Influences of Math Anxiety on Undergraduate Students

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Abstract

The purpose of this study was to examine the effects of sex, major, and school on undergraduate students' levels of math anxiety and math performance. First, the participants completed a math experience questionnaire designed to compute their level of math anxiety. In the questionnaire, participants answered demographic information including their sex and primary major. After completing the questionnaire, participants were given three separate one minute math tests that consisted of basic equations. The first test completed was exclusively addition questions, the second was exclusively subtraction, and the final test was exclusively multiplication. After collecting data from undergraduate students who attend either Ripon College or Johns Hopkins University, two separate 2 x 2 x 5 factorial analyses of variance (ANOVAS) were completed, along with Pearson Correlations. The results showed that the math anxiety level of math majors is significantly lower than natural science majors, social science majors, and humanities majors. However, after analyzing the data concerning the math performance, it was found that there was no significant difference in the scores from each major cluster. Lastly, it was found that a significant negative correlation exists between the level of math anxiety of an individual and his or her math performance score.

Keywords: math anxiety, math fluency, cognitive dissonance, major clusters, undergraduate students

Influences of Math Anxiety on Undergraduate Students

Math anxiety is the feeling of fear, apprehension, or dread that many people experience when they are in situations that require solving math problems (Hembree, 1990). If a person has math anxiety, it can threaten both their achievement and participation in math (Helal, Hamza, & Hagstrom, 2011). In addition, math anxiety can occur in situations not involving math tests. Some people encounter math anxiety when they calculate a tip at a restaurant, or when they just have to look at numbers or statistics (Hembree, 1990). Therefore, math anxiety can have an impact on the type of majors undergraduate students choose to pursue. Since math anxiety can be very influential in a college student's life, we chose to conduct a study that examines the effects of sex, major, and school on undergraduate students' levels of math anxiety and math performance.

Helal et al. (2011) demonstrated that numerous students who receive high grades in English, science, and social studies, struggle in their math classes because of math anxiety. Hence, the math anxiety of these college students is affecting their math participation, and their options regarding careers are reduced (Helal et al., 2011). As a result of math anxiety, students are choosing majors where they can avoid math. Thus, any careers involving math are not an option for these students (Helal et al., 2011). This is especially true for females because it has been shown that females display higher levels of math anxiety, particularly in college (Hembree, 1990). Math and science majors have demonstrated the lowest levels of math anxiety, and students preparing to teach in elementary schools seem to have the highest levels (Hembree, 1990). Also, Hembree (1990) discovered that higher achievement coincides with reduction in math anxiety, but treatment can restore the performance of formerly high anxious students to the level of their low math anxious peers. Therefore, we want to examine if these results are occurring with undergraduate students from Ripon College and Johns Hopkins University. If we find that math anxiety seems to be affecting the type of major students are choosing, then elementary and middle school education systems may need to take additional steps to assist their students with their math anxiety. Eliminating math anxiety in elementary school could prevent college students from avoiding classes and majors with math content.

Math anxiety does not only influence college students' career choices, it also has a profound impact on their daily lives (Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016). Since it is an emotional response to numbers and other math related situations, the math performance of the students is usually disrupted (Suárez-Pellicioni et al., 2016). However, math anxiety is not recognized in the Diagnostic and Statistical Manual of Mental Disorders 5 even though there have been suggestions that in contrast to other subjects taught through formal education, math appears to evoke enough difficulty to be considered a genuine phobia (Suárez-Pellicioni et al., 2016). Also, there has been a lack of research attempting to investigate the emotional problems associated with math problem solving especially in college students (Suárez-Pellicioni et al., 2016). This should be more prevalent because math anxiety can have an impact on professional development, employment opportunities, and even salary prospects of students and workers who suffer from it. Suárez-Pellicioni et al. (2016) emphasizes the importance of research that reveals the effects of math anxiety. Our research on the math anxiety levels of Ripon College and Johns Hopkins University students is important because it will add to the limited research that has been done on math anxiety.

Furthermore, the emotional problems that occur because of math anxiety are sometimes eliminated when students evade situations involving math (Hembree, 1990). This is connected to cognitive dissonance which refers to a situation in which an individual has inconsistent beliefs or attitudes (Festinger, 1957). These cognitions result in the desire to avoid whatever is creating the feeling of uneasiness (Levy, 2010). Our study looked at how students avoid math anxiety by actively seeking out majors in which less math is required.

Scott-Kakures (2009) demonstrates that a student's cognitions about math may be unfitting or inconsistent which leads to an "uncomfortable" psychological state. This state results in the desire of finding a dissonance-reducing strategy, and it brings about action intended to reduce or eliminate dissonance. Thus, math anxious individuals may avoid situations that involve math at all costs. Finally, after the activity or thought is complete, it results in a reduction in dissonance. Therefore, after a person evades the math situation, he or she feels much better. McKimmie (2015) argues that dissonance can be reduced by adding a separate cognition, which has a reverse effect and increases consonance to a particular activity. When being faced with problems in mathematics, it is somewhat the norm to have anxiety. Because of this anxiety, students find ways of avoiding these situations, often by selecting courses in different subjects.

When students avoid situations involving math and choose majors with less math content, they encounter the global avoidance effect (Faust, Ashcraft, & Fleck, 1996). This effect develops when a student enrolls in fewer math courses or selects college majors that involve less numbers and statistics. Consequently, those individuals become less well-trained in math, less knowledgeable about math, and have a harder time in situations involving math (Faust et al., 1996). The cognitive dissonance theory claims that these students will exert minimal effort if presented with a situation involving math, and they will try to leave the math situation as soon as possible. This relates to the local avoidance effect which results from people having a desire to complete a math task as soon as they can and leave the uncomfortable situation as soon as possible (Faust et al., 1996). Our study aims to find out which groups of students, based on their academic major, are suffering from the global and local avoidance effects. According to the cognitive dissonance theory, these students are the ones who would be most likely to avoid taking mathematics courses.

In addition to the relationship between math anxiety and math avoidance shown by the cognitive dissonance theory, a study by Faust et al. (1996) concluded that a relationship between math anxiety and numerical cognition exists. In the study, four groups were formed according to the students' level of math anxiety. The four groups were very high math, high math, low math, and very low math anxious individuals. Then, the authors manipulated the complexity of the task by having four different stimuli: two simple sets that included single digit addition and multiplication, and two complex sets that included two digit additions and mixed arithmetic operations. The authors discovered that only the complex addition and multiplication problems elicited the effects of math anxiety. Therefore, they proposed the anxiety-complexity effect which states that there is a deterioration in high math anxiety individuals' performance only when the stimulus conditions become more difficult or complex (Faust et al., 1996). This could explain why less people experience math anxiety when they are doing everyday math tasks like calculating a tip at a restaurant. There is a low level of math difficulty in that task, so the anxiety is not shown. This is critical because it could explain why a person gets very nervous before taking a difficult calculus exam, but that same person can complete addition and subtraction problem with no effects of anxiety.

In addition, the anxiety-complexity effect could be demonstrated when children complete the math section in standardized tests (Jameson, 2014). In an attempt to uncover why United States children score so poorly compared to the rest of the world on standardized math tests, Jameson (2014) examined the highest predictors of math anxiety. One's self-concept was shown to be the strongest predictor in producing math anxiety. Self concept is the students' perceptions of their own abilities resulting from their own beliefs or the reactions of others. Other factors that had minimal impact were self-efficacy, which is the belief in their ability to succeed, and parental attitudes toward mathematics. The argument is made that when placed in a social situation, such as math activities, students who feel their skills are inadequate experience higher levels of anxiety due to social pressures. The students in our study may feel that their math skills are below average; therefore, that could increase their math anxiety and affect their score. The parents of our participants could also influence our participants' math anxiety. Jameson (2014) indicated a strong positive correlation between students' math anxiety and parental math anxiety.

As displayed by Jameson (2014), the parents' math anxiety is not the only environmental factor that has an impact on the students' math anxiety. The teachers are also very important in the development of students' math anxiety (Bekdemir, 2010). If elementary teachers have had bad experiences in math classes and they try to teach math to students, there can be a negative effect. For example, preservice teachers with the lowest degree of math anxiety had the highest levels of math teacher efficacy (Bekdemir, 2010). This is because the teacher is not conveying any anxiety that could transfer to the students. In addition, these teachers with low levels of math anxiety may have a better understanding of the math content; therefore, the students have an easier time learning the information. Also, Suárez-Pellicioni et al. (2016) demonstrated that a high math anxious teacher can have a negative influence on girls who have a traditional idea of gender abilities. Thus, if a girl believes that the man should be the head of the household and make the money, and the woman should stay at home and take care of the children, then anxious teachers have more of an influence on her. In addition, Suárez-Pellicioni et al. noted that the more anxious the female teachers were about math, the harder time girls with high levels of math anxiety had at performing well in math. Clearly, in our study, the math anxiety levels of the teachers of our participants may have a major influence. If our participants' teachers are females and anxious about math, then our female participants may have a higher chance of being math anxious.

As Suárez-Pellicioni et al. (2016) emphasized, teachers can have a major impact on the math anxiety of their students. A different study by Beilock, Gunderson, Ramirez, & Levine (2010) again focused on female teachers and how their anxiety regarding math carried over to, and impacted, their female math students. Comparisons were done at the beginning and end of the school year in elementary schools, where around 90 percent of teachers are female. When the first test was done, there was no relationship between the teachers' math anxiety and her female students' success in mathematics. However, as the school year progressed and came to an end, a relationship emerged between the anxiety of the teacher toward math and the achievement of the female students in the subject. The authors explained that the more anxious the teacher was about math, the more likely the female students were willing to accept the stereotype of males being better at math than females (Beilock et al., 2010). This is similar to the ideas of Suárez-Pellicioni et al. (2016) in the sense that educators are a large part of the environment that can possibly lead to higher or lower levels of math anxiety. Therefore, the math anxiety levels of the female educators who taught the students in our study may have had an impact on the current math anxiety levels of those students.

Negative environmental math experiences from teachers are not the only factor involved in the development of math anxiety. Wang et al. (2014) showed that genetic factors account for roughly 40 percent of the variation in math anxiety. The research assessed twins beginning in kindergarten or first grade and continued for a maximum of eight home visits. The levels of math anxiety were measured using the Revised Mathematics Anxiety Rating Scale of Elementary Students (MARS-E). The results indicated that the development of math anxiety involves genetic risks related to both general anxiety and math cognition. Additionally, independent genetic influences associated with math-based problem solving also have an impact (Wang et al., 2014). This demonstrates that some individuals do not have control of their level of math anxiety. They may be born with some math anxiety, but environmental factors like the parental educational expectation toward each child, unique parent child relationships, and the different quality of math education experienced in math classes could increase their math anxiety levels (Wang et al., 2014). These increased anxiety levels toward the subject could result in avoiding math classes in the future. If these students pursue academic courses and fields that require fewer math courses, then they are following the cognitive dissonance theory by taking action to avoid the negative cognitions caused by math. These genetic factors could have an influence on some of the participants in our study; however, we do not have the resources to test genetic components.

Moreover, another aspect to the genetic makeup of math anxiety is the undergraduate students' biological sex. Devine, Fawcett, Szucs, and Dowker (2012) show that there are no differences in math performance between males and females in middle school. However, they discovered that females have higher levels of both math anxiety and test anxiety. A negative correlation was found between math anxiety and math performance. The argument is made that math anxiety correlates to lower math performance in future years, thus researching methods of reduction are worthwhile. Devine et al. (2012) argue that given the lack of difference in math performance by sex, higher levels of math anxiety in females shows that females have greater potential than males in mathematics. Since math anxiety is correlated with lower performance, if females were to reduce or eliminate their anxiety, there is a chance that their performance would be higher than that of males. However, the cognitive dissonance theory predicts females will avoid situations involving math in the future because of their current high levels of math anxiety. If females continue to avoid math situations, they may never reach their full math potential. Our study examined the females of Ripon College and Johns Hopkins University to see if their math anxiety levels were significantly different than the males.

Even though Devine et al. (2012) demonstrates that there is no difference in math performance scores between men and women, women are still severely underrepresented in fields requiring high levels of math and science such as technology and engineering. Seligman (2007) revealed that there are 20 males for every female in engineering fields (Seligman, 2007). This underrepresentation of women in these areas of work are likely due more to the math anxiety level, rather than the math performance level. This is also evident in countries outside the United States. Stoet, Bailey, Moore, and Geary (2016) looked at math anxiety and math performance in comparison to sex differences across different countries. When comparing levels of math anxiety between genders, it was found females have higher levels of math anxiety regardless of the country's standard of living (Stoet et al., 2016). There was a significant difference in math anxiety found between adolescent boys and girls in the numerous countries they observed. In a smaller set of countries, parents of females placed less emphasis on mathematics than parents of males (Stoet et al., 2016). We hypothesized that females would have higher levels of math anxiety than males; these higher levels of anxiety could be the result of a lack of emphasis on mathematics from parents during childhood. In addition, the number of male and female participants in the different major clusters in our study was likely to be unevenly distributed. Seligman (2007) demonstrated this by showing that math and natural science majors are usually male dominated.

Females' reduced interest in math seems to start in elementary school because Cvencek, Meltzoff, & Greenwald (2011) indicated that elementary aged girls showed lower levels of self-identification with mathematics than boys did. This suggests the stereotype of boys being better at math than girls develops at an early age (Cvencek, et al., 2011). In elementary school, students are more likely to conform to beliefs held by authority figures. Because of this, female teachers with anxiety toward math could lead female students to having less success and more negative attitudes toward mathematics. Boys being better at math and girls being better at English are common stereotypes involving males and females at lower levels of schooling (Cvencek, et al., 2011). If these beliefs are accepted as given and not challenged when students are young, it can lead to gender inequalities in schools and eventually the workforce. Thus, girls showing lower levels of self-identification with math than boys, could have an influence on the majors that the girls eventually choose (Cvencek, et al., 2011). This is important because at Ripon College and Johns Hopkins there might be more girls in the humanities and social science majors and more boys in the math and natural science majors.

In addition to the research on elementary students done by Cvencek et al. (2011), Gierl and Bisanz (1995) studied how students in grades three and six view math. This study was able to look at the differences between children's levels of math anxiety, and it was indicated that there are two main areas of math anxiety in children. The first is in regard to taking the mathematics test in itself. The second form of anxiety is the worry from children that their math skills are not at a high enough level. The latter could lead these students to avoid math classes in future years, which is problematic because these thoughts were found to exist in students as young as nine years old (Gierl & Bisanz, 1995). This is important because the cognitive dissonance that pushes students into choosing certain majors can be traced back all the way to their time in elementary school. Therefore, implementing after school math programs when students are in elementary or middle school could help alleviate some of the math anxiety symptoms (Gierl & Bisanz, 1995). This could lead to students having less math anxiety in high school and college; hence, the majors the students choose will not be influenced by math anxiety.

Similar to Gierl and Bisanz (1995) who researched the two main areas of math anxiety in children, Wigfield and Meece (1988) examined how the math anxiety of third and sixth grade students is correlated with their attitudes toward math. To investigate one's attitude toward math, six different categories were looked at: usefulness of math, intrinsic value, worry, confidence in ability, believed parent mathematical values, and attitude toward success. It was demonstrated that the importance placed on math by the elementary students is positively related to the amount of effort put forth in the subject (Wigfield & Meece, 1988). In addition, in third grade, confidence, enjoyment of math, and positive attitudes toward being successful were all related to math anxiety. In sixth grade, it was found that worry was the only significant category contributing to math and problem solving anxiety (Wigfield & Meece, 1988). This shows that in sixth grade, math anxiety likely comes from the worry of solving problems incorrectly rather than a lack of confidence, usefulness of math, or attitude toward success. These different attitudes toward math could also impact college students' math anxiety levels. There are very few studies who focus on this aspect in older students; therefore, we would like to put more of an emphasis on this in future research.

Although the levels of math anxiety in elementary school students is very important, the impact that math anxiety has on college students can sometimes be seen for the rest of the students' adult lives (Helal et al., 2011). Research has found that it extends to the career choices because being scared of math influences the majors that college students choose (Hembree, 1990). For example, a student may have all the tools to be a great chemist, but his or her math anxiety may influence the decision on whether to major in chemistry. Instead of majoring in chemistry, this particular student may major in English where he or she can avoid math. However, the chemistry department may have just lost one of their top students because of math anxiety that could have been dealt with. Also, it has been shown that math and science majors are predictably low in math anxiety, and the highest levels of the construct have occurred in students preparing to teach in elementary school (Hembree, 1990). For our study, we expected the math and natural science majors to have lower levels of math anxiety than the social science and humanities majors.

However, a study by Helal et al. (2011) has disputed some of these data and indicated that college students explicit math anxiety scores are not significantly different among majors. This conclusion is different than a lot of past research done in this area, which often concurs with the cognitive dissonance theory. In the study, Helal et al. suggested that the lack of difference between the four areas of majors (hard sciences, social sciences, health sciences, and fine arts) may be explained by the number of students in each major who participated in the experiment. In their research, only 15% of the participants were fine arts or social science majors. This could have definitely skewed the data because the vast majority of students in the study were hard science and health science majors. Students in those two majors may already have adequate math skills and less math anxiety. In order to combat this in our research, we attempted to have more balance across our major cluster groups.

Furthermore, research by Sizoo, Jozkowsia, Malhotra, and Shapero (2008) disagrees with the conclusion that math anxiety scores are not significantly different among majors. They demonstrated that many business students express that they have difficulty in their finance classes because of the amount of coursework in finance that deals with numbers. This study investigated possibility of finance anxiety in these business majors. Finance anxiety is very similar to math anxiety, and the math related material in these classes have created anxiety in these students which can impede their learning and performance (Sizoo et al., 2008). To measure finance anxiety, Sizoo et al. (2008) used a 25 item Revised Mathematics Anxiety Rating Scale as their template. The participants of the study were a convenience sample because the students were easily accessible to the authors and not randomly selected. The study showed that there was only significantly high finance anxiety in undergraduate students under the age of 25 and low finance anxiety in graduate students over the age of 25. The faculty familiar with the students concluded that in general, the graduate students over the age of 25 came back to school rusty in their quantitative skills; however, they have learned over time that they can get through tough situations and thus have high self efficacy scores. These high self efficacy scores may have helped with making their finance anxiety much lower than the undergraduate students under the age of 25 (Sizoo et al., 2008).

However, a different article by Jameson and Fusco (2014) showed that traditional aged undergraduates do not have different levels of math anxiety than adult learners. Jameson and Fusco concluded that students who are older than traditional undergraduates have a lower level of math self-efficacy. This is the opposite of what Sizoo et al. (2008) concluded, so there is still some debate on the levels of math anxiety for undergraduate students compared to older adult learners. In our study, we specifically looked at undergraduate students under the age of 25; therefore, we agree with Sizoo et al. (2008) that the business majors, who are in the social science major cluster, would have higher levels of math anxiety than the math majors or natural science majors. We believe that the amount of math business majors are required to use in their finance classes will have an influence on their math anxiety.

Business students are not the only undergraduates who have trouble with the numeracy aspect of some courses. Psychology, nursing, and medicine are also other degrees that require students to attain a level of numerical competence for graduation (Thompson, Wylie, Mulhern, & Hanna, 2015). Some of the students from these majors extremely dislike the math elements of their courses, which can influence how they perform. Thompson et al. (2015) wanted to identify what factors most strongly predict performance in these particular courses. Undergraduates from these three majors were given measures of numeracy performance, math anxiety, math attitude, and various demographic and educational variables. The results showed that math anxiety was the strongest predictor of poor performance in both psychology and nursing students. However, for medical students, the motivational factor was much more influential than any of the other components (Thompson et al., 2015). Past research has shown that students in science and especially students who are looking to go on to medical school, like medicine majors, usually have low levels of math anxiety (Hembree, 1990). Yet, some students in those majors may develop poor math scores because their particular field does not require high amounts of math; therefore, the students have a lack of ambition and experience in the subject. In our study, we have to take into account that the scores of the natural science majors may be affected by lack of ambition or lack of experience in math instead of math anxiety.

However, unlike medicine majors who go into math classes with very little math anxiety, most social work majors have an immense problem dealing with the effects of math anxiety (Royse & Rompf, 1992). This study analyzed the math anxiety and math backgrounds of undergraduate social work majors and non-social work majors. The authors used a 24-item Mathematics Anxiety Ratings Scale-revised (MARS-R) to observe the math anxiety of the students. It was discovered that there was a significant difference in math anxiety scores of social work majors and a cross section of students enrolled in classes that were not connected with social work. The authors hypothesized that the reason for this could be that the social work majors have taken fewer math courses, have more "bad experiences" in math courses, and have greater use of tutors than non-social work majors. Yet, their evidence showed that none of those factors were significantly different from the social work majors to the comparison group (Royse

& Rompf, 1992). The authors were perplexed by the finding that none of the hypothesized reasons were significant in causing math anxiety, but there could be other reasons for the math anxiety of the social work majors such as genetics or environmental factors. As previously shown by Wang et al. (2014), genetic factors account for roughly 40 percent of the variation in math anxiety, and that is something that Royse and Rompf (1992) did not take into account. Additionally, the environmental influences of parent and teacher attitudes toward math may also account for the perplexing findings.

Given the importance of math skills in a variety of situations including in the classroom, in the workplace, and in everyday life, it is important to realize which majors and sex are typically associated with higher levels of math anxiety. Our research looked into this through the use of a math experience questionnaire and a math performance test to measure participants' math anxiety and performance. It is hypothesized that females will have significantly higher levels of math anxiety than males. Similarly, we hypothesized that students with majors in social sciences and humanities will have significantly higher levels of math anxiety than students who fall into the natural science and math major categories. Finally, we hypothesize that students who attend Johns Hopkins University will have higher levels of math anxiety than students who attend Ripon College. The reason for this hypothesis is the pride that liberal arts schools, like Ripon, have in developing well-rounded students. The admission counselors sell this to prospective students, and emphasize the importance of students having the opportunity to complete a number of classes within several different major clusters during their time at Ripon. Lastly, for all the hypotheses mentioned, it is predicted that there will be a negative correlation between math anxiety and math performance.

Method

Participants

In this study, we used students from Ripon College and Johns Hopkins University. We had five different major clusters from each school. The different major clusters were humanities majors, natural science majors, social science majors, math majors, and undeclared. Majors placed in humanities category were English, philosophy, religion, literature, musicology, and art. The natural science cluster consisted of biology, chemistry, physics, earth science, astronomy, exercise science, and psychobiology. The social science cluster was all students with majors in anthropology, economics, cultural studies, environmental studies, linguistics, military science, political science, sociology, and psychology. The participants at Johns Hopkins consisted of 75 individuals, 52 of which are majoring in natural science, 7 math majors, 8 social science majors, 8 humanities majors, and 0 undeclared. The participants at Ripon College consisted of 70 individuals, in which 35 were males and 35 were females. Of the participants from Ripon College, 24 were included in the natural science cluster, 4 were math majors, 21 were social science majors, 14 were humanities, and 7 were undeclared. All participants involved in the study were treated in accordance with the “Ethical Principles of Psychologists and Code of Conduct” (American Psychological Association, 2002).

Materials and Procedure

The participants were given a questionnaire and each participant, who was tested individually, had an unlimited amount of time to complete the assessment. In the questionnaire, there was a series of situations, some of which related to math activities and some of which did not (see Appendix). For each, the participants were told to imagine themselves in the situation and then circle the number corresponding to how anxious this situation made them feel. A score of 1 means “not at all anxious” and a score of 5 means “very anxious.”

After the math anxiety questionnaire, the students then took a math performance assessment (see Appendix). The short math performance assessment was from the math fluency section of the Wechsler Individual Achievement Test (WIAT) (Treloar, 1994). The math fluency portion of the WIAT examined the number of problems the student can answer within a 60 second time limit. There were three different 60 second intervals where the students took an addition portion, a subtraction portion, and a multiplication portion. The students were tested on their speed and accuracy. After the participants finished the two assessments, we explained to them that we were doing a study that looked at the different math anxiety and math performance levels of students in different major clusters from Ripon College and Johns Hopkins University.

Results

Math Anxiety Scores

In this study, we wanted to look at the effects of sex, type of school, and major cluster on math anxiety scores. We ran a 2 x 2 x 5 factorial analysis of variance (ANOVA) with 145 participants consisting of 73 female participants and 72 male participants. Of the three main effects, only the effect of major cluster was statistically significant for math anxiety scores, $F(4, 129) = 3.678$, $p = .007$, $\eta^2 = .102$ with an observed power of .871. After completion of a Bonferroni post hoc, it was discovered that math majors (*M* = 9.25, *SD* = 15.898) had a significantly lower math anxiety score than the humanities majors (*M* = 32.09, *SD* = 18.434), $p < .000$, natural science majors (*M* = 25.18, *SD* = 16.250), $p = .005$, and social science majors (*M* = 26.45, *SD* = 16.809), $p = .019$ (see Figure 1). However, the math majors did not have a significantly lower math anxiety score than the undeclared majors ($M = 12$, $SD = 19.183$), $p >$ .05. Also, the undeclared majors had significantly lower anxiety scores than the humanities majors. That was the last Bonferroni post hoc that showed significance. The other main effects of sex and school were both not significant as shown in Table 5. In addition, as shown in Table 5, there were no significant interactions between sex and major cluster, sex and school, major cluster and school, or sex, major cluster, and school. Finally, there are no significant differences between the descriptive statistics of sex and major cluster (see Table 6), school and major (see Table 7), and school and sex (see Table 8).

Math Performance Scores

For the math performance scores, we again looked at sex, type of school, and major cluster. We ran a 2 x 2 x 5 factorial ANOVA and found that the main effects of sex, major cluster, and school were all not significant as shown in Table 1. The interaction between sex and school ($F(1, 129) = 3.986$, $p = .048$, $\eta^2 = .030$, with an observed power of .509) was statistically significant. It was shown that the females from Johns Hopkins University ($M = 110.329$, $SD = 3.312$) had a significantly higher math performance score than the females from Ripon College ($M = 100.055$, $SD = 3.344$), $p < .031$, $\eta^2 = .360$ with an observed power of .582. The other interactions of sex and major cluster, major cluster and school, and sex, major cluster, and school were not significant as shown in Table 1. Also, there were no significant differences between the descriptive statistics of sex and major (see Table 2) and school and major (see Table 3). Lastly, the non significant descriptive statistics between school and sex are shown in Table 4.

Pearson Correlation

Multiple Pearson correlation coefficients were computed to assess the relationship between the math anxiety scores and the math performance scores of the participants. When the participants from both schools were observed, there was a significant negative correlation between the two variables, $r(143) = -.320$, $p < .000$. Similarly, when only Ripon College students were examined, there was again a significant negative correlation between the two variables, $r(68) = -.456$, $p < .000$. However, when only Johns Hopkins University students were inspected, there was still a negative correlation, but the results were not significant, $r(73) = -.161$, $p = .169$. Figure 2 demonstrates the negative correlation between math anxiety scores and math performance scores. An increase in math anxiety was correlated with a decrease in math performance scores.

Discussion

Our first hypothesis that students with majors in social sciences and humanities will have significantly higher levels of math anxiety than students who fall into the natural science and math major categories was partially supported. The math majors had significantly lower math anxiety scores than the other major clusters except individuals who were undeclared. However, the natural science majors had very similar math anxiety scores to social science and humanities majors. These results coincide with the findings of Hembree (1990) which emphasized that the type of major college students pursue impacts their level of math anxiety. Yet, Hembree goes on to demonstrate that natural science majors also have lower levels of math anxiety than humanities and social science majors. Our study does not support this claim. We believe this could be a result of the abundance of natural science majors that participated in the study. Of the 145 participants, 74 were natural science majors. Also, the number of individuals in each major cluster may have an influence on why the math majors' math anxiety is not significantly different than the undeclared individuals. There were only seven people in the undeclared group, and they were all from Ripon College. If the major clusters had a more even distribution, the results could align more with the findings of Hembree.

The problem of having uneven groups in the different major clusters also occurred in the research by Helal et al. (2011). They concluded that college students' math anxiety scores are not significantly different among majors, but it was noted that less than 15% of the participants were fine arts or social science majors. This dilemma seems to transpire rather frequently in studies involving major clusters. In the future, we would try to talk to professors who teach classes in humanities, social sciences, and math and see if we could ask the students in their classes if they would like to participate in our study.

However, even with the uneven distribution of participants in the different major clusters, we found that social science majors have lower levels of math anxiety than math majors. This aligns with the research from Sizoo et al. (2008) and Royse and Rompf (1992) who demonstrated that business majors and social work majors have high levels of math anxiety. First, Sizoo et al. (2008) showed that many business students express that they have difficulty in their finance classes because of the amount of coursework in finance that deals with numbers. The business majors in our study, who are in the social science major cluster, had significantly higher levels of math anxiety than the math majors. However, our study did not show that their math performance scores suffered because of the anxiety. Math majors and business majors had very similar math performance scores. In addition, Royse and Rompf (1992) indicated that most social work majors have an immense problem dealing with the effects of math anxiety. They found that there was a significant difference in the math anxiety scores of social work majors and a cross section of students enrolled in classes not connected to social work. This was also evident in our study because the math majors had significantly lower math anxiety scores than the social science majors. Yet, again, the math performance scores between math majors and social science majors were not significantly different.

Moreover, we predicted that females will have significantly higher levels of math anxiety than males. Our study found no significant difference between the math anxiety levels of females and males even though we had almost the same number of male (n = 72) participants as female (n = 73). This could be a product of our female participants having non math anxious teachers in their math courses before college. As Suárez-Pellicioni et al. (2016) demonstrate, high math anxious female teachers can have a negative influence on girls who have a traditional idea of gender abilities. The math anxiety of a female teacher positively correlates with the math anxiety of her female students. Therefore, the females in our study may have learned from teachers with minimal math anxiety. Additionally, our research showed no difference in the math performance scores between males and females. This hypothesis is consistent with the research by Devine et al. (2012) which indicated that there are no differences in math performance between males and females in middle school. These similar math performance scores seem to stay stable throughout high school and into college. However, unlike our study, Devine et al. (2012) had similar findings to Suárez-Pellicioni et al. (2016) when it was shown that females have higher levels of math anxiety.

Another hypothesis not supported examined the difference in math anxiety between Ripon College and Johns Hopkins University. We hypothesized that students who attend Johns

Hopkins University will have higher levels of math anxiety than students at Ripon College. Our reasoning was that admission counselors at liberal arts schools like Ripon College, emphasize the importance of the well rounded education prospective students would get at their school. The students are not solely focused on one area of study, they have the opportunity to complete a number of classes within different major clusters. However, our study did not exhibit this finding. A factor that could have had an influence is that Johns Hopkins University is a very prestigious school that is very difficult to get into. The students may come in as freshman already very well rounded in several academic areas. This could eliminate the advantage that a liberal arts school like Ripon may have. In any case, the schools did not have a significantly different level of math anxiety.

Finally, for all the hypotheses mentioned, we believed that there would be a negative correlation between math anxiety and math performance. The Pearson correlation supported this claim as it showed a significant negative correlation between the two variables. For the individuals in the study, as their math anxiety increased, their math performance decreased. The results from Devine et al. (2012) found this same conclusion in middle school students. They argued that math anxiety correlates to lower math performance in future years. Therefore, researching methods of reducing math anxiety is worthwhile. In addition, Faust et al. (1996) revealed some reasons why this correlation may occur. Their study demonstrated that high math anxious students encounter a global avoidance effect. This develops when a high math anxious individual enrolls in fewer math courses or selects a major that involves less math content. Thus, this person becomes less trained and less knowledgeable in math, and his or her math performance scores suffer.

A major limitation to this experiment was the lack of students who were declared as math majors. An increased number of students in this major cluster could reduce the variability for math majors and impact the significance. Also, a possible limitation to the study was the ease of each math test. Had the tests been more difficult or longer, fewer students would have been able to finish with perfect scores. By lengthening the tests there could be more variability between groups and result in one cluster separating from the others.

Future research on this topic could address the limitations previously mentioned. Recruiting more math majors to get a better representation of the major would be highly beneficial. Similarly, having longer tests for addition, subtraction, and multiplication would be advantageous. Lastly, future researchers could collect data concerning students' attitudes toward math based on previous events or how important math was considered to be in their environment during childhood.

Our study aimed to compare levels of math anxiety among different major clusters, school, and biological sex. Ultimately, our research did not fully support our hypotheses in regards to sex and school. However, we showed that there is a significant difference between math majors and all other declared majors. In addition, we did not find a significant difference between levels of math anxiety between males and females. It was also shown that there is a significant negative correlation between math anxiety and math performance. This raises the question of what educators should emphasize. Should their primary focus be on reducing math anxiety or increasing math performance? This is an issue for future studies.

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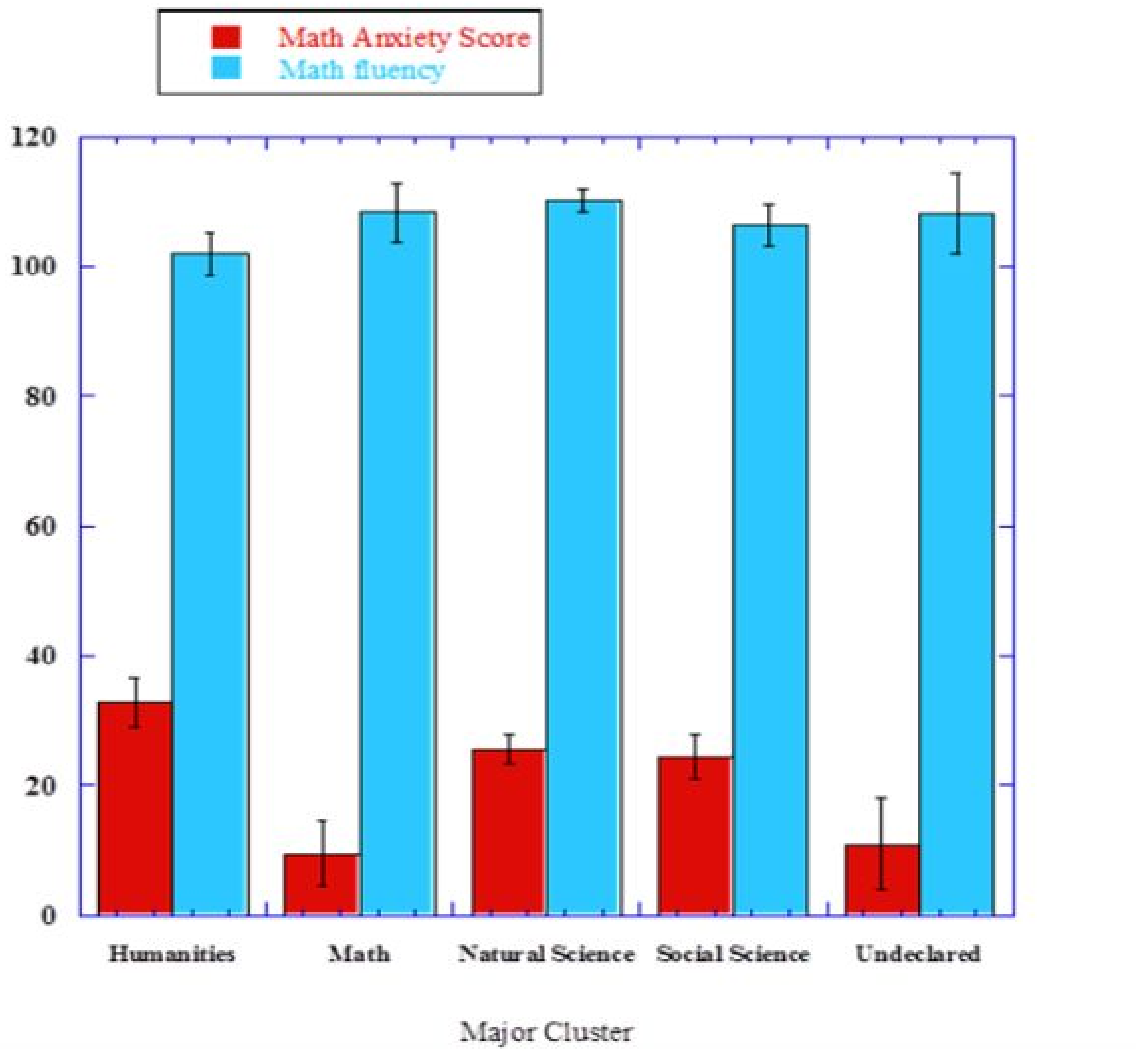

Figure 1. Bar graph of the mean math anxiety scores and math fluency scores for each major cluster. The error bars represent the standard error of the mean.

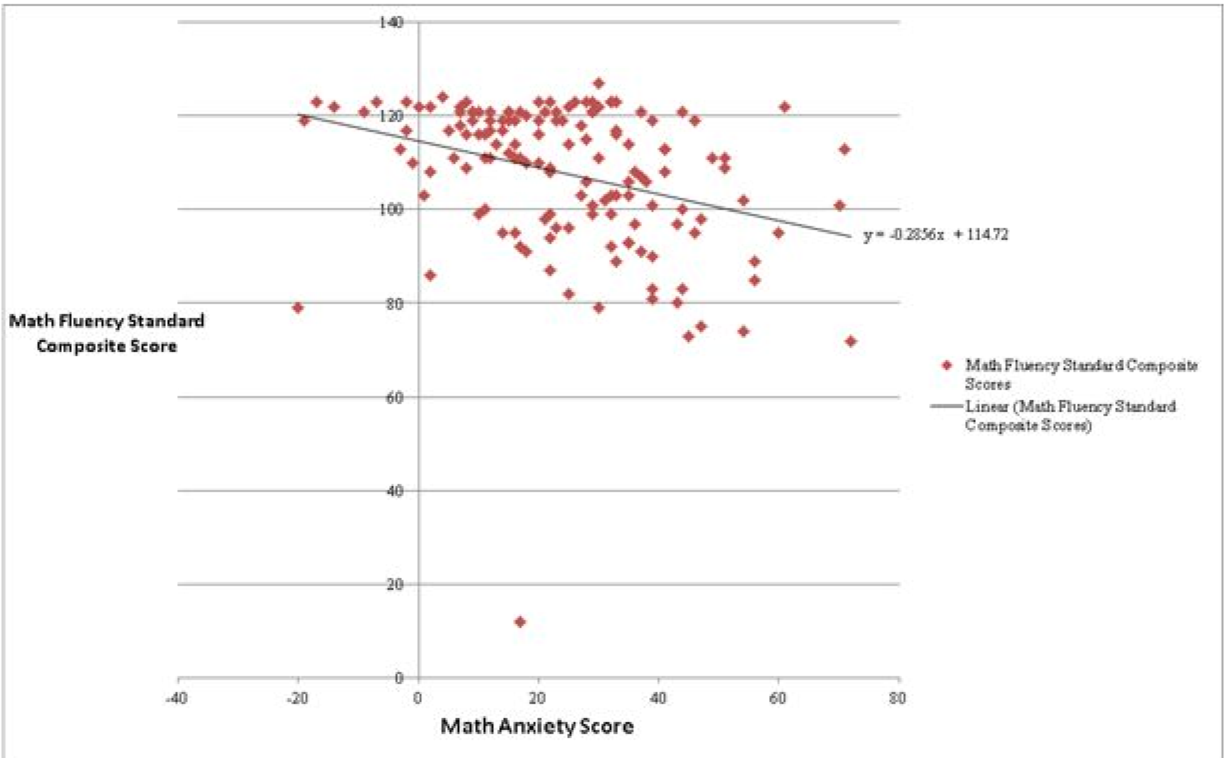

Figure 2. Pearson correlation of the relationship between math anxiety scores and math fluency standard composite scores.

Source	*df*	*F*	η^2	*p*
Major Cluster	4	1.328	0.040	0.263
Sex	1	0.608	0.005	0.437
School	1	2.617	0.020	0.108
Major Cluster*Sex	3	0.642	0.015	0.589
Major Cluster*School	3	0.248	0.006	0.863
Sex*School	1	3.986	0.030	0.048
Major Cluster*Sex*School	2	2.842	0.042	0.062
Error	129			

Table 1. This table shows main effects and interactions between all independent variables and the dependent variable of math fluency composite score.

	Humanities	Math	Natural Science	Social Science	Undeclared
Males	102.270 (17.721)	107.330 (31.373)	115.870 (8.460)	109.860 (13.688)	108.400 (11.739)
Females	99.83 (11.060)	-----------	107.320 (13.464)	100.800 (15.722)	108.000 (15.556)

Table 2. Mean math fluency composite score for the independent variables of sex and major cluster. Standard deviations appear below the mean math fluency composite score.

	Humanities	Math	Natural Science	Social Science	Undeclared
Ripon	98.860 (16.756)	111.000 (14.697)	104.000 (14.437)	103.900 (15.313)	108.290 (11.499)
Johns Hopkins	104.330 (9.394)	105.500 (37.981)	114.040 (9.842)	108.500 (15.483)	------------

Table 3. Mean math fluency composite scores for the independent variables of school and major cluster. Standard deviations appear below the mean math fluency composite scores.

	Ripon	Johns Hopkins	Simple Effects: F df (1,129)
Males	109.060 (13.867)	112.220 (19.767)	0.098
Females	98.490 (14.114)	110.550 (10.722)	4.765*

Table 4. Note. *= p < .05. Mean math fluency composite scores of sex and school. Standard deviations appear below the mean math fluency composite scores. Simple effects for the interaction between sex and school are analyzed.

Source	*df*	*F*	η^2	*p*
Major Cluster	4	3.678	0.102	0.007
Sex	1	0.176	0.001	0.676
School	1	0.483	0.004	0.488
Major Cluster*Sex	3	0.992	0.023	0.399
Major Cluster*School	3	0.658	0.015	0.579
Sex*School	1	0.003	0.000	0.958
Major Cluster*Sex*School	2	0.225	0.042	0.776
Error	129			

Table 5. This table shows the main effects and interactions between all independent variables and the dependent variable of math anxiety score.

	Humanities	Math	Natural Science	Social Science	Undeclared
Males	34.550 (19.232)	9.250 (15.898)	21.170 (11.335)	20.29 (14.430)	13.400 (12.857)
Females	29.830 (18.215)	-----------	27.910 (18.514)	32.200 (17.272)	8.500 (38.891)

Table 6. Mean math anxiety scores for the independent variables of sex and major cluster. Standard deviations appear below mean math anxiety scores.

	Humanities	Math	Natural Science	Social Science	Undeclared
Ripon	30.500 20.026	10.750 (22.247)	28.630 (17.176)	28.710 (17.370)	12.000 (19.183)
Johns Hopkins	34.560 (16.478)	8.500 (13.533)	23.52 (15.694)	20.500 (14.570)	------------

Table 7. Mean math anxiety scores for the independent variables of school and major cluster. Standard deviations appear below mean math anxiety scores.

	Ripon	Johns Hopkins
Males	23.14	18.03
	16.691	(14.515)
Females	29.540	27.680
	(20.605)	(16.944)

Table 8. Mean math anxiety scores for the independent variables of sex and school. Standard deviations appear below the mean math anxiety scores.

Appendix

Math Experience Questionnaire

Subject ID:
Date this questionnaire was completed:
Year in school:

Instructions for Part 1:
Below is a series of situations, some of which are related to math activities and some of which are not. For each, imagine yourself in the situation and then circle the number corresponding to how anxious this situation makes you feel. A score of 1 means "not at all anxious" and a score of 5 means "very anxious."

	Not at all anxious				Very anxious
1) Spelling words you have never heard before.	1	2	3	4	5
2) Walking into a math class.	1	2	3	4	5
3) Being told how to interpret probability statements.	1	2	3	4	5
4) Reading and interpreting a paragraph of text.	1	2	3	4	5
5) Being given a homework assignment of many difficult math problems that are due the next class meeting.	1	2	3	4	5
6) Taking a final examination in a literature course.	1	2	3	4	5
7) Waiting to get a math test returned in which you expected to do well.	1	2	3	4	5
8) Listening to a lecture in a history class.	1	2	3	4	5
9) Reading the word "statistics".	1	2	3	4	5
10) Being given a pop quiz in a history class.	1	2	3	4	5

11) Looking through the pages of an archaeology textbook.	1	2	3	4	5
12) Taking an examination in a math course.	1	2	3	4	5
13) Working on writing the introduction to an essay.	1	2	3	4	5
14) Signing up for a course in statistics.	1	2	3	4	5
15) Starting a new chapter in a math book.	1	2	3	4	5
16) Listening to another student explain a math formula.	1	2	3	4	5
17) Buying a math textbook.	1	2	3	4	5
18) Taking a final examination in a math course.	1	2	3	4	5
19) Listening to another student translate German.	1	2	3	4	5
20) Watching a teacher work out an algebraic equation on the blackboard.	1	2	3	4	5
21) Having to use the tables in the back of a math book.	1	2	3	4	5
22) Thinking about an upcoming math test one day before.	1	2	3	4	5
23) Reading a formula in chemistry.	1	2	3	4	5
24) Picking up a French textbook to begin working on a homework assignment.	1	2	3	4	5
25) Walking on campus and thinking about a math course.	1	2	3	4	5
26) Being given a pop quiz in a math class.	1	2	3	4	5
27) Reading a sentence in a foreign language.	1	2	3	4	5
28) Picking up a math textbook to begin working on a homework assignment.	1	2	3	4	5
29) Solving square root problems.	1	2	3	4	5
30) Getting ready to study for a math test.	1	2	3	4	5
31) Listening to a lecture in a math class.	1	2	3	4	5
32) Reading and interpreting graphs or charts.	1	2	3	4	5

33) Working on an abstract mathematical problem, such as: "if x = outstanding bills, and y = total income, calculate how much you have left for recreational expenditures".	1	2	3	4	5
34) Being given a homework assignment of writing a ten-page essay that is due the next class meeting.	1	2	3	4	5
35) Being told how to interpret the meaning of a famous quote.	1	2	3	4	5
36) Looking through the pages of a math textbook.	1	2	3	4	5

Sex:
Primary Major:
Number of math classes taken in college:

Math Fluency Tests

Subject ID:
Math Fluency—Addition

2+1 =	1+5 =	4+0 =	1+1 =
6+2 =	4+6 =	1+7 =	3+6 =
3+3 =	9+0 =	2+8 =	5+4 =
5+3 =	3+2 =	8+0 =	5+1=
1+8 =	0+9 =	2+4 =	5+5=
4+1 =	8+1 =	2+6 =	6+3 =
0+10 =	2+9 =	3+8 =	6+6 =
4+7 =	3+9 =	8+2 =	5+6 =
7+6 =	5+8 =	6+5 =	7+3=
5+9 =	9+1 =	7+8 =	9+5=

6+8 =	9+3 =	6+4 =	7+5=
8+7 =	8+4 =	7+7 =	9+7 =

Subject ID:
Math Fluency--Subtraction

7-1 =	3-3 =	7-7 =	3-1 =
5-4 =	9-8 =	3-0 =	6-4 =
9-6 =	10-8 =	8-3 =	10-3 =
8-7 =	5-0 =	10-6 =	8-1=
9-2 =	2-2 =	10-7 =	4-0 =
8-8 =	10-1 =	7-0 =	6-6 =
12-4 =	14-7 =	15-10 =	16-8 =
11-8 =	8-6 =	11-6 =	12-9 =
13-6 =	15-7 =	9-7 =	12-6 =
11-5 =	14-4 =	14-9 =	11-2 =
14-8 =	14-14 =	11-7 =	12-7 =

18-9 =	14-10 =	18-8 =	16-9 =

Subject ID:
Math Fluency--Multiplication

1x7 =	2x1 =	4x2 =	3x5 =
7x2 =	4x4 =	2x7 =	5x1 =
2x8 =	3x0 =	1x8 =	6x2 =
2x9 =	8x2 =	7x0 =	5x4 =
3x7 =	4x5 =	3x4 =	4x6 =
6x3 =	9x4 =	5x8 =	3x10 =
3x8 =	6x5 =	8x8 =	5x6 =
7x9 =	9x5 =	7x6 =	6x8 =
7x5 =	4x8 =	6x9 =	10x5 =

8x6 =	9x9 =	9x3 =	8x9 =