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Math Anxiety in Female and Underrepresented Minority Students a Literature Review

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Dr. Lucietto has focused her research in engineering technology education and the understanding of engineering technology students. She teaches in an active learning style which engages and develops practical skills in the students. Currently she is exploring the performance and attributes of engineering technology students and using that knowledge to engage them in their studies.

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Therese Azevedo is a third year student at Sonoma State University pursuing a Bachelor of Science in Statistics. Over the summer she had the opportunity to work with Dr. Anne Lucietto and Meher Taleyarkhan (Graduate Student) on a project related to math anxiety focused on female and minority students. Therese has been able to continue this project with her research advisor, Dr. Natalie Hobson, at her home institution.

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Abstract

Educators have noticed that some students respond to exercises requiring mathematical calculations with numerical answers that are not correct and far from realistic. These student solutions are often given without further comment or calculation by the students and seem to be such avoidance by the students to engage with the numerical calculations. Anecdotal evidence, by these educators, suggest that such responses are more prevalent from female and underrepresented minority groups — raising the question of whether demographics play a role in a student's approach to numerical problems. Researchers have searched for existing work in this area and find that there are gaps in reports on factors that may contribute to students' decision to avoid math in their problem solving and a lack of research on how to support students who respond in these ways. Further focus on previous studies on female and underrepresented minority students is undertaken and shared through this document with the intent of sharing these findings and determine the gaps for work that may be done in this crucial area.

Introduction

The inspiration for this project originates from a professor teaching a dynamics course and noticing that students, including males, females, and minorities, responded differently and incorrectly to in-class problems involving mathematics. The answers provided seemed at times to be arbitrary due to a lack of supporting calculations or written explanation to describe the student's thought process. The answers for the problems could have been obtained through class notes, however, it was evident some of the students were avoiding the use of math to solve the problems. This observation highlighted the possibility that some of the students may have been exhibiting an anxiety related to math.

Math anxiety is a common occurrence which controls one's mindset and perception of mathematics. Additionally, this type of anxiety has the ability to impact one's confidence about their abilities in math which may result in a person believing that they are not capable of excelling in math [1].

This paper focuses on math anxiety as it occurs in the classroom. The authors would be remiss if they did not acknowledge that anxiety associated with math is not only found in the classroom but even outside of academia [2]. The scope of this paper, however, will analyze common factors which may contribute to the emergence of math anxiety for students in academia and specifically whether females and minority students are impacted differently from males and the general holistic student population.

Literature Review

Math anxiety occurs when one lacks confidence or is hesitant when using math, as also evidenced from the research study of college student's anxiety involving simple math problems. One of the biggest issues when one has math anxiety, is avoiding the subject. This avoidance then impacts one's coursework throughout their academic career. One research study conducted highlighted that many college students have anxiety when it comes to solving simple addition and subtraction problems. Within this study, the researcher noted that research participants had varying emotions when responding to given math problems ranging from sadness to happiness [1]. The goal of this study was to examine math anxiety in varying scenarios, not solely academic related. Participants of Ashcraft's [1] study had to determine whether a mathematical statement was accurate. Higher levels of math anxiety resulted in an increase of errors while lower levels of math anxiety resulted in a decrease of mistakes. Highly complicated and advanced problems for students with higher levels of math anxiety found these problems to be challenging and caused them to answer the problems faster, however, responses were off. This led the researchers to believe that memorization played a role for these students when answering the complex questions. Furthermore, they found that mistakes occurred as the addition problems increased in difficulty especially for those with math anxiety.

Moreover, the researchers also found that there was a relationship between the grades one receives as well as confidence a person has in regard to math. Females were more likely to have math anxiety than males. In addition, females were also more likely than males to have test anxiety as well [3].

This same study and others have also noted a difference when participants completed an assignment in the traditional format of paper versus an online version [1, 4]. The online version had significantly higher anxiety rates in comparison to the alternative method. Furthermore, research on community college students experiences with online versus traditional face-to-face learning was found that students preferred the face-to-face interactions, especially for courses they perceived to be difficult. For online courses students felt there was a low instructor presence and that they needed to teach the material to themselves. As such, students would prefer to take the online version for "easy" courses and traditional face-to-face for difficult courses [25]. Another study investigated student success between three different learning mediums for a math course: online, blended, and face-to-face. The online course offered all course materials to the students via course management software and never met face-to-face. The blended learning environment comprised of students having access to all course materials online as well as meeting face-to-face. The blended environment course met twice a week with one day of solely online instruction and the other a face-to-face interaction. The face-to-face course refers to the traditional class of meeting face-to-face a certain number of days a week. No online materials were used and no part of the student's grade depended upon online technology

[26]. The results of the study differed depending upon the perspective but overall the students from the blended learning environment did worse than students enrolled in the online and face-to-face courses. Further, the students from the online math course did not score as well when compared to students from the face-to-face, traditional course environment [26].

Factors Influencing Math Anxiety. Examining math anxiety is challenging because there are many factors that fuel this occurrence. Some of these factors include mindsets, structure of the math class, and female elementary teachers. The response of being afraid of math and having the need to avoid math is a general descriptor for math anxiety.

Mindset. Math anxiety from a mindset angle has strong effects. When a person holds the idea that they are incapable of achieving success in a math class, they have a “fixed” mindset about math. These students place themselves at risk of failure because they do not work towards growing in their understanding of mathematics [9]. A person’s dislike for math often occur during the beginning stages of school [9]. Moreover, one’s dislike and uncomfortableness towards math may remain with a person for many years and can lead to a lack in self-confidence by hurting one’s rationale and thoughts [4].

Possessing a fixed mindset can hinder one’s potential for math success as this mindset lacks self-reflection and embracing new ways of learning [3]. A person with a fixed mindset is likely to define themselves by their mistakes, contrasted to that of a growth mindset, which encompasses the idea that learning can take place with persistence and effort [7]. A person with a growth mindset is more likely to reattempt a problem, if a mistake occurred. According to Dweck [7], those who had a growth mindset were more mindful of the learning aspect rather than that of the grade they received [7]. Whereas, those who have a fixed mindset are apt to be afraid of failure and as such having a fixed mindset within mathematics can be problematic as math consists of trial and error when attempting a problem [3]. Research has shown that these mindsets can be shaped by educators and can be used predict whether one will perform well in math over time. Additionally, these mindsets have been shown to also influence women and minorities as it relates to math and science. However, interventions to change a mindset has been shown to help increase one’s ability to grasp math and science topics [7].

Parental Influences. Parents’ beliefs also impact how their child sees themselves within math [16]. Specifically, parental beliefs and expectations were shown to influence children’s attitudes and performance involving math [10]. When these beliefs are presented to children from a young age it can have a significant affect upon the attitudes of children and intercept any future pursuits towards a mathematical field of study. Additionally, it as been shown that when a parent encourages their child in math, the student’s grades were much higher when the student had parents who were encouraging

in their pursuit in math. Likewise, if a parent has a favorable view toward math and science, the student is much more likely to pursue a major and subsequent career in a math or science field [21].

Parental influences of culture may also play a role in a student's beliefs and acceptance of math. Students, especially of minority ethnicities and low-income families, may have connections between a student's view of math stemming from a young age and of which any negative stigmas developed from a young age may stay with the student throughout their maturation [19]. This ties into the influence of how parental support, or lack thereof, impacts a child's view of math from a young age and guides their decisionmaking when choosing a college major and subsequent career based on whether math is involved.

Structure of Math Courses. The structuring of a math class may also hinder one's success in learning and performing math problems. For example, timed tests and the pressure brought on with timed testing, may cause students to negatively label themselves within math [9]. Some math courses utilize timed tests and reward students who answer a certain amount of questions within a certain timeframe. The students who answered the questions within the time frame were given a star next to their name. If a student did not finish in time, they had to retake the test until they earned a star. By the end of the school year students could see publicly who had more stars than another. Methods such as these promote a feeling of inadequacy for those who had less stars which then leads to stress preceding a math test and an overall dislike towards math [9].

Furthermore, it was found that females have a higher chance of comparing their test scores with one another, which can then increase their math anxiety [9]. An additional study found that female's performance and willingness to compete is sensitive to the gender a female is competing with [22]. When competing with other females, especially when measuring one's math ability, females are more comfortable competing among one another. However, when competing while competing a task that measures one's math ability, females scored lower when competing with a both males and females, but not all-female groups. This occurrence may be due to many factors, however a female's schools environment and climate does play a significant role in how a female may perceive math [22].

Another aspect of the structure of math courses that may induce anxiety is if math is portrayed as a tool that has a foundation of memorization. When faced with this viewpoint, students may begin to lose interest in math since there is a lack of active learning being implemented in the classroom [9]. Additionally, relying on memorization for success in a math class can lead to higher levels of math anxiety [9]. When a student memorizes a mathematical concept without understanding it and when combined an

already predisposed anxiety towards math, causes the student to forget what they memorized [23]. This then leads to stress which then further cultivates a student's dislike for math.

Female Elementary Teachers. When students are introduced to mathematics in elementary school, their teachers may not have a lot of academic training in math since pursuing an elementary education usually does not require many math classes [4]. Furthermore, many of those teachers within elementary education have math anxiety themselves [4]. As such, there is a potential domino effect between female teachers and female students when the educator is not an advocate for math. As a result, female students may begin to develop the idea that they are not ideal candidates for understanding or pursuing a future with math [9].

Math Instructors. Teachers have the ability to impact how their students perceive math, though not all teachers are adequately prepared to teach math [13]. When a teacher possesses a fear of math, a student is then at risk for developing the same feeling [5] [13]. Additionally, if a teacher teaches math poorly it fuels a student's propensity towards math anxiety [5] [13].

Teachers play a critical role in students' lives as they help determine their students' future. Teachers have the ability to deter students away from STEM related classes often impacting females the most [15] [13]. According to one study from 1984, advisors from a high school negatively impacted female student's decision towards STEM classes [14] [13].

There has been much research that demonstrates poor results on math related material which occurs due to a negative mindset towards math. When a person is anxious towards math, they may try to escape it, creating math avoidance. According to research by Turner and team (2002), even if the situation is not math related, it was found that when a teacher, who was inhospitable towards the students, the students reacted by not being engaged with the instructor [18] [2]. This then revealed how strong of an impact educators have on students. Math anxiety also has the ability to harm one's thinking towards a math problem [2]. In addition, math anxiety is more common for those within fields that do not involve math [2]. Moreover, a teacher's reactions to students utilizing math plays a strong role as to how a student perceives math [20] [13].

Females and Math Anxiety. The environment of a math class is shaped by gender as seen in the study completed by Campbell and Evan, in 1997, since they observed that math anxiety decreased when only females were present [6] [13]. On the other hand, math anxiety was

lowered for males when they were in an all gender inclusive space. Hence, math anxiety may look different for different genders [13].

Haynes, Mullins, and Stein conducted a study focused on math anxiety among males and females [13]. From their study, they observed math anxiety occurred for different factors in regard to the genders analyzed. And furthermore, up until preteen age for females, females are expected to perform better than males mathematically [13].

Underrepresented Students. Underrepresented minority students such as students of Black, Hispanic, Native American, etc. groups were researched as to whether these particular ethnicities were prone to developing anxieties related to math. A study predicting math achievement when considering race, gender, socioeconomic status found that racial and socioeconomic gaps in math achievement [27].

The researchers found several research studies on minority students, notably that of Black and Hispanic students. The research takes place over varying levels of schooling ranging from early schooling to college level and the majority have shown that when compared to White students, Black students scored lower on math related concepts questions [11]. The research for Hispanic students is not as numerous as that for Black and the research that is there is not very insightful into whether Hispanic students score differently than the predominant White students in regards to math concepts [12].

Researcher Uri Treisman lead a study on underrepresented students who enrolled in calculus classes at UC Berkeley with the goal of inquiring into to the students' thought process towards calculus [17]. The researcher further discussed experiences teaching calculus at UC Berkeley and aiming to be a well-liked instructor. From the beginning the students' viewpoint of the calculus course was not favorable as they viewed the course as a requirement rather than a class for enjoyment and coupled with the added concern for the exams.

The research study resulted in Treisman [17] requesting the teaching assistant to interview the students from various grades in the class. From their interviews, they found that those who had an underrepresented identity were the ones who were doing the worst in the class. After looking at past data from UC Berkeley, they discovered that less than a handful of minority students performed above average in a calculus class.

In this same study, Treisman [17] also noted that one's drive and willingness may be a determinant of academic success. Additionally, students' academics before college can impact how well they do during college as past stigmas may have stayed with the students [17].

The structuring of STEM classes also has bearing on the matter. A common thread in a math class is that the concepts build upon each other, requiring students to pass each topic before advancing to the next [17]. Family, environment, and income are other components that affect student's views towards math. For instance, there can be a disconnect among the family and student if no one has attended college prior to the student [17].

Black and Chinese Students. Treisman and his team focused on Black and Chinese students who studied and prepared for his math class. Motivation was not an issue for the Black students as they got themselves to UC Berkeley. Some students had a high SAT score but may have done poorly in high school [17]. Additionally, parents had the desire for their child to attend college [17]. When it came to the analysis of how the Black students studied math, the researchers noted that they were independent, attended class, did the homework, and studied [17]. With the Chinese students, there was a mixture of working by themselves and working together [17]. A sense of community was established where they helped one another out [17]. Treisman integrated a “workshop” related class with some of the math classes at UC Berkeley [17]. This helped create a community for students. He was able to make a difference within these students lives as he saw an increase in scores and students taking STEM related classes after that experience [17].

Conclusions

After searching for work in the area of math anxiety these researchers identified a number of gaps in the existing work. Most studies focus on research completed in the formal learning environment, most often in the younger grades K-6. While most studies find that individuals believe they will not do well in a subject, generally do not. This is also true of mathematics, and sometimes more so than many other subjects. This affliction is also known to linger and become a root cause of a lack of self-confidence, which then leads to influencing one's success in the subject, such as in this case mathematics.

Existing studies provide a basis for how a lack of self confidence in math, which is sometimes attributed to family or parental influences. Children when exposed to a belief or feeling by someone they respect, often results in a significant impression on the individual. Cultural issues, impact of teachers, math course structure and delivery all are factors in how a student responds to a subject or particular item in their environment. In the case of math, it is often noted that students are impacted by a variety of negative stereotypes and thus develop an aversion to math.

Unfortunately, females and underrepresented minority students are found to enjoy math until something happens to negatively impact their interaction with the subject. Later in their studies,

more specifically in high school, males generally out perform females. White students, as well as those exposed to a positive math environment, are those that do well in math.

Overall the literature shows that math anxiety is rooted in one's experiences and interactions with those that they interact and share experiences with. To encourage these students to pursue subjects often associated with mathematics, involves changing or influencing those stereotypes positively towards mathematics. Further research in ingraining a positive attitude towards mathematics is required prior to making any changes or recommendations on how to deal with the negative stereotypes and further influence those underrepresented in STEM due to these issues.

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