

CONFIDENCE COUNTS: GENDER, MATH ANXIETY, AND
ACHIEVEMENT IN MIDDLE SCHOOL MATHEMATICS
STUDENTS

by

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Female students have long been disadvantaged and underrepresented in STEM fields. The gender disparity between male and female students seems particularly strong in mathematics. Moreover, many students experience extreme negative feelings towards mathematics, regardless of gender. These negative emotions often manifest as anxiety and lack of confidence. The current study used data from grade 8 students ($n = 235$) to examine how gender and course-taking are associated with math achievement and math confidence for middle school students. Analyses revealed statistically significant relationships between course-taking and math confidence, course-taking and math achievement, and gender and math achievement. These results demonstrate the importance of course trajectories for long-term success in math, as well as the role that gender plays in student identity. Understanding what makes strong math students will help answer the broader question of why there are so few female students enrolling in math-heavy majors at the undergraduate level and beyond. Factors associated with gaps in math education for both male and female students and areas for future research are discussed.

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Introduction

As a math major at the University of Oregon, I have had 6 male math professors and 5 female math professors. This gives the illusion that the math faculty at UO is equally representative of men and women. However, of the fifty listed math faculty members, 37 are male and 13 are female. Moreover, of the 34 faculty members who have reached professorship, only 3 of them are female. For this reason, when I first sit down in a new math course, I always take the same first step; I scan the room for other females in the course. While scanning, I find myself asking “Who else has made it to this point?” As a female mathematician, I know that barriers exist that exclude women from math spaces. Therefore, when I see other girls sitting alongside me in an upper-level undergraduate math course, I feel a sense of pride and accomplishment. I know that those of us in that room have overcome gender stereotyping in math. The stereotype that women can’t do math has always existed. In the 1800s, females who wanted to earn a degree in math could not even enroll in the institutions that offered these degrees. So, they would petition to get a seat in every math course needed to get their degree (Liu, 2023). Today, girls are still fighting this stereotype and are working to diminish the gender gap in mathematics education and to remind people that math is for everyone.

The skills that students learn in a math class are essential. Mathematical literacy is vital for people to understand the world of numbers, finance, statistics, and concepts they encounter every day. Additionally, being knowledgeable in mathematics allows people to study challenging subjects, such as many of the natural sciences, and therefore work in important, high-paying careers later in life. Essential math skills, however, are not easy for all students to acquire. Math achievement is determined by so many factors. To begin, students have to genuinely want to improve as mathematicians. This can be difficult if a student is placed in a course that is either

far too difficult or not challenging enough. Additionally, students should feel safe and comfortable while learning math, which is challenging if the student does not feel properly represented in the course. Finally, a student must believe that they are capable of growing into someone who can solve difficult problems.

For any student, it can be difficult to feel successful in each of these categories, however, it is particularly difficult for female students. Female students are at a disadvantage in many of these components. With a higher pressure to perform academically and less overall representation in the field of mathematics, female math students of all ages may have to work harder to be successful in math. This leads to drastic gaps in gender representation in the field of mathematics, specifically within higher education and the workforce. The US Department of Education revealed that in the 2013-2014 academic year, women were awarded only 43% of undergraduate degrees, 41% of master's degrees, and only 25% of doctoral degrees in the mathematics and statistics fields. This gap continues as women enter the workforce. The US Department of Labor reports that despite making up 46.8% of the workforce, women only make up 25.5% of “Computer and Mathematics Occupations” (*National Mathematics Survey – Women In Math*, n.d.). If the degree or occupation requires more challenging math, fewer women will be represented in those populations. Likely, oppressive stereotypes are largely what are keeping women out of these spaces. The belief that math is not for women still exists.

These statistics highlight that there is a gender representation problem in mathematics. However, it is not exactly clear when these negative feelings toward math begin. When do students begin to feel uninterested in the challenge that math often offers? When do female students learn the idea that math is a male subject? Middle school might be the answer to these questions. By middle school, students have begun developing their specific academic

preferences. Thus, they start to decide how much effort and energy they will put into a particular subject. Additionally, anxious feelings towards school, and specifically math, may have begun to develop for students in middle school. As students begin to be placed in different math courses based on their achievement, there may be more pressure to appear smart and be placed in a high-level course. Yet, female students face a different challenge. They must balance appearing smart to their friends when it matters, but also never looking too interested in a boyish subject like math. Appearing too interested in math only earns them the title of nerdy or tomboyish. These ideas combine and can lead to low levels of math confidence and leave students feeling discouraged by math. Some students who have a genuine interest in math are left behind by the social pressure to fit in. In my research, I aim to analyze the relationship that gender and grade 8 course-taking have on math performance and confidence.

Literature Review

Interest and Intention

Sarah Grigg defines math interest and math intention as two important factors relating to math achievement. In her study, *math interest* is defined as “a cognitive-affective construct denoting positive affective experiences with, and arousal of attention toward, math-related activities” (Grigg et al., 2018). Math interest develops as a student is repeatedly exposed to math-related content and stimuli. Some students will show very little interest in math as a subject, while others may only be interested in certain topics within mathematics. Grigg states that a student's interest in math affects them not only in school but also later in life during education and career pathway selection. This concept of how likely a student is to continue to study or work with mathematics is defined as *math intention* in Grigg's work. It is necessary to inform students of the need for people willing to work in STEM-related careers. As Grigg's work points out, in Australia, the demand for STEM workers currently outweighs the supply. If students continue to have low math intention, then this gap could widen and worsen the intellectual disparity between the people creating and developing crucial new technologies, and those using them. The study goes on to say that while other research aims to analyze the relationship between all these variables, they do not always look for ways to improve the low number of people in math-focused fields. Thus, Grigg highlights that understanding a student's interests, both related and unrelated to math, is key to creating engaging and personalized content and lessons for each student.

Further, it is known that low levels of math interest and intention, and therefore math achievement, do not affect all students equally. Specifically, it may be more difficult for a female student to feel that math will be a valuable skill for her to learn. This can lead to low math

interest and achievement. There are beliefs that “STEM fields require more time and commitment toward work over family needs than do non-STEM fields.” These ideas, rooted in the idea that a woman must care for her husband and family at home, cause some girls to believe that they would not be a good fit for a STEM-related higher education or career (Fernandez et al., 2024). Girls should not be excluded from math simply because they want to have a well-built family life.

Course-taking

Course-taking is another important component that goes into a student's success as a mathematician. In elementary school, and through much of middle school, all students take the same math class. There are often areas within a lesson where an advanced student may be able to challenge themselves, but overall, each student is in the same course. Then, as students enter the later years of middle school and early high school, they experience different course-taking trajectories. For 8th-grade students, the different course options are often a pre-algebra course or an algebra course. Algebra is an essential math course for students to be exposed to during this age. Algebra is needed to unlock higher-level math courses that are often required for high school graduation. Therefore, if a student has a hard time grasping concepts from Algebra by the end of 9th grade, they may have a more difficult time graduating from high school.

A study by Simzar et al dives into the way that Algebra can act as a barrier course. That study also looks at the difference in mathematics motivation for 8th-grade students in algebra versus general grade 8 math courses. The research illuminates how prerequisite knowledge is a key determining element for how successful a student will be in their math course, regardless of which class they are placed in. Specifically, students who do not have adequate prerequisite knowledge are likely to struggle more in the next course. This can lead to lower math confidence

and declining interest in math. Simzar hypothesizes that this feeling of struggling and therefore losing interest will be heightened for students who struggled in 7th grade math and are then placed in general grade 8 math. Alternatively, students who may have excelled in 7th-grade math and are then placed in algebra in 8th grade will have exceptionally high math confidence. Not only do these students have the confidence to be successful in 7th grade, but they also know that they are in an advanced course. This combination of details allows these students to maintain their interest in math and continue to grow as mathematicians. This study shows that course-taking is an important aspect of a student's math success (Simzar et al., 2016). If a student is placed into a course that is either far too challenging or too easy, it may cause a student to lose interest and confidence and therefore be less interested in continuing their math education.

Math Anxiety

Another key term within this work is math anxiety. This topic, which has been researched by many groups trying to answer a myriad of questions, illuminates that learning math can lead to deeply anxious feelings for certain students. Specifically, *math anxiety* is defined by author Xiaoxia Huang as, “a feeling of worry, fear, or discomfort towards mathematics that impedes mathematics performance” (Huang et al., 2019). Huang’s definition points out that a cause-and-effect relationship between math anxiety and low performance and achievement exists. In this source, Huang highlights that one of the most widely studied areas of math anxiety is its connection to career and field choice. Huang writes, “Mathematics anxiety is another key affective variable directly contributing to career interest.” This is an essential lens to be aware of as it confirms that math anxiety has very direct and tangible effects. When a person feels anxious about a subject, they remove themselves from an entire field of well-paying and relevant jobs.

This affects people at the individual level, but also on a societal level. Society needs STEM-minded individuals to fill required positions in math fields.

Existing literature about the complex relationships between big ideas, such as math anxiety and achievement, also introduces theories that are often used in the field. A study by Connie Barroso introduces a theory known as the *processing efficiency theory*. This theory states that when a student has feelings of anxiety or worry surrounding a particular subject, these feelings take up a large amount of cognitive processing power, and thus the student is left with less cognitive capacity to perform academic tasks (Barroso et al., 2021). This theory will support the current study as it provides an answer to why anxiety can be such a limiting factor for students. It also points out that even students who want to do well in math or have high math interests might feel constrained by anxious thoughts.

Self-efficacy and Self-concept

Author Xiaoxia Huang also points out that there is a powerful and evolving relationship between math anxiety and math self-efficacy. Huang defines *math self-efficacy* as a student's "perceived confidence in math." The key to this definition is that it is the student's own idea of his or her success. Self-efficacy does not need to be compared with a student's actual success in that subject to hold merit. In the same way that it is interesting to look at what types of students are performing well in math, it is also interesting to look at what students believe they are doing well in math. Research done by both Huang and other experts in the field asserts that the relationship between math anxiety and math self-efficacy can work in both directions. That is, math anxiety can be the result of low math self-efficacy, but anxious feelings towards math can also lead to a student feeling unconfident in his or her math abilities. Math self-concept is a closely related topic to math self-efficacy. *Self-concept* is defined by author Bethany Rittle

Johnson as “students’ self-concept of domain-specific ability captures their perceived academic capabilities and [the] likelihood of succeeding in a domain” (Rittle-Johnson et al., 2024). Rittle-Johnson goes on to explain that current field theory suggests that students with higher math self-concept will be more actively engaged with their math courses and will look for ways to connect with math outside of the classroom. Rittle-Johnson also highlights that students who do seek out these opportunities to further their math education are then more likely to continue to have positive feelings towards math. Therefore, a positive feedback loop is created where students who began with higher math self-concept are on track to continue to feel positive, while students who feel more anxiety surrounding math are stuck furthering those negative feelings.

These findings by Rittle-Johnson parallel theories used in Grigg’s work. Grigg introduces the Social Cognitive Career Theory (SSCT). This theory introduces the connection between a student’s academic interests as they develop into academic intentions and eventually his or her career selection and success. Specifically, the SSCT claims that self-efficacy has a large, positive effect on a student's math interest and intention. That is, when a student believes that they can solve challenging math problems and understand complex concepts, they are more likely to keep seeking out math, thus increasing their math interest. As math interest grows, math intention will also grow. These students who believe they are succeeding in math also begin to believe that they could continue their math education, and even use those skills in their careers (Wang et al., 2022). This idea shows that self-efficacy and understanding how students feel about their success in math is a salient indicator of how interested a student is in math. Therefore, if educators can work on improving students’ self-efficacy and the way that each student thinks of themselves concerning math, these educators may, in turn, be able to boost math interest for all students regardless of gender.

Representation

Despite math self-concept and self-efficacy varying greatly for all students, field literature reveals that female students may have lower overall math self-efficacy. There are many hypotheses for why this might be true. One component may be the harmful stereotypes that create the idea that it is not a feminine trait to be good at math. A study in Seattle found that “as early as second grade, about 75 percent of the little girls and boys have caught the stereotype that girls don’t do math” (*How Early Do Girls Decide Math Isn’t for Them?*, 2017). This statistic was revealed using an implicit bias test where young girls and boys see an image and choose whether that image or icon is associated with boys or girls. Female students seemed to associate numbers with boys. What makes these findings even more surprising is that the female students who are being asked this in second grade have not even learned their multiplication tables yet. Thus, despite seeing very little math in the classroom, young girls have already learned that society functions as though girls do not do math. That study claims that this learned idea must develop somewhere between kindergarten and first grade, and therefore, by second grade, the idea is already well cemented in these young girls’ minds. This is likely an issue of representation. By second grade, both male and female students may have learned about a few well-known STEM role models such as famous astronauts, or scientists who made important discoveries in the field of medicine and technology. Unfortunately, many of these societal figures are men. As a result of more oppressive times for women, young girls grow up seeing and hearing that the people who make a big impact on the STEM community are male.

Thus, self-perception, or self-concept, is not the only variable that goes into a person determining if they belong in math. Along with representation, outside recognition is also crucial for someone to believe that they can be a mathematician (Fernandez et al., 2024). Interestingly,

one study found that for female students, the relationship between self-concept and mathematical performance was mostly one-directional. That is, female students who felt accepted by math were more likely to perform better in math. But the same was not true in the opposite direction. Just because a female student was performing well in math did not necessarily mean that she would feel accepted as a mathematician.

Math Confidence

Much of the literature in the field of math education discusses both math anxiety and *math confidence*. These two variables seem to function as inverses. That is, students with high levels of math anxiety are likely to have low levels of math confidence. Literature suggests that the relationship between math confidence and math interest is “mutually reinforcing” (Ganley & Lubienski, 2016). Ganley’s study also aims to understand the relationship more deeply between math confidence and math achievement. Ganley hypothesizes that the gender gap in math achievement and interest will be smaller than the gender gap in math confidence. Therefore, even if female students are performing at the same level as their male peers, they may feel less assured in their math identity. The study found that from third to eighth grade, girls were both less confident and less interested in math than boys. This illuminates the relationship between math confidence, math interest, and eventually career choice. Moreover, it highlights that boys and girls have different math identities even when they are performing similarly. Math confidence is a key pillar in many math education studies and can act as the negation of math anxiety. This will be an important idea in this research as it further illuminates a student’s feelings towards math. Math confidence combines ideas of math anxiety, self-efficacy, self-concept, and math performance to better understand a student’s math identity and how these identities vary across genders.

Gaps

There is an abundance of literature written about math anxiety, gender, and racial inequities in mathematics, and how these ideas might be correlated with math achievement. As a result, there are few gaps in the vast field of math education research. However, many of the studies in this field are quite broad. Whether it be a very large sample population, a broad question, or research designed as a systematic review, studies in this field tend to want to extrapolate generalized ideas that could apply to students across the United States or even to wider populations. One benefit of this research is that it is relatively narrow and therefore focused. Apart from demographic information, the data used for this project contains only self-reported answers to math confidence and math anxiety questions as well as courses taken and course grades for each student. The only aspect of the data that could be considered outside opinion or perspective is each student's course grade. Course grades are determined by teachers, and thus do contain some outside opinion on each student. Otherwise, all data is self-reported and thus creates an image of how these middle school students feel about math. Because the data is more focused and narrower, the correlation between confidence and performance can be closely studied with statistical testing. Therefore, this research will help zoom in on a particular case study to help confirm that the results found on large-scale studies remain true for smaller, specific groups of students.

Additionally, the age demographic that was surveyed for this project is compelling. When it comes to math anxiety and math achievement, the middle school age range is slightly less researched than later in high school or college. Specifically, Huang highlights that the analysis of the relationship between math anxiety and math achievement in middle schoolers is a newer field. Previously, much of the literature focused on students in high school or college, and thus

also focused on career and higher education motivations. Alternatively, other studies focus on elementary-aged students to better understand when gender stereotyping and the belief that they are true develop for young students (*How Early Do Girls Decide Math Isn't for Them?*, 2017). Other studies that look at younger students ask when math anxiety begins to develop.

This leaves middle schoolers to be a less frequently studied group of students. However, there is still so much that can be learned by looking at middle school students. Huang writes that middle school is a time when anxiety may be peaking for students, and therefore, math anxiety could also be heightened. Other studies have illuminated that students begin to understand gender stereotypes and develop math anxiety in elementary school, so it can be said that by middle school, students have already spent time with those anxious emotions and are beginning to battle with their own math identity. Further studies highlight that in high school when students have more choices in their course selection, they are likely to make those choices based on what they think will be most helpful to their higher education and eventually career. At this level, students have more concretely formed their academic preferences, whereas, in middle school, students are still developing these preferences. Factors such as confidence, identity, and anxiety will be crucial as a student decides what subjects they prefer. Therefore, even though students in this data set are not at the cusp of making a large decision such as what they will study in college or are young enough to be experiencing their first taste of anxiety and gender inequality, they represent how feelings of math anxiety, confidence, identity, and representation can affect mathematical performance as well as have impacts on many later decisions.

Current Study

Despite the extensive field of research into the relationship between gender and math performance, there is still a gap in the total number of female students choosing to study math and pursue math-related fields. Even though interest in the field is strong, the question has not been answered in its entirety. An analysis into what variables affect math confidence in middle school students, and how these components affect male and female students in different ways was performed. Analyzing this relationship among middle schoolers creates hypotheses about how math confidence at this age translates to future math course-taking and eventually major and career selection.

The research question is: How are gender and course-taking associated with math achievement and math confidence for middle school students?

The following are the original hypotheses made:

1. Students who take a more advanced math course in grade 8 will have higher overall levels of math achievement and math confidence.
2. Female students will have lower overall math confidence scores.
3. The confidence boost that male students obtain from being in a higher-level grade 8 course will not be as strong for female students in terms of confidence or performance.

Methods and Analysis

Data Collection

The data used in this study was originally collected in the fall of 2017. The Making Middle School Mathematicians project administered a survey to all 8th-grade students in a local Eugene school district. The survey, containing 23 questions as well as some demographic data, aimed to gain insight into students' confidence and self-concept concerning their mathematics class and learning. Students completing the survey were told that the researchers wanted to learn more about how students felt about math, and thus the students were not blind to the goals of the study. A level of anonymity was achieved by telling students that their responses would be matched with their ID number and therefore securely stored without the use of their names.

Apart from demographic questions, survey questions were presented as a statement, such as, "I am confident that I am able to support my solutions to a math problem in class using objects, drawings, or diagrams." The choices for responses were *never*, *rarely*, *sometimes*, *always*, and *I don't know*. The inclusion of the "I don't know" option was important to the study because it allowed students an option to answer when they did not know how they wanted to answer or did not fully understand what the question was asking. This allowed the study to require students to answer every question, even if it meant utilizing the "I don't know" response. Five of the total questions asked were worded in a reverse way, such as, "I am NOT confident that I am able to compare my approach to a problem to another classmate's and explain why my solution works better." On these questions, the response choices were unchanged. This negative wording on some of the questions was used to detect whether students were providing the same response to every question.

The final step of data collection involved attaching students' responses to the survey to their math grades in both 8th and 9th grade. Overall, the data included some demographic information, responses to the survey questions, and course grades in 8th and 9th grade. Students were not explicitly told that their grades would be attached to their responses, however, they were aware that the survey responses would be part of the general information collected about students in their district. One of the original research questions attached to this data was, "To what extent is math self-concept associated with math achievement growth and/or future math course taking for 8th-grade students? And, to what extent do those relations differ based on student demographics, math course taking in middle school, and/or prior math scores?" To answer this question, it was helpful to have demographic information, self-concept scores, as well as grades at two different periods in the student's life. Although my question is a slight departure from the original goal of the study, it still contains useful information to answer the research question posed in this project.

Data Analysis

Many online resources played an important role in the data analysis phase of this research. Specifically, the utilized software was Excel (*Microsoft Excel*, 2018) and Jamovi (*The Jamovi Project*, 2025). Excel allowed me to clean and recode the data. The first edits I made to the raw data in Excel were converting the grading scale (A-F) to a numerical scale. To make this change, I utilized a weighted GPA scale. That is, I let A= 4, B= 3, C= 2, D= 1, and F= 0 with any plus and minus signs adding or subtracting 0.3 from this amount. For example, a B+ converted to a 3.3, and a C- became a 1.7. It was useful to have student grades in a numerical format so they could be easily compared to the confidence scores, which were also in a numerical format.

Another relevant step in the data analysis process was obtaining an overall confidence score for each student. To compute this average, I converted the never, rarely, sometimes, always, and I don't know scale into a numerical scale. I computed the average on this 1-4 scale, where always confident answers were treated as a 4, never confident answers were a 1, and "I don't know" responses were excluded from the calculation. Some questions were asked in a negative form. That is, the question started with, "I am NOT confident in my ability to..." For the questions that were asked in this way, I flipped the numerical scale so that always was treated as a 1, while a response of never was treated as a 4. Then I could build an average formula in Excel using only completed cells where the student did not respond with "I don't know." Thus, if any data was missing, the total number of entries was updated to reflect that missing cell. The formula I used for each student was:

Average Confidence Score= (Sum of confidence scores 1-4)/ (Total number of completed cells - number of "I don't know" responses)

This is an advantageous formula because I did not want the "I don't know" responses to heavily skew the averages towards 5, so instead, they were removed. Additionally, I was still able to get a total math confidence score even if there were a few empty cells in a student's response row. I needed to obtain these total overall math confidence scores to statistically compare different student attributes with his or her confidence.

After completing all data cleaning and preparation steps, I began my data analysis. Statistical tests including Analysis of Variance (ANOVA) and Correlation Matrix were run to explore my research questions. These statistical tests were accessed and implemented in Jamovi. In all cases, an alpha value of .05 was used to evaluate statistical significance. Below are descriptions of both statistical methods used.

Correlation Matrix

A correlation matrix was generated to identify the relationship between math confidence and math achievement. A correlation matrix compares two continuous variables and provides correlation coefficients. These correlation coefficients demonstrate the strength of the relationship between the two variables. This value, called an r -value, has a magnitude between 0 and 1. If the magnitude (absolute value) of the r -value is very close to 1, the two variables have a very strong correlation. If the magnitude of the r -value is close to 0, there is no strong relationship between the two variables, and they do not follow the same relationship. The correlation matrix was an applicable tool at the beginning of the analysis, as it provided an overview of the association between two variables. If the matrix revealed that two variables were correlated in some way, then further and more rigorous testing could be done.

Analysis of Variance (ANOVA)

Two ANOVAs were run to explore relationships between gender, course-taking, math confidence, and math achievement. An ANOVA is a statistical test that compares the means of multiple groups within a data set. The ANOVA assumes that the average in each group will be equal. After testing, the ANOVA returns an F statistic that determines how likely it is that the group averages are different due to chance. If the F statistic is larger than a critical value based on the F distribution, we can conclude that the relationships in our data are unlikely to have occurred due to chance. Additionally, if the ANOVA does reveal that there is some significant difference between the averages, pairwise comparisons or simple effects between all combinations of two groups can be tested to determine which groups are statistically significantly different.

Because there were many potential grouping variables, such as gender, selected 8th-grade math course, and course grade, it was productive to run an ANOVA to compare many of these potential grouping variables at once. A factorial ANOVA was used to examine how the combined effects of gender and course-taking affected math confidence and math achievement. Being able to test two variables at the same time is useful for better understanding the many factors that shape a student's math identity.

Results

Initial correlational analyses seen in Table 1 confirmed a relationship between math confidence and math achievement. Results of the correlation matrix between math performance on the x-axis and math confidence on the y-axis reveal a moderately positive correlation between the two variables, $r(205) = .374, p < .001$.

A two-way, between-subjects analysis of variance (ANOVA) was conducted to examine the extent to which gender and grade 8 math course affected reported math confidence. ANOVA results in Table 2 indicate that there was not a statistically significant interaction between the effects of gender and course-taking, $F(1,225) = 0.0642, p = .80$. Follow-up main effects analysis revealed that gender did not affect math confidence, $F(1,225) = 0.058, p = .810$. However, additional main effect testing showed that course-taking did have a statistically significant effect on 8th-grade math confidence, $F(1,225) = 46.896, p < 0.001$. Students in Algebra 1 had higher average confidence scores ($M = 3.34, SD = 0.347$) than students in Grade 8 Math ($M = 2.94, SD = 0.485$).

Table 3 details the results from the second two-way ANOVA. The ANOVA examined the extent to which gender and grade 8 math course were associated with math performance in 9th grade. Like the results from Table 2, the ANOVA did not reveal a statistically significant interaction between the effects of gender and course-taking, $F(1, 200) = 1.46, p = .229$. Additional main effect testing reported that gender had a statistically significant effect on math performance, $F(1,200) = 6.17, p = 0.014$. Female students were earning higher course grades ($M = 2.61, SD = 1.22$) than their male classmates ($M = 2.15, SD = 1.33$). Similarly, course-taking also had a statistically significant effect on math performance, $F(1,200) = 34.7, p < 0.001$.

Students in Algebra 1 reported higher grade 9 course grades ($M = 2.95$, $SD = 1.04$), than the students in Grade 8 Math ($M = 1.99$, $SD = 1.29$).

Correlation Matrix

		Total Math Confidence (1-4)	S1_Grade
Total Math Confidence (1-4)	Pearson's r	—	
	df	—	
	p-value	—	
S1_Grade	Pearson's r	0.374 ***	—
	df	205	—
	p-value	< .001	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 1. Math Confidence and Math Performance

ANOVA - Total Math Confidence (1-4)

	Sum of Squares	df	Mean Square	F	p
Gender (Numeric)	0.0109	1	0.0109	0.0580	0.810
Grade 8 Course	8.8390	1	8.8390	46.8960	< .001
Gender (Numeric) * Grade 8 Course	0.0121	1	0.0121	0.0642	0.800
Residuals	42.4083	225	0.1885		

Table 2. Course Taking, Gender, and Math Confidence

ANOVA – Math Performance

	Sum of Squares	df	Mean Square	F	p
Gender (Numeric)	8.47	1	8.47	6.17	0.014
Grade 8 Course	47.64	1	47.64	34.70	< .001
Gender (Numeric) * Grade 8 Course	2.00	1	2.00	1.46	0.229
Residuals	274.61	200	1.37		

Table 3. Course Taking, Gender, and Performance

Discussion

Every student should have the right to feel uplifted and encouraged by their teacher and education. This should be true regardless of gender or skill. Unfortunately, math education has shown a favorability towards male students. Through poor representation and the idea that math is not ladylike, girls have been left out of math for years. Moreover, students who struggle in foundational math classes often feel abandoned. As the content becomes more difficult, these students lose confidence and fall further behind in math. Both gender stereotyping and confidence gaps have created inequity in math. Given this, the present study explored relations between gender, course-taking, math achievement, and math confidence for middle school students. Using survey data collected from 8th-grade students in a suburban school district in Oregon, analyses examined students' confidence and feelings toward math. Survey data was analyzed to test the following hypotheses:

1. Students who take a more advanced math course in grade 8 will have higher overall levels of math achievement and math confidence.
2. Female students will have lower overall math confidence scores.
3. The confidence boost that male students obtain from being in a higher-level grade 8 course will not be as strong for female students in terms of confidence or performance.

Previous literature in math education and gender gaps in the field aligned with these hypotheses. A myriad of startling statistics illuminates the way that women are continually left out of math-centered spaces. Additionally, studies reveal that math anxiety restricts any student's ability to engage in learning math comfortably (Huang et al., 2019). One area where differing levels of math anxiety may emerge is within math course trajectories (Dougherty et al., 2017).

Thus, this research hoped to gain insight into how all these factors interact with one another. How do these components combine and leave some students behind? Findings from this study will provide additional context to inform efforts to help math become a more inclusive space for all learners, especially women.

Course-Taking and Math Confidence

Results of this study indicate that students in more advanced grade 8 courses had higher overall math confidence scores. This result aligns with previous research (Dougherty et al., 2017) and the hypothesis that students in a more advanced course in grade 8 will demonstrate increased levels of math confidence and math achievement. It is likely that students in a more advanced grade 8 math course feel a sense of pride and ability simply by being placed into that advanced course. This confidence boost manifests in student confidence levels. Knowing that another person believes you have the skill to be in that course helps quiet the doubts that a student may have regarding their mathematical ability. The processing efficiency theory states that when students spend substantial amounts of their cognitive functioning worrying about outside stressors, they leave less cognitive space to be utilized on their course content (Barroso et al., 2021). The results of this data in many ways agree with the processing efficiency theory. Students who are placed into higher-level grade 8 math courses may have to spend less time questioning if they belong in that math course or more generally, if they are good at math. By being in that advanced course they know they are good at math. This could lead to an increase in cognitive resources and time spent on math coursework.

An interesting lens to consider, however, is the increase in pressure that might be present in a more advanced math class. In an accelerated course, many of the students will likely have greater math interest and intention. Therefore, these students might care more about their

performance in that math course, thus creating a very high performing average in these courses. If a particular student is struggling in a course where their peers are driven to grasp the concepts, they could feel like their knowledge gap is more extreme and more detrimental. This could lead to lower overall math confidence. However, the data does not show that this heightened pressure creates confidence deficits for students in the more advanced, Algebra 1, course.

It is important to consider that the confidence boost indicated by the data for Algebra 1 students in grade 8 likely widens the gap of math interest, intention, and success between these students and those placed in Grade 8 Math. Despite grade 8 math being the grade-level appropriate course, students in that course might feel left behind or less skilled than their peers in Algebra 1. Additional support should be in place for Grade 8 Math students to ensure that their confidence remains strong and is not diminished by their course placement. This additional support could be offered in many ways. For example, teachers could focus on emphasizing that the skills acquired in Grade 8 Math will be the foundation for future courses. Therefore, having a strong and unhurried introduction to these foundational topics may lead to greater success further on in mathematics.

Additionally, Grade 8 Math teachers should be sure to consistently provide positive reinforcement to their students. They should remind their students that they are strong mathematicians and are doing work that they should be proud of. As mentioned earlier in this paper, self-concept alone is not the whole picture of math confidence. Being viewed and accepted as a mathematician by outside influences also affects a student's math identity (Fernandez et al., 2024). Suppose teachers always call their students mathematicians and highlight the ways that students are growing and learning. In that case, the students may feel a stronger sense of math identity and therefore report higher levels of math confidence.

Course-Taking and Performance

In this study, 8th-grade math course placement was significantly associated with math performance. As discussed in the methods section of this paper, the metric for math performance was grade 9 course grades. Therefore, the statistically significant result reveals that students who took Algebra 1 in 8th grade received higher math grades in 9th grade. In many ways, this result is expected. The students who are in an advanced course in 8th grade expose themselves to higher-level content. This advanced content is likely seen again in the different 9th-grade courses. Therefore, the students who have already previewed that content in 8th grade have an advantage. Similarly, Algebra 1 as a course may have a more similar teaching style to a high school level course. Maybe this means the students are more comfortable taking their own notes or sitting through longer lectures without breaks. Having familiarity with the format of higher-level math courses will also give the students who took Algebra 1 in 8th grade a lead on their math education.

Additionally, the students in Algebra 1 in 8th grade might be performing well due to higher math confidence. As the ANOVA in Table 2 stated, students in the more advanced grade 8 course reported higher levels of confidence. It is possible that this math confidence carries into 9th grade and leads to higher math achievement for that group of students. Much of the literature in the field speculates that higher math confidence could be associated with higher math performance, which was the case in this study (see Performance and Confidence below). One explanation for this idea is that students with higher math confidence likely have greater math interest. Due to their higher interest in math, they may seek out more opportunities to do math outside of the classroom and therefore end up with a more complete understanding of the subject.

Having a strong understanding of the subject not only eases some of the stress of math but also increases math performance.

This idea is closely linked with the Social Cognitive Career Theory (SCCT). As Wang et al. write, the SCCT claims that an individual develops their career interests as a result of being exposed to the building blocks of that career. For example, someone choosing to pursue a career in mathematics was likely exposed to positive mathematical role models and exciting math classes. They saw math as an attainable yet appealing career path when they were developing academic and career interests. The students on a more advanced math course trajectory may be beginning to develop an interest in math as a potential major in college or something they would be interested in continuing to learn about and work into their careers. However, to get close to these goals of studying math beyond high school, the students must perform well in their math classes. This could drive students to work harder to earn good grades in 9th-grade math.

It is necessary to note that ANOVA results alone do not reveal a causal relationship. The statistically significant relationship between Grade 8 math course and later achievement only reveals that the average 9th-grade math grade for 8th-grade students in Algebra 1 and 8th-grade students in Grade 8 Math are significantly different. Students in Algebra 1 had higher average grades than students in Grade 8 Math, but there could be various explanations or causes for this difference. ANOVA results do not imply that different grade 8 math courses *cause* students to earn different grades in future courses.

Performance and Confidence

Another possible interpretation of the confirmed hypotheses is that there is a strong correlation between confidence and performance. The data seems to suggest that the 8th-grade students in Algebra 1 were more confident and then went on to perform better, meaning receive

better course grades, in 9th grade. So, maybe confidence leads to an increase in performance. In this study, a correlation matrix was utilized to analyze the association between confidence and performance. As seen in Figure 1, the matrix produced an R-value of 0.374, which suggests a moderately strong positive association between math confidence and math performance. As student grades increase, confidence scores increase, as well. Like ANOVA results, correlations do not indicate causal relationships. Just because the relationship between the two variables appears linear, does not mean that increased performance is the result of high confidence or the inverse. The correlation matrix simply reveals that there is a relationship between the two components.

Gender and Math Confidence

In contrast to the third hypothesis made, there was no significant interaction between gender and course-taking on math confidence in this study. The confidence and assurance that students receive from being placed in a more advanced 8th-grade course were no stronger for male students than female students. This hypothesis was tested by the ANOVA in Table 2. If the hypothesis I made had been true, the ANOVA would indicate a significant interaction between gender and the grade 8 course on reported math confidence.

I also hypothesized that female students would have lower confidence levels regardless of the math course they took in 8th grade. This result, however, was not confirmed by the ANOVA seen in Table 2. Interpreting these results accurately is critical. The result does not mean that the opposite assumption is true. In other words, based on this data it is not true that female students had *higher* math confidence scores either. Instead, the data reports no significant difference between overall math confidence for male and female students. In some ways, this finding is a

positive result. Perhaps efforts to include women in mathematics are in place and are paying off. It is possible that in this 8th-grade cohort gender stereotypes are slowly becoming less prevalent.

It may also be the case that gender disparities are more pronounced later in schooling. Many of the startling statistics surrounding gender gaps in math education highlight the idea of a “leaky pipeline” for female involvement in math. The leaky pipeline is the idea that the total number of females involved with and engaging in mathematics greatly decreases as the field becomes more specialized. That is, there are far more women in undergraduate math programs than in graduate math programs. Or there are more female math teachers at the high school level rather than at the college professor level. As mentioned in the introduction, the Association for Women in Mathematics brings to light that throughout the different levels of education, the number of women participating in mathematics steadily declines. In the context of the leaky pipeline, the students who were surveyed for this study are still at the beginning of the pipeline. Female students are still engaging with math because it is a requirement within their education. That may explain why confidence levels are still relatively equal between male and female students in 8th grade. As the math becomes more challenging and the female representation becomes worse, these same students may end up being deterred from the field.

The lack of a gender difference in confidence could also be related to the gender composition of the math courses. Since math course taking is required for middle and high school students, the number of girls engaging with math should be approximately equal to the number of men. The female math students in 8th grade are likely surrounded by female classmates. The data reveals that in either grade 8 course, the number of male and female students was very nearly equal. Therefore, a female student should not have felt outnumbered in the course at least based on the number of other female students in the room. Feeling represented

in the classroom may lead to increased levels of confidence for these girls. And understanding that the other girls in the class are also working to defy gender stereotyping.

Other possible explanations for why the data did not report a significant difference between male and female overall math confidence include the relatively small sample size. Within the data, there were 230 rows of usable data. This means the student attached to that row answered enough of the survey questions to create an accurate math confidence score, and the correct demographic information was also recorded for that student. Although this population sample does a good job of understanding math confidence in the participating district, it may not be representative of larger populations. For example, the students in the study are attending school in a city that has a highly educated population. With the University of Oregon being in Eugene, many of these students likely grew up with parents who value education and might still be associated with the university in some way. This might mean these students come from families where they saw both parents, irrespective of gender, engage in meaningful careers. Some of the students might have seen their mothers battling gender stereotypes in STEM-related fields. Ideas like this might not be as prevalent for students growing up in communities where gender roles are still more prevalent, and girls are more actively taught that their family life should be valued more highly than their career. Again, this may be a reason why these middle school students had roughly even levels of overall math confidence across males and females. Perhaps, the weight of gendered expectations was not weighing as heavy on these students. Overall, the relatively small group of students who were surveyed may not properly represent the feelings of students across the United States but do give a good insight into feelings towards math in this sample.

Gender and Math Performance

Comparable to math confidence, there was not significant interaction between gender and course taking on math performance in this study. The performance boost that students display when placed in a more advanced 8th-grade course was no stronger for male students than female students. This hypothesis was tested by the ANOVA in Table 3. In contrast to math confidence, there was a statistically significant difference in math performance based on gender where female students earned higher grades in Grade 9. There are many possible interpretations for why this may have been true. Oftentimes, there is more pressure on female students to perform well in their academics. This idea creates the image of a female student who does not cause any problems and excels in school while remaining ladylike. On the other hand, male students receive more pressure to excel in physical endeavors such as athletics. This split in expectations might cause female students to work hard to perform well even in a male-dominated field.

Another reason why the data suggests girls are outperforming their male classmates in 9th grade may be the metric used to describe math performance. To measure math performance, I used each student's 9th-grade math grade. This grade is not entirely subjective. It may be partially based on raw scores on tests and assignments, but grades from high school teachers also be based on some partiality. For example, participation is often one component of a course grade. Different inherent biases may shape the way that participation is viewed for male and female students. If a male student is participating in class by frequently speaking up, he may be considered disruptive. In fact, a teacher might believe that because the male student should be better at math, his quick and frequent participation does not give less skillful students the time to think through the problem for themselves. The combination of the ideas that boys are better at math but also less academically well-behaved may lead a teacher to see a talkative male student

as an interruption. On the other hand, teacher expectations of a female student are likely that she is calm and composed in class. Thus, if a female student is actively engaging by speaking up often, a teacher may reward that level of engagement and participation. Biases like these may lead a teacher to be more partial to female students, and thus grant them better grades.

Interestingly, another hypothesis for the success of female students in math despite existing stereotypes is that these female students are more likely to utilize outside resources such as tutoring support (Dougherty et al., 2017). Dougherty's study found that women were more likely to persevere on a difficult math track. Succeeding in a challenging math course becomes more achievable if outside help is utilized. A negative stigma exists around what it means to be tutored in math. Some people believe that getting this type of help means you are a bad student and not a skilled mathematician. These negative perceptions might be stronger for male students who want to appear strong and tough. However, female students do not face these ideas as strongly. Instead, they are willing to enlist outside help to remain ladylike by being a good, high-performing student.

For these reasons, despite the daily hardships that female math students face, female students within the data were receiving better math grades in 9th grade.

Limitations and Future Research

One of the drawbacks of using self-reported data, specifically from young students, is the level of unreliability. During data collection, it is possible that some students were uninterested in providing accurate responses and may have answered quickly and recklessly. It would be challenging to completely control for this unpredictability; however, this limitation was considered in the data analysis. To control for students who may have answered exclusively the “I don’t know” response option, I utilized an average formula with a denominator of “number of total responses-number of “I don’t know responses.” Thus, if a student only utilized the “I don’t know” response, their average confidence score would be undefined and therefore removed from further testing. This is a small adjustment that can be used to remove unreliable data.

Another limitation of the utilized data set is that it does not control for related factors such as what teacher a student may have had or how much non-math related anxiety a student has. Thus, the data only provides an image of how the students themselves feel about math. Since the goal of the present study is not to look at teacher effects on a mathematics student’s confidence, it might be overly restrictive to also control for this and other potentially related elements. Many components affect math confidence and thus math anxiety, however, the specificity of controlling only for course taking and gender will provide specific insights into the relationship between these three variables.

Additionally, the age of the data used in this project acts as a limitation. The data was originally collected in 2017 making it roughly eight years old. The topics that relate to this data and these research questions are constantly changing with society. For example, gender roles and gender stereotyping are a recurring theme throughout this work. Luckily, within society, there are constant efforts to uplift women and work towards fair and equal treatment for men and

women in all fields. Thus, the way that students of any gender feel towards math, specifically relating to representation and identity, may have shifted since 2017. Similarly, school curriculums are always changing. It is possible that in the eight years since the data was originally collected, they have introduced more math course options. This would, in turn, affect math trajectories. Understanding updated math course pathways might give more updated insight into what math course track is best for a particular student. The interplay between confidence and course-taking is largely affected by what courses are available to a student, so it is important to note how these options change over time. It is useful to have local data to analyze, but it is also valuable to keep collecting current data and understanding how the field changes over time.

Parental influences are another pillar of math identity and confidence not specifically measured in this study. The stereotype that math is for men will only be furthered if parents tell their daughters that they want them to participate in a more “traditionally female” academic area. However, none of the survey questions asked students what outside influences might affect their belief that they could succeed in math. In the data, parental attitudes should have been evenly distributed across all 8th-grade students. Some students likely have parents who have strong opinions about what fields are suitable for women versus men. Some students have parents who encourage the student to focus on whatever subject is most appealing to them. And some students have parents who do not offer their opinion at all. Either way, human randomness should spread out these different parental beliefs across students in 8th grade. If the research questions that were being explored questioned outside influences more, it would be helpful to include survey questions such as, “My parents believe I can succeed in math,” or, “My teachers want me to be a successful mathematician.” Including these questions would allow the analyses to also consider the way that outside perceptions shape an individual’s math identity.

Furthermore, gender as a binary seems to be a limitation throughout the entire project. The relationship between math and gender exists on a scale that is not necessarily binary. Moreover, gender has evolved so much since 2017 when the data was initially collected. Since the data was coming from school students, the data used school records to assign gender to each response based on student ID number. Within school records, all students were classified as either “male” or “female.” It is important to acknowledge that this data might not best reflect self-reported gender identities. Due to school-reported genders lying on a binary scale, this same gender binary was used in the conducted data analysis, however, a more focused discussion of the interplay between math confidence and gender, as *gender* as a term continues to become more inclusive, is a valuable and growing field of research.

An area of focus for future research could be learning more about the teachers that these students had for math. This ties into the theme of representation discussed in the Literature Review section. When female students feel represented by their teachers, they will be more likely to believe they can be mathematicians. Analyses comparing students who had male math teachers in 8th and 9th grade with students who had female math teachers would offer more insight into the extent of the role of gender representation in math education. Additionally, as discussed above, there could be future studies that explore the interplay between parental influences as well as influences and representation from teachers. It would be interesting to understand if parents or teachers seemed to make a bigger impact on students during their formative academic years. Moreover, future research could explore the effect of internal dissonance when parents and teachers may have different expectations and influences on a particular student. If this dissonance does occur, does it present itself as math anxiety?

Conclusion

As I approach graduation, I have an intense feeling that the achievement I am most proud of so far is obtaining a bachelor's degree in mathematics. Even before starting this project, I felt the weight of being a female mathematician. When I would tell people that I was studying math, little moments such as dropped jaws and questions of judgment left me questioning if male mathematicians had to go through the same adversities. For me, working through these stereotypes and achieving what I set out to do was an extremely rewarding process, and I hope that other female students will feel similarly about math. That idea is what led me to formulate this thesis. I know that every person deserves access to a strong math education and opportunities to be uplifted and encouraged by their teachers.

Success in math has many noteworthy implications. The article written by Rittle-Johnson opens by stating, "Proficiency in mathematics is critical to academic, economic, and life success. For example, mathematics knowledge helps people make medical and financial decisions and provides access to college and jobs." This short quotation shows that mathematics achievement and comfort unlock higher education, high-paying jobs, and an understanding of math-related fields. A study by Molly Jameson and Brooke Fusco highlights that adult learners are also restricted by a lack of mathematical literacy. Specifically, as STEM jobs become some of the highest-paying jobs, adults with low math literacy might not be able to obtain a high-paying job to support themselves (Jameson & Fusco, 2014). This study suggests that math anxiety not only affects "traditional" students but also adult learners who have career aspirations in which comfort in mathematics is required. Difficulties in math can limit access to high-paying STEM employment opportunities. The lack of access to STEM careers, however, does not affect all people equally. Women are largely underrepresented in STEM fields specifically math-heavy

STEM careers such as engineering. Women make up only 10% of civil engineers, 8% of electrical engineers, and 10% of aerospace engineers. And the gap is not only present in engineering. According to the same study, females only make up 33% of chemists and 29% of geoscientists (Leopold, 2021). These alarming statistics show that although every person needs to achieve a certain level of numerical literacy, it remains particularly difficult for women to feel comfortable enough in their mathematical abilities and mathematical representation to pursue math-heavy STEM careers.

Difficulties in math have implications for educational attainment, as well. Rising levels of math anxiety are also lowering levels of math achievement on international assessments. The Program for International Student Assessments (PISA) report revealed that for one-third of countries sampled globally, 15-year-old students in 2015 had significantly lower overall math achievement than in 2012 (Barroso et al., 2021). Thus, there is evidence that math achievement everywhere is lowering, and leaving a less mathematically literate society. This can again have impacts on the workforce. Sarah Grigg points out that with the overall comfort surrounding mathematics declining, “these educational issues foreshadow a potentially bleak social and economic landscape characterized by young people entering the workforce with math knowledge and skills equivalent to only a Year 7 or 8 level, which threatens their effective participation in the 21st-century workforce and, concomitantly, major shortages of well-trained STEM professionals.” Regardless of a student’s desire to obtain a mathematics or STEM-related career, there could be a lack of math achievement that leads to very few people being equipped with the necessary skills to strive for these high-paying, 21st-century careers. Without math-minded people to drive important areas of the workforce, the landscape of jobs will have to change or become very exclusionary for people battling math anxiety.

Along these lines, results from this study emphasize the role of middle and high school math course-taking on long-term math confidence and success. Students in 8th grade who are placed into a more advanced math class seem to gain an advantage. This advantage presents itself as increased confidence and increased academic achievement. These factors likely allow these students to continue to take challenging math courses that continue to uplift their confidence. Conversely, 8th-grade students who did not take the accelerated math course seem to be left behind. There is not an opportunity for these students to make up for the confidence lost in 8th grade.

Schools and educators should work to make sure that students of all math abilities in 8th grade are offered the same opportunities for success. Whether this means stimulating and engaging lessons that have real-world applications or opportunities to test into a more challenging course, these options should be available to all students who want to push themselves. Additionally, time needs to be spent ensuring that students of all genders are treated equally in math. Again, this can start at the teacher level. Students need to see teachers of diverse backgrounds, including gender and racial diversity. This allows students to feel represented as a learner and mathematician.

When math is a comfortable part of someone's life, it can be used as a tool to teach problem-solving techniques, tenacity, critical thinking, and community. For these reasons, it is necessary to encourage safe math learning for all students. No student should feel excluded from such a fundamental subject due to their gender identity, natural ability, or confidence levels. I am hopeful that continual efforts will make math a more inclusive space, and I know that asking questions and performing research is what helps the field grow. As of now, we know that course-taking plays a large role in student confidence and success, and gender stereotypes affect the

perception of girls doing math. These findings can act as baseline knowledge for future research to build from. With more questions asked and answered, I hope to see an increase in female involvement in math in the future.

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