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Factors Impacting Students' Perceptions of Mathematics

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Commonwealth Interdisciplinary Honors in Mathematics and Secondary Education

Bridgewater State University

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Introduction

As someone who studied mathematics in college and had many experiences in a classroom environment as a future educator and as a student, I heard students proclaim their hatred for math more times than I can count. When I told people about my decision to study math in college and turn my passion for math into a career in an educational setting, the first reaction that many people had was to tell me about how much they dislike math. During this time, it was uncommon for me to encounter someone who seemed just as excited for me to study math in a higher education setting as I was.

In my experience, math is commonly known as the subject that most people love or hate. At first, I was in the minority – I once had mixed feelings towards math, but over time, my interest in math and my love for it have grown. I want to be able to present math in a positive light to all of my future students, regardless of race, gender, and math background. However, for teachers as a whole to be able to take this important step, they must first develop a deeper understanding of why math is a sore spot for many students.

This thesis provides a background on the factors in and out of the classroom environment that influence the ways in which students perceive mathematics. First, this thesis will review the literature on these factors from an educational perspective and a personal perspective. The thesis will then look at how these factors affect students in their choices to explore possible career paths and what measures can be taken to adjust how students perceive math in terms of its importance and applications to life outside of the classroom. Lastly, this thesis will discuss the gaps within the literature and research to show what aspects of this topic need to be addressed in a broader sense.

Factors Impacting Students' Perceptions of Mathematics

The literature review demonstrates four categories relating to factors that impact how students perceive mathematics: math anxiety, race, gender, and how math is taught in classrooms. It is important to note that many of the topics overlap with each other, so some articles cited in one section may include findings that were presented from articles in previous sections.

Math Anxiety

There are many different types of anxiety, but one type of anxiety that is prominent in classrooms of all different grade levels and sizes is math anxiety (Ashcraft, 2002). At first glance, math anxiety might appear to only affect students, but math anxiety is also prominent in teachers. Math anxiety is “a feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002, p. 181) and is more commonly found in women than in men. Starting at a young age, children tend to mimic the behaviors that they see of the adults who are the same gender as them, so young children, particularly female children, who see their female teachers feeling anxious about math are very likely to develop those same feelings towards math (Beilock et al., 2010). Shields (2007) found in a study that 61% of participants mentioned that their teachers contributed to their math anxiety. A female teacher's own math anxiety can significantly lower the math achievement of their female students (Beilock et al., 2010). To combat this, teachers who experience math anxiety should be made aware of how their actions – particularly their actions towards math based on their anxiety – impact their students and how their students approach math.

Not all students become math anxious because of their teachers. Many students develop

math anxiety because of the math itself. Math-anxious people tend to experience numeracy-related stress. Numeracy is defined as “the cognitive ability to understand mathematical concepts and work with basic probabilities” (Choi et al, 2020, p. 2). There are several types of numeracy-related stress. Two main types of numeracy-related stress include numeracy stress that directly involves math computations, and numeracy stress that does not directly involve math computations – such as a parent trying to comprehend numeric health information during their child’s routine doctor visit (Choi et al., 2020). For many students, the first time they learn algebra is when they begin to feel math anxious. Since algebra involves the use of variables, negative numbers and many new rules, feelings related to math anxiety may begin to develop (Shields, 2007). Numeracy-related stress can also impact how students perform in more demanding topics in math, such as algebra or long division, due to their reliance on working memory (Ashcraft, 2002). Ashcraft (2002) also goes on to mention that students who are math anxious are not necessarily mathematically incompetent – their math anxiety might just disguise their competence. Teachers who have students in their classroom that are math-anxious should be made aware of the impacts that a student’s math anxiety can have on their academic performance as well as their perspectives of math outside of the school environment.

Math anxiety in particular can impact students both in and out of the classroom. Regarding academics, math anxiety can have an impact on a student’s performance in math courses along with their enrollment in future math classes. Students who experience math anxiety tend to take fewer math courses in high school and in college when possible, and when they must take math courses, they tend to receive lower grades than their peers who do not experience math anxiety (Ashcraft, 2002). Additionally, students who have math anxiety tend to

focus on “getting by” in the course rather than being more involved in the math content and math-related activities in class (Shields, 2007). These impacts that occur while a student is in school can also have an effect on students outside of school. Math-anxious individuals are likely to experience math-related stress that can cause them to make worse decisions based on inaccurate interpretation when presented with numerical information (Choi et al., 2020). Reducing math anxiety can help relieve stress in those who are math anxious.

To combat math anxiety in classrooms, teachers should be open to discussing math anxiety with their students. To start, teachers can educate their students on what math anxiety is and how to recognize that students are experiencing it (Shields, 2007). If teachers are able to tell when their students are feeling math-anxious, they will be able to adjust their practice and their methods of teaching the concepts in a way that encourages students to put effort in. This also shows students that their teachers not only care about their performance in class pertaining to math, but their emotional and mental well-being as well. Some students may feel anxious because the math concepts taught in class may come across as being too difficult. One recommendation is to build in a 70% success rate to “promote perseverance because the work is perceived as challenging enough to warrant effort and easy enough to expect success” (Shields, 2007, p. 60). This can motivate students to put in effort towards their schoolwork since students are likely to believe in their ability to succeed while still feel like they are being challenged. If the math concepts that are being introduced in class come across as being too difficult for students, they are less likely to feel motivated, less likely to put in the effort, and more likely to feel math anxious (Shields, 2007).

Race

Classrooms are supposed to be environments that encourage students to learn and reach their full potential. However, not all students are given the same opportunities as others. White students are more likely to enroll in gifted programs, honors programs, and advanced placement classes than Black students (Chambers, Walpole, & Outlaw, 2016). Not all schools are created equal, either. Secondary schools with more low-income students tend to have fewer math courses available to students. This limits opportunities for students who attend these schools since they do not have access to rigorous coursework that is found in these programs and prerequisites of these programs (Chambers et al., 2016). There are general math courses that students are expected to take throughout the course of their high school career that serve as prerequisites for college enrollment. Chambers et al. (2016) found in a study that by their senior year of high school, over 33% of students in the low-income schools that participated in the study reported Algebra 2 as being their highest math class. According to Chambers et al. (2016), this is the bare minimum math requirement for entering a four-year college. Students who do not have access to higher level math classes are at a disadvantage when it comes to college enrollment and pursuing a degree.

Teachers may view their students differently in terms of race based on cultural mismatch, or differing cultures between the teacher and their students. The teachers who are teaching the students in classrooms are not representative of the varying cultural and ethnic backgrounds of the students themselves. In fact, around 90% of public school teachers are White (Howard, 2006). Teachers also may believe stereotypes that impact how they view their students. Female Black students are often perceived as being more disruptive and less attentive than girls of other

racess and ethnicities. Teachers in particular may view these students as being disruptive even when they are asking for assistance with classwork, which in turn can cause these students to be at a disadvantage for honors recommendations (Chambers et al., 2016). In the classroom environment, teachers should challenge stereotypes that can have a detrimental impact on students – even if they believe that these stereotypes appear to be “positive” at face-value.

Exposure to race stereotypes can have an impact on how students perceive their mathematical capabilities. Starting as early as second grade, children are sensitive to academic stereotypes, which include academic stereotypes relating to race (O'Connor & Wischnia, 2014). Stereotypes can be broken into two categories – explicit stereotypes, which are stereotypes that are controlled and conscious; and implicit stereotypes, which are stereotypes that are automatic and unconscious. Data based on explicit stereotypes shows that students are aware of harmful stereotypes such as the stereotypes that “Asian students are better at math than White students” or “Black students are not good at math” and even endorsed these stereotypes (O'Connor et al., 2014). On the other hand, data based on implicit stereotypes shows that children associated math more strongly with certain races than with others. For example, children tend to associate math with Asians rather than with Whites (O'Connor et al., 2014). Racial stereotypes that many people might view as being “positive” at face-value can have negative impacts on individuals of that race. Stereotypes that pinpoint students of different races as being good at math can cause students of those races to have a negative self-image pertaining to math if they feel like they are not living up to those stereotypes (O'Connor et al., 2014). This can discourage students from studying math in the future and potentially pursuing math-related careers and careers in STEM.

The people who are in math-related fields and STEM (science, technology, engineering,

and mathematics) fields do not reflect the diversity of the people in the United States. A majority of individuals in STEM fields are White, and Black and Latinx youth are less likely to pursue STEM fields than White and Asian youth (Seo et al., 2019). Underrepresentation in STEM fields is a contributing factor in why Latinx and Black youth are less likely to pursue a career in STEM. On the other hand, White youth and Asian youth are more likely to pursue a career in STEM partly because of having more representation in STEM fields (Seo et al., 2019). If individuals see their race being represented in STEM fields, then they are more likely to believe that they can pursue a career in those respective STEM fields due to personal connections to identity.

Gender

Similar to the lack of representation in math regarding race, there is also less representation in math-related fields for women. Females are less likely than males to pursue careers relating to math partly because of gender role association and their own mathematical self-concept. Mathematical self-concept refers to how someone views their math abilities in comparison to those of other genders (Sax et al., 2015). Gender differences in mathematical self-concept appear as early as elementary school and are present until college, where it then widens even further (Sax et al., 2015). Stereotypes involving gender can have many impacts on an individual's math performance, particularly the math performance of females. Starting as early as the first years of elementary school, females are aware of the concept of gender. They are already made aware of the stereotype that "men are better at math than women", which is often reinforced when young women have a math-anxious female teacher (Beilock et al, 2010). As a result, young women often end up believing this stereotype, which causes lower math

achievement and a lower math self-concept among these individuals. Even when female students are capable of meeting and exceeding expectations relating to math abilities, stereotypes can have a negative impact on their overall math performance.

Expectations and stereotypes related to gender-appropriate behavior can also influence women to participate in career-related activities that differ from the career-related activities that men are encouraged to participate in (Rowan-Kenyon et al., 2012). Since these stereotypes push the notion that women are not as good at math as men, women have a lower math self-concept than men and are less likely to choose a STEM-related major when they enroll in college (Sax et al., 2015). Female students also tend to greatly underestimate their mathematical abilities due to stereotypes and underlying math anxiety (Shields, 2007). Social cognitive career theory states that an individual's beliefs about themselves and the careers typically associated with their gender have an impact on their career decisions (Seo et al., 2019). Additionally, math is often viewed as being a "male field", whereas careers relating to humanities, such as teaching, are often considered to be feminine domains (Sax et al., 2015). Over 90% of early elementary school teachers in the United States are female (Beilock et al., 2010). These factors together heavily contribute towards why females are less likely than males to pursue math-related careers, and as a result, are not represented in math-related fields.

How is Math Taught?

The ways in which math is taught and presented to students can have a strong impact on how students view math. Many school subjects, such as history and science, are taught in a way that shows students the importance of the subject in terms of everyday applications and out-of-classroom applications. Math, on the other hand, is traditionally presented to students as extra

knowledge rather than as a tool that can benefit society and help others (Rodriguez, Romero-Canyas, Downey, Mangels, & Higgins, 2013). To change this, teachers can incorporate out-of-classroom or “real-world” examples that connect to the math concepts taught in class to show students that the concepts they are learning do have important applications. Another approach towards teaching math to students is to present math in a way that fits a person’s individual beliefs (Rodriguez et al., 2013). For example, some students may have goals for themselves that involve helping others and their community. Math can be taught in a way that shows students that math is a tool that can help the world around them, which can be shown through real-world applications. This gives students a reason to study math and also allows them to connect to the subject in a personal way, which can boost their overall math performance and change their perspectives of math-related fields.

A teacher’s attitude towards the subject that they teach can also have a significant impact on how students view this subject. A teacher who is math anxious is likely to present math-related concepts with a negative attitude and may not display as much confidence (Shields, 2007). Teachers in this position are also less likely to present math in a way that encourages students to pursue math-related careers, which impacts the development of math-related interests in students (Rowan-Kenyon et al., 2012). Science and engineering occupations are projected to grow at a much higher rate than the overall work force due to an increased demand for STEM-related jobs. Starting in the classroom, teachers should present math concepts in a way that can motivate students to explore math further while also emphasizing the benefits of learning math. (Rodriguez et al., 2013). Additionally, teachers should use positive reinforcement as a way to boost overall motivation in students. Encouragement from teachers to pursue certain tasks can

help students form positive self-efficacy beliefs, which from a math-related perspective, makes it more likely for students to develop an interest in math (Rowan-Kenyon et al., 2012). Self-efficacy refers to how one views their ability to complete a certain task (Rowan-Kenyon et al., 2012). Teachers have a tremendous impact on their students in ways that shape their students in and out of the classroom. Adjusting their attitudes towards math can help students see math in a more positive light while encouraging them to pursue any interests in math that they may have.

Gaps in Literature and Research

Although there is research discussing some of the shortcomings of math instruction, a large portion of the research being done in topics such as race, gender, and math anxiety is by individuals in the education field. These topics of research within the education field have a strong focus on classroom implications and how students' experiences in class impact their future as it relates to career choice and overall perceptions of math. Experts from math-related fields do not appear to be focusing on this topic as much as those from education-related fields. Addressing these issues in math-related fields can help to create solutions and encourage individuals to pursue math-related careers and careers in STEM.

Gender-related research strongly focuses on issues with women in math-related fields from a variety of cultural and ethnic backgrounds. However, this research fails to mention issues that minoritized men face regarding math career attainment and a desire to pursue math-related careers. Although the research suggests that men appear to be represented more in math and are more likely to pursue math-related careers than women, the research does not mention how this may be different for men who are minoritized. Overall trends show that men are more likely to

pursue math-related careers than women, and minoritized individuals are less likely to pursue math-related careers than White individuals (Seo et al., 2019).

Implications

Being aware of the factors that impact how students view math can help teachers adjust their methods of instruction to motivate students to put effort into their math coursework. Simply changing the ways in which teachers talk about math can make a tremendous impact in how students view math. Additionally, showing students the importance of math as it relates to society as a whole can inspire students to pursue careers in math-related fields. To do this, teachers can introduce new topics in math by first presenting a “real-world” problem to students and then exposing students to the concepts used to solve the problem. This frames the math that is being taught in a way that teaches students the concepts and also shows them applications of the math concepts from an out-of-classroom context.

The students that sit in classrooms across the country come from many different cultures, ethnic backgrounds, and races. Teaching is a career that involves working with all students regardless of their race and gender identity while being a mentor that inspires them to reach their full potential in and out of the classroom. Having more diversity within the teaching profession and having more culturally proficient White teachers can potentially reach to all students, including those who are minoritized. Teachers who teach a specific discipline are also in a position where they can educate their students on how their discipline makes an impact on society as a whole. Math teachers must make sure they are relaying the importance of math in terms of out-of-classroom and “real-world” contexts. Teachers must transmit this message while refraining from transmitting their own personal negative biases towards math onto their students.

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