dyscalculia, which bring up bad thoughts and memories. I find myself having mental breakdowns even when math is mentioned. I just need to pass in this class, that's all I need this year. Why do we need to learn stuff we don't need in the future? No I do not want a career involving math.

Journal 227 (Male):
My experience in math class has been mostly positive, I struggled quite a bit in Algebra I. And I exelled in Geometry. I understand and that I have a really hard time with numbers. I liked geometry because it focused on conceptual stuff instead of numbers. I did exceptionally well last year. I hope to be a computer engineer. I'm not sure if it involves math, but I am willing to be challenged to be in that career. I feel very nervous that I will be made fun of for my ability in math. My dyscalculia is something I cannot simply control. And I fear that I will be judged. If I get a wrong answer in front of the class.

Journal 228 (Male):

A positive experience was in Geometry last year at the end of the year I had great success with test. I had a hundred or close to a hundred with the last three tests. A negative is that I struggled at the beging of the year to get on track with math. What I like about math is that there is a set system a way to do math so it is not opienated and it just is what it is. What I dislike is trying to rember the process to solve an equation every time. I hope to learn the new steps to more complex math problems. I know math is used for every job and so I will end up using it in every job perfesion.

Journal 229 (Male):
My experience in math is mostly positive. I had a lot of fun in Geometry during sophomore year and made a lot of friends. I'm usually able to understand most of the material in math class and when it doesn't make sense, I'm able to understand it quickly.

Journal 230 (Male):
One positive experience in math that I had was learning geometry and using (SOH CAH TOA) and other equations to find the volume and surface area in a shape. That was a strength. A negative experience was learning a lot in algebra as I can recall. I need help and work on it. A negative memory I remember was always getting stuck on the homework.

Journal 231 (Male):
I aced my final Algebra I exam. I got a detention for turning around to borrow a pencil. I like the problem solving aspect. I don't like the fact that Geometry exists.

Journal 232 (Male):
Math has always been one of my favorite subjects. I have always done better in this subject. This past year I took the second semester of my math class with a concussion. This made learning harder for me. I somehow continued to work hard and get good grades in the class.

Journal 233 (Male):
I think my favorite part about math is when something takes a lot of steps but you still find the solution correctly. I dislike word problems. I feel word problems are less about math more English. I hope to learn things that I didn't know. I think that my career field might be in sports so most likely math is involved.

Journal 234 (Male):
One positive experience I have had with math is proofs in geometry. One negative experience was learning division for some reason. I dislike writing out my work and I hope to learn more about algebra. I don't think I am interested in a career related to math. I don't think I have any questions.

Journal 235 (Male):
When I first started math at my old school I didn't understand it and it felt like I was 2 years behind on it. But when I went to ---school name omitted--- and started Algebra I it was really hard at first I still didn't understand it. But my teacher told me to stay after school one day so we can have a one on one talk with math. Slowly but surely I was starting to get it, I started getting the equations and learned something new every day. By the end of my freshman year I got a B in math. In my sophomore year I got it even more and got an A.

Journal 236 (Male):
My experience in math class is good. I have been in classes above my grade level, so I'm used to that, but I've never been in an honors class, so this is new. The way I think has often coincided well with math, but that is balanced out by my struggle with taking my time and showing my work.

Journal 237 (Male):
I have always been good at math even though I haven't always been good at it. In elementary school the math teacher would always try and help me with homework but I still wouldn't do good. But once I got a really good

teacher and I did good on my test. I like how math is like life there are problems but you solve them with solutions. I don't like how hard it can be to solve those particular problems. I hope to learn more about what I can do in my up coming math. I will later in life probably go for a more artist based and it may deal with numbers because what job doesn't.

Journal 238 (Male):
One positive was the very fun classmates and teachers to be around, but always serious. One negative is that if you miss a day of class, you miss a lot of crucial information. I don't like math. I hope to learn more in general. None [questions]. No [interest in a career field].

Journal 239 (Male):
I've never had a good experience with math until sophomore year because it was really fun. I will have a lot of questions and try my hardest even if it doesn't look like it. Dyscalculia causes this but I wanna do better in math cuz my girlfriend makes fun of me for it.

Journal 240 (Female):
I like math bc I like the whole problem solving aspect. I did not like math in 8th grade bc of the teacher I had. I do not like working w/graphs. I hope to learn more math. I also do not like the vocab for math. I'm somewhat interested to have math in my career. Math will help me solve problems and taxes.

Journal 241 (Male):
In math class I have always been a worker, I try to stay focused as much as I can. This usually end in me with my head down focused on the material, trying my best to figure it out as I go. For the most part I do fairly well but if I cant figure something out it really affects my work. I like math because the second you understand all the rules it becomes very easy, and I like achieving that sort of ease in a subject in math. Math can annoy me when it doesn't make any sense but that usually comes from a lack of understanding I hope I can learn as much as can in this class so I can hopefully apply it into a potential. All the math I use daily is for subdividing in music and quantizing while mixing. I want to get better at math this year, it's a small goal.

Journal 242 (Male): I had a fun experience in math last year. I enjoy solving variables. I dislike the reflexive property. I liked how you were okay with jokes, though some days we didn't get much done. I hope to learn about functions and statistics. I don't really see a career that needs math, but I still want to learn it. Over the summer, counselors made a pokemon go ripoff, with cards, and it got me wondering if there was a way to calculate the overall power with statistics (had a lot of probability).

Journal 243 (Female):
I have always struggled with math. My past years in math have been difficult for me. Last year in geometry I had a lot of trouble with remembering steps to a problem. I don't always pick up on the concept right away. Having extra support has helped me a lot. Also, having a formula sheet is so helpful. Sometime could we talk about if I can use one?

Journal 244 (Male):
I have never been a strong math student. At my old school, I had to take algebra twice. Since I've gotten older, I can comprehend topics better. I like the problem solving, but not the mess of numbers.

Journal 245 (Male):
In elementary school (k-8) I was very doodoo at math. I think I did not have meds. Once I got to ---school name omitted--- that all changed. I was doing much better at math. The last 2 years I don't think I got below a 96 as a grade for math. I like that math has a easy to learn equation for everything. I don't like how math can take super long to do cause like man I got other stuff to do. I hope I learn new stuff I don't have any questions right now. I could or could not be interested in a career with math.

APPENDIX G

Journal Entry Profiles Based on Coding Process

Journal Entry #	Gender	Confidence Level	Career Interest Level	Motivation Level	Anxiety Level
201	Female	Low	Low	Mid	High
202	Male	Low	Low	Mid	Mid
203	Female	Mid	N/A	High	High
204	Male	Low	Low	Low	N/A
205	Male	High	High	High	Mid
206	Male	Mid	N/A	Mid	N/A
207	Female	High	High	High	Mid
208	Male	Mid	N/A	Mid	High
209	Male	Mid	High	High	N/A
210	Female	Mid	Mid	Mid	N/A
211	Male	Mid	High	High	Mid
212	Male	High	High	High	N/A
213	Female	Low	High	Mid	High
214	Female	Mid	Low	High	Mid
215	Female	High	High	High	Low
216	Female	Mid	Low	High	Mid
217	Female	High	N/A	Mid	Mid
218	Male	Mid	N/A	Mid	Mid
219	Male	High	High	High	N/A
220	Male	High	Mid	Mid	N/A
221	Male	Mid	Mid	High	N/A
222	Male	Mid	N/A	Mid	Mid
223	Male	Low	High	High	Mid
224	Male	Mid	High	Mid	N/A
225	Female	Mid	Mid	High	N/A
226	Male	Low	Low	Low	High
227	Male	Mid	High	High	High
228	Male	High	High	Mid	Mid
229	Male	High	N/A	High	Low
230	Male	Mid	N/A	Mid	High
231	Male	High	N/A	Mid	N/A
232	Male	High	N/A	High	Mid
233	Male	High	High	Mid	N/A
234	Male	Mid	Low	Mid	N/A
235	Male	Mid	N/A	Mid	Mid
236	Male	High	N/A	Mid	N/A
237	Male	Mid	Mid	Mid	Mid
238	Male	Low	Low	Mid	High
239	Male	Low	N/A	High	High
240	Female	N/A	Mid	High	Mid
241	Male	Mid	Mid	High	High
242	Male	Mid	Low	High	N/A
243	Female	Low	N/A	High	High
244	Male	Mid	N/A	Mid	High
245	Male	High	Mid	Mid	Mid

APPENDIX H

Journal Entry Frequency Tables – Category Levels by Gender

Table H.1

Journal Entry Frequencies – Association of Confidence Levels by Gender

		Confidence Levels			Total
		Low	Mid	High	
Male	Observed	6	16	11	33
	Expected	6.8	15.8	10.5	33.0
	% within Gender	18.2%	48.5%	33.3%	100.0%
	% within Confidence	66.7%	76.2%	78.6%	75.0%
	% of Total	13.6%	36.4%	25.0%	75.0%
Female	Observed	3	5	3	11
	Expected	2.3	5.3	3.5	11.0
	% within Gender	27.3%	45.5%	27.3%	100.0%
	% within Confidence	33.3%	23.8%	21.4%	25.0%
	% of Total	6.8%	11.4%	6.8%	25.0%
Total	Observed	9	21	14	44
	Expected	9.0	21.0	14.0	44.0
	% within Gender	20.5%	47.7%	31.8%	100.0%
	% within Confidence	100.0%	100.0%	100.0%	100.0%
	% of Total	20.5%	47.7%	31.8%	100.0%

Table H.2

Journal Entry Frequencies – Association of Career Interest Levels by Gender

		Career Interest Levels			Total
		Low	Mid	High	
Male	Observed	6	5	10	21
	Expected	6.3	5.6	9.1	21.0
	% within Gender	28.6%	23.8%	47.6%	100.0%
	% within Career Interest	66.7%	62.5%	76.9%	70.0%
	% of Total	20.0%	16.7%	33.3%	70.0%
Female	Observed	3	3	3	9
	Expected	2.7	2.4	3.9	9.0
	% within Gender	33.3%	33.3%	33.3%	100.0%
	% within Career Interest	33.3%	37.5%	23.1%	30.0%
	% of Total	10.0%	10.0%	10.0%	30.0%
Total	Observed	9	8	13	30
	Expected	9.0	8.0	13.0	30.0
	% within Gender	30.0%	26.7%	43.3%	100.0%
	% within Career Interest	100.0%	100.0%	100.0%	100.0%
	% of Total	30.0%	26.7%	43.3%	100.0%

Table H.3

Journal Entry Frequencies – Association of Motivation Levels by Gender

		Motivation Levels			Total
		Low	Mid	High	
Male	Observed	2	18	13	33
	Expected	1.5	16.1	15.4	33.0
	% within Gender	6.1%	54.5%	39.4%	100.0%
	% within Motivation	100.0%	81.8%	61.9%	73.3%
	% of Total	4.4%	40.0%	28.9%	73.3%
Female	Observed	0	4	8	12
	Expected	.5	5.9	5.6	12.0
	% within Gender	0.0%	33.3%	66.7%	100.0%
	% within Motivation	0.0%	18.2%	38.1%	26.7%
	% of Total	0.0%	8.9%	17.8%	26.7%
Total	Observed	2	22	21	45
	Expected	2.0	22.0	21.0	45.0
	% within Gender	4.4%	48.9%	46.7%	100.0%
	% within Motivation	100.0%	100.0%	100.0%	100.0%
	% of Total	4.4%	48.9%	46.7%	100.0%

Table H.4

Journal Entry Frequencies – Association of Anxiety Levels by Gender

		Anxiety Levels			Total
		Low	Mid	High	
Male	Observed	1	11	8	20
	Expected	1.3	10.7	8.0	20.0
	% within Gender	5.0%	55.0%	40.0%	100.0%
	% within Anxiety	50.0%	68.8%	66.7%	66.7%
	% of Total	3.3%	36.7%	26.7%	66.7%
Female	Observed	1	5	4	10
	Expected	.7	5.3	4.0	10.0
	% within Gender	10.0%	50.0%	40.0%	100.0%
	% within Anxiety	50.0%	31.3%	33.3%	33.3%
	% of Total	3.3%	16.7%	13.3%	33.3%
Total	Observed	2	16	12	30
	Expected	2.0	16.0	12.0	30.0
	% within Gender	6.7%	53.3%	40.0%	100.0%
	% within Anxiety	100.0%	100.0%	100.0%	100.0%
	% of Total	6.7%	53.3%	40.0%	100.0%

APPENDIX I

DePaul University IRB Research Protocol Letter of Approval

DEPAUL UNIVERSITY

Office of Research Services
Institutional Review Board
1 East Jackson Boulevard
Chicago, Illinois 60604-2287
312-362-7593
Fax: 312-362-7574

Research Involving Human Subjects

NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

To: Ravi Shah, MS, Graduate Student, College of Education

Date: May 14, 2019

Re: Research Protocol # RS040819EDU
"Mathematical Identity Formation: Preparing Students with Learning Disorders for Post-secondary Education and Careers""

Please review the following important information about the review of your proposed research activity.

<u>*Review Details*</u>
This submission is an initial submission. Your research project meets the criteria for Expedited review under 45 CFR 46.110 under the following categories:

> *"(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis)."*

> *"(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies."*

<u>*Approval Details*</u>
Your research was originally reviewed on April 24, 2019 and revisions were requested. The revisions you submitted on April 28, 2019 and April 30, 2019 were reviewed and approved on May 14, 2019.

Approval date: May 14, 2019
Please note: Under the revised regulations, protocols requiring expedited review no longer require annual continuing review. We have approved your protocol under the revised regulations. However, if any changes are made to your research, you still need to submit an amendment prior to initiating the amendment changes.

Approved Consent, Parent/Guardian Permission, or Assent Materials:
1) Adult Consent, version 04/28/2019 (attached)
2) Parent/Legal Guardian Permission, version 04/28/2019 (attached)
3) Assent for aged 14-17, version 04/28/2019 (attached)

Other approved study documents:

1) Recruitment materials: Initial Recruitment Email, Follow-up Recruitment Email, Instructions for Students Prior to Questionnaire Participation, Version 04/30/2019 (attached)

Number of approved participants: 150 Total
You should not exceed this total number of subjects without prospectively submitting an amendment to the IRB requesting an increase in subject number.

Funding Source: 1) None

Approved Performance sites: 1) DePaul University; 2) School Omitted (non-engaged recruitment site)

The Board determined that the research satisfies 45 CFR 46.404; it is not involving greater than minimal risk, therefore children may participate in this research project. The Board determined that according to 45 CFR 46.408 one parent must sign the permission document, as one parent's signature is sufficient, and age appropriate assent will be obtained from each child.

Reminders

- Only the most recent IRB-approved versions of consent, parent/legal guardian permission, or assent forms may be used in association with this project.
- Any changes to the funding source or funding status must be sent to the IRB as an amendment.
- Prior to implementing revisions to project materials or procedures, you must submit an amendment application detailing the changes to the IRB for review and receive notification of approval.
- You must promptly report any problems that have occurred involving research participants to the IRB in writing.
- **Once the research is completed, you must send a final closure report for the research to the IRB.**

The Board would like to thank you for your efforts and cooperation and wishes you the best of luck on your research. If you have any questions, please contact me by telephone at (312) 362-7593 or by email at sloesspe@depaul.edu.

For the Board,

Susan M. Loess-Perez

Susan Loess-Perez, MS, CIP, CCRC
Director of Research Compliance
Office of Research Services

Cc: Leodis Scott, PhD, Faculty Sponsor, College of Education