The Relationship Between Achievement in and Attitude toward Mathematics in the Digital Age

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Abstract

The goal of this paper is to investigate the relationship between students' attitude toward the subject of mathematics (ATM) and their achievement in mathematics (AIM) in the context of online schooling. Further, this project seeks to compare the AIM-ATM relationship of students who take a math course online with that of students who take math in a physical classroom setting. While previous studies have explored the AIM-ATM relationship, the results have been inconsistent, and none have been performed in the age of digital learning. In this project, the data were collected from 144 high school respondents through a Google Form that was shared on social media and several forums. Spearman Rank Correlation Coefficient (SRCC) tests were conducted on the AIM and ATM data provided by respondents, and further testing was done on the demographic characteristics of the respondents in order to control for confounding variables. The results suggest that there is a positive, monotonic relationship between AIM and ATM for students taking math online, but there is no AIM-ATM relationship for students taking math in-person. No demographic characteristics appeared to influence AIM except for sex. These findings have the potential to affect future pedagogical methods for mathematics.

Keywords
AIM, ATM, online, SRCC, regression.

1. Introduction
The COVID-19 pandemic has been ongoing for the past two and a half years. During this period of time, educational systems across the globe have been reshaped dramatically as schools and universities closed to prevent the spread of the virus. As a result of the inability to meet in person, online schooling programs became widespread. This new method of learning has understandably affected both how courses are taught and how students learn.

1.1 Objectives
Although previous research papers have investigated the relationship between students' attitudes towards the subject of math and their levels of achievement in their math classes, most of these studies were conducted before the advent of online schooling. Besides, many studies concerning this subject had conflicting results; while some findings demonstrate a strong relationship between achievement in math (AIM) and attitude toward math (ATM), others show that the AIM-ATM relationship is quite weak. This paper seeks to:

1. Investigate the relationship between AIM and ATM for high school students who attend school online,
2. Compare the relationship between AIM and ATM between high schoolers who take math online and those who take math in brick-and-mortar schools, and
3. Provide new data to this pre-existing body of research and clarify prior inconsistent findings.

The ultimate goal is to explore the AIM-ATM relationship in the context of the digital age.

2. Methodology and Data Collection
To recruit respondents for this project, a Google Form was posted on Instagram® and sent to various social groups and public forums; 151 respondents were recruited. These respondents included students attending Stanford Online High School (SOHS) as well as other schools. Each respondent provided their age, race, and sex. They were also asked to provide:

1. Their grade level: 7th through 12th grade;

2. Their mode of math learning: online or in-person;
3. The math course they are enrolled in: pre-algebra, algebra I, geometry/trigonometry, algebra II, pre-calculus, calculus, university-level math, or other; and
4. The range that their average grade in math is in: >95%, 90% < x ≤ 95%, 85% < x ≤ 90%, 80% < x ≤ 85%, …, ≤55%.

Lastly, respondents subjectively rated their attitude toward the subject of mathematics in general on a scale of 1 to 10, where 1 indicated negative feelings and 10 indicated positive feelings. Respondents were also given a space to provide additional comments related to their response to the preceding question.

The math course options are ranked in order of increasing difficulty. Responses from students taking multiple math courses were discarded to prevent possible confounding effects of taking more than one math course. With these responses removed, data from 144 respondents remained.

3. Data Description

This is an overview of the data from 144 respondents that were collected in the survey.

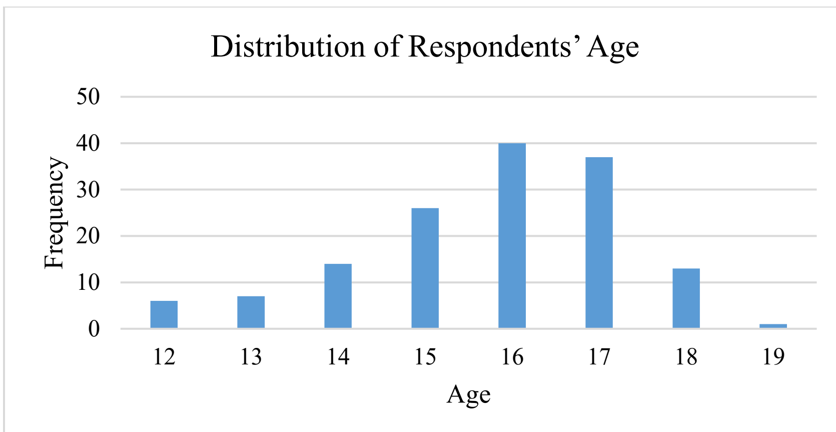

Figure 1. Respondents' Age

The distribution of respondents' ages is skewed to the left. The mean age of respondents is approximately 15.77 years old, and the median and mode age is 16 years old. Around 27.78% of respondents are 16 years old, forming the relative majority of the age groups. The second largest age group is 17 years (approximately 25.69% of respondents). Only one respondent is 19 years old (approximately 0.69% of respondents). The range of respondents' ages is 12 to 19 years old, or 7 years. (Figure 1).

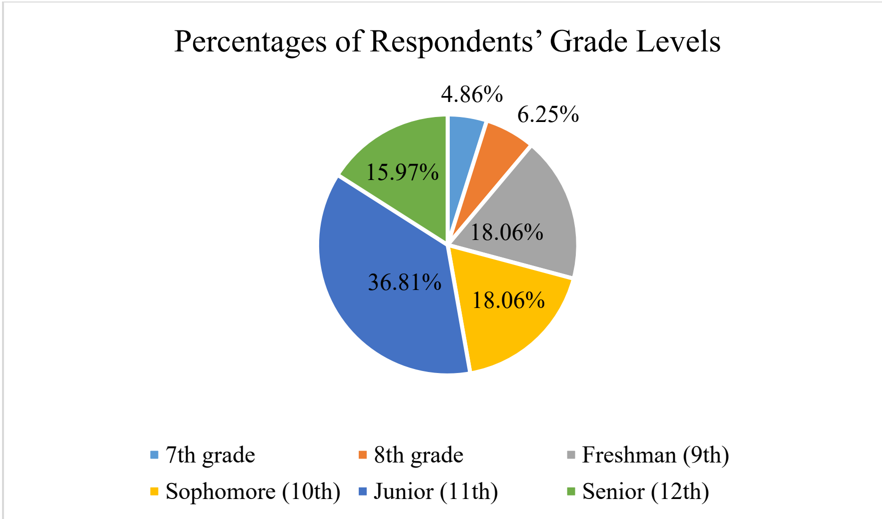

Figure 2. Percentages of Respondents' Grade Levels

In figure 2, The relative majority of respondents are juniors (11th grade), comprising of approximately 36.81% of respondents. The freshmen (9th grade) and sophomores (10th grade) are tied for the second largest group of grade level for respondents, both including about 18.06% of respondents. The smallest group of respondents is those in 7th grade, taking up only 4.86% of responses.

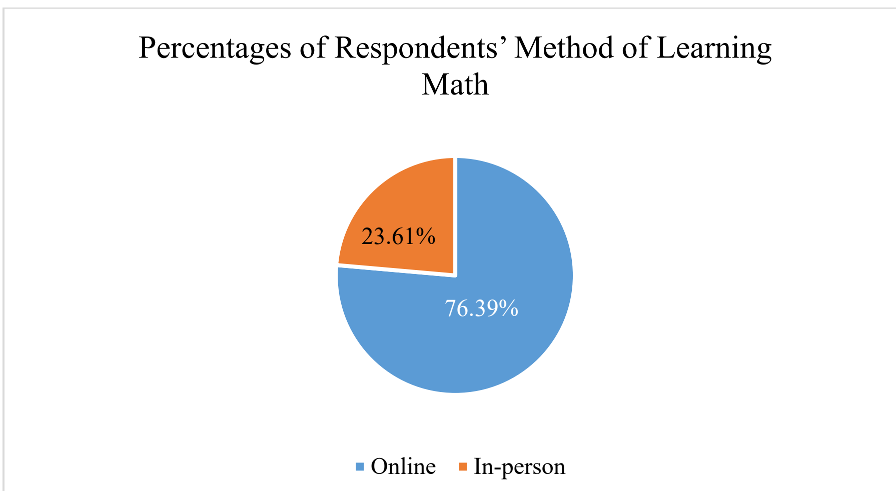

Figure 3. Percentages of Respondents' Method of Learning Math

In figure 3, A majority of respondents (approximately 76.39%) indicated that they are taking an online math course. Around 23.61% of respondents stated that they are taking math in-person.

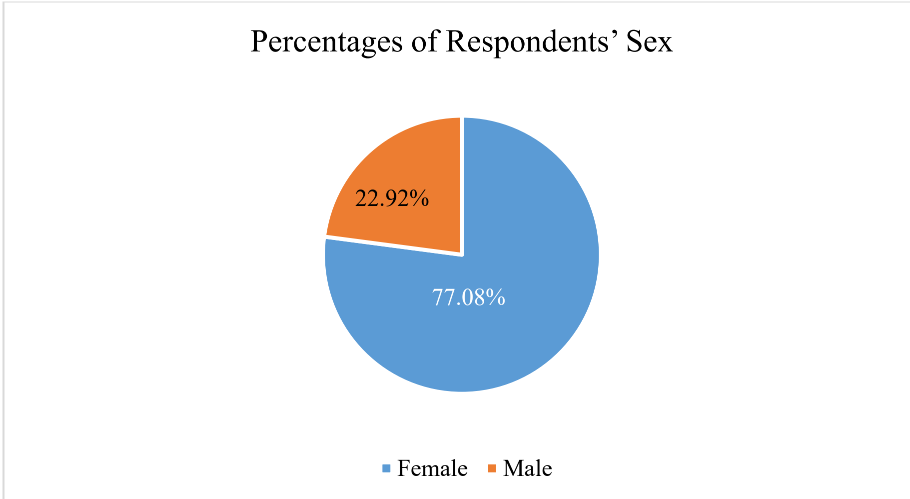

Figure 4. Percentages of Respondents' Sex

Most respondents (77.08%) are female, and only 22.92% of respondents are male (Figure 4).

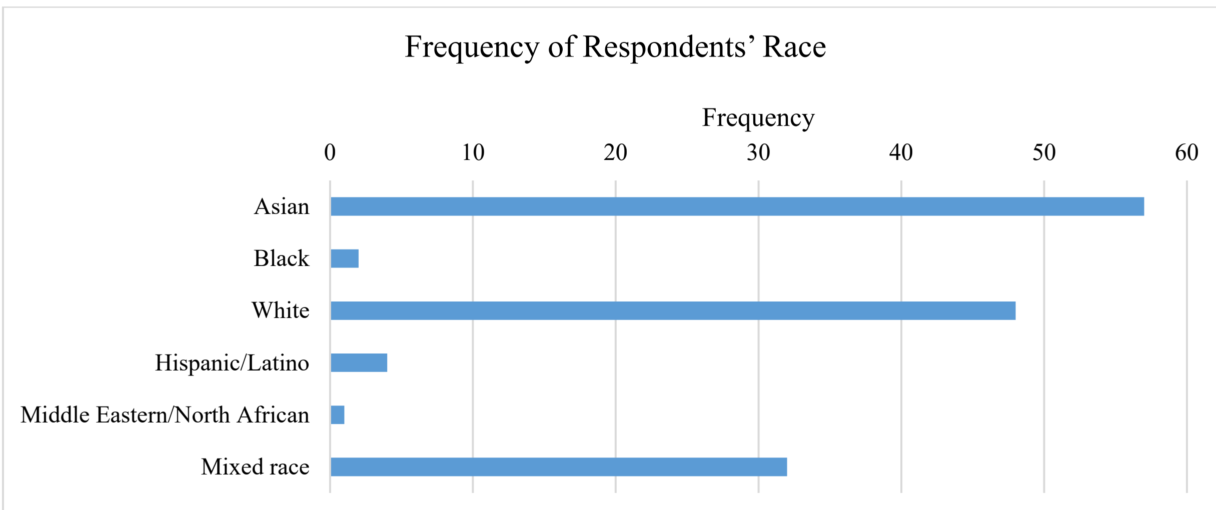

Figure 5. Frequency of Respondents' Race

Asian respondents (excluding mixed-raced Asian respondents) form a relative majority, comprising approximately 39.58% of all responses. The second largest racial group are those that identified themselves as white (about 33.33%). The third largest racial group are those that identified themselves as mixed race (about 22.22%). Of the mixed-race respondents, almost half (approximately 40.63% of the mixed-race respondents) are white and Asian (Figure 5).

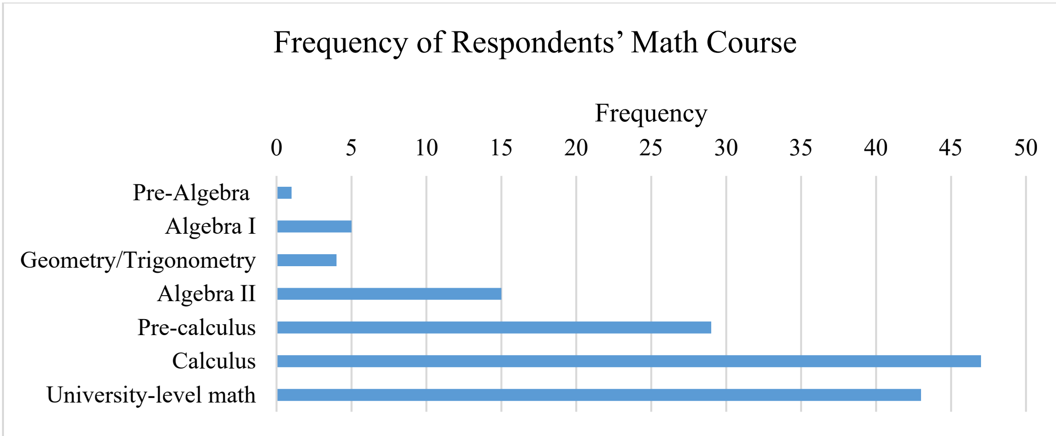

Figure 6: Frequency of Respondents' Math Course

The largest percentage of respondents indicated that they are enrolled in a calculus course (approximately 32.64%). The second largest group is those taking university-level math (about 27.78%), and the third largest group is those in pre-calculus (approximately 20.14%) (Figure 6).

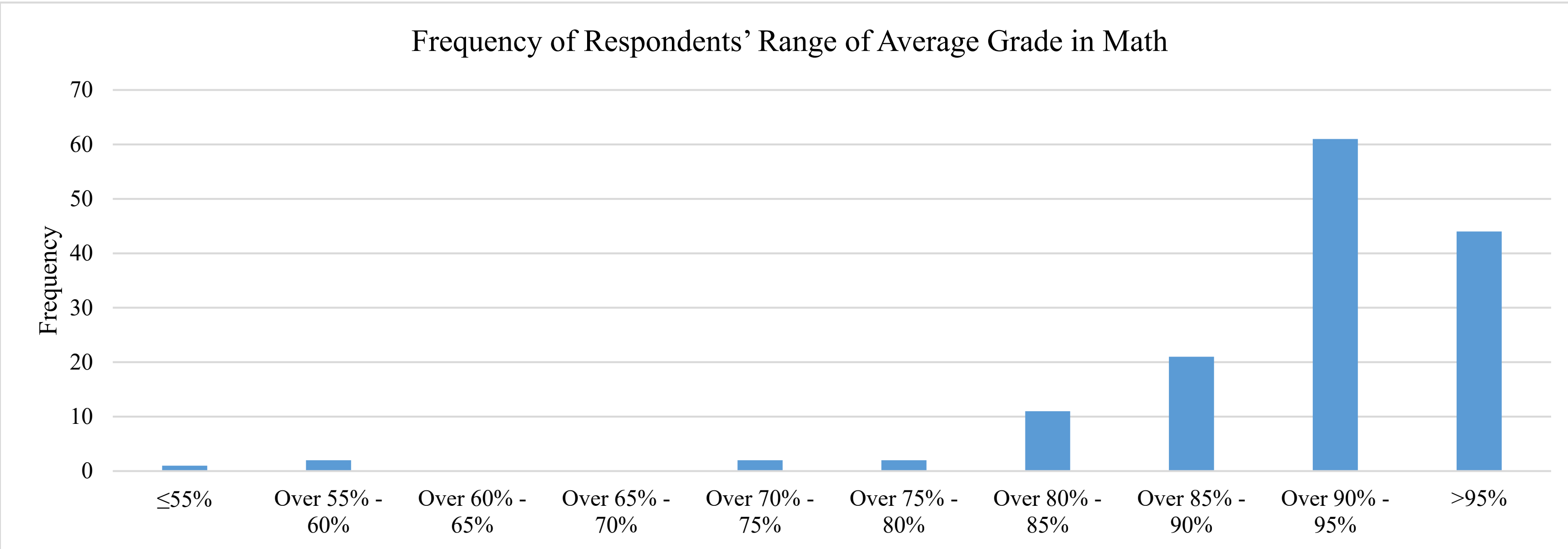

Figure 7: Frequency of Respondents' Range of Average Grade in Math

The distribution of respondents' average grade in math is skewed to the left. The median and mode grade range are over 90% but less than 95% (approximately 42.36% of respondents). The second most common range for respondents' grade average is greater than 95% (approximately 30.56% of respondents). These data indicate that most respondents are high achieving math students (Figure 7).

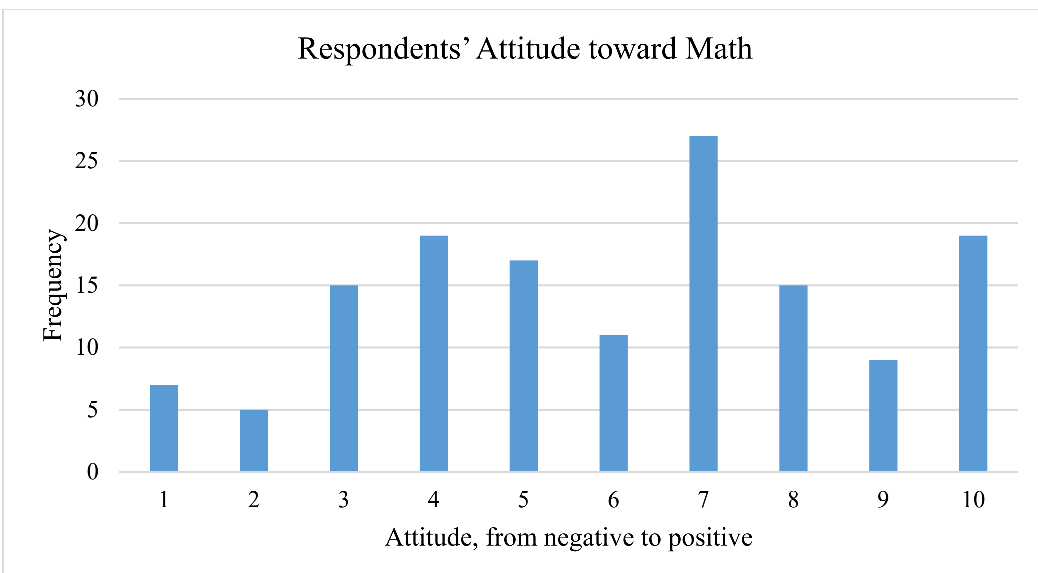

Figure 8: Respondents' Attitude toward Math

The distribution of ATM is slightly skewed to the left. The median attitude rating is 6 (approximately 7.64% of respondents), and the mode rating is 7 (18.75% of respondents). The ratings of 4 and 10 are tied for the second most common rating (both include approximately 13.19% of respondents). The least common rating is 2 (only around 3.47% of respondents). The range of the rankings is from 1 to 10 (Figure 8).

4. Statistical Testing

4.1 AIM and ATM

In order to test for a monotonic relationship between AIM and ATM, a Spearman Rank Correlation Coefficient (SRCC) test was conducted using the grade averages of the respondents and the rating of their attitude toward math. To carry out the test, a ranking of the ranges of average grades was produced: "less than 55%" was assigned the number 10, "Over 55% - 60%" was assigned the number 20, and so on. The SRCC test is appropriate for these as the two variables used to measure AIM and ATM are paired, ordinal scale variables.

For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no monotonic relationship between a respondent's AIM (as measured by their grade average) and ATM (as measured by the rating of their feelings).
H_a: there is a monotonic relationship between a respondent's AIM and ATM.

The Spearman coefficient is calculated through the following formula: $p = 1 - \frac{6\Sigma d_i^2}{n(n^2-1)}$, where p represents the correlation coefficient, d_i represents the difference between the two ranks of each observation, and n is the number of observations. Here, n equals 144. The SRCC test yields a p test statistic of 0.3534 and a P-value that is less than 0.001. Because the P-value is less than α, the null hypothesis can be rejected. The positive correlation coefficient indicates that a positive, monotonic relationship exists between AIM and ATM; respondents that perform better in their math class are more likely to have a more positive attitude toward the subject in general. It is necessary to note that, while the test indicates that a positive relationship exists, the relationship is somewhat weak.

4.2 Schooling method, AIM, and ATM

The primary goal of this paper is to compare the AIM-ATM relationship between respondents that take an online math course versus an in-person course. First, an SRCC test between AIM and ATM for respondents that take math online was conducted. For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no monotonic relationship between AIM and ATM for respondents that take math online.
H_a: there is a monotonic relationship between AIM and ATM for respondents that take math online.

There are 110 respondents that answered that they take math online, so n is 110. The SRCC test yields a p test statistic of 0.3943 and a P-value that is less than 0.001. Because the P-value is less than α, the null hypothesis can be rejected. The positive correlation coefficient indicates that a positive, monotonic relationship exists between AIM and ATM for respondents that take math online; respondents that perform better in their online math class are more likely to have a more positive attitude toward the subject in general.

Next, an SRCC test between AIM and ATM for respondents that take math in-person was conducted. For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no monotonic relationship between AIM and ATM for respondents that take math in-person.
H_a: there is a monotonic relationship between AIM and ATM for respondents that take math in-person.

There are 34 respondents that answered that they take math in-person, so n is 34. The SRCC test yields a p test statistic of 0.2629 and a P-value of 0.066696. Because the P-value is greater than α, the null hypothesis cannot be rejected. The results of the test do not indicate that a relationship between AIM and ATM for respondents that take math in-person exists.

4.3 Age and AIM

Further testing was needed to find if other demographic variables had an effect on respondents' AIM. First, regression analysis was performed on respondents' age and their AIM. For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no relationship between age and AIM.
H_a: there is a relationship between age and AIM.

The test yielded a t test statistic of -0.9746 and a P-value of 0.3314 for the age variable, which is not statistically significant. Thus, there is insufficient evidence of a relationship between age and AIM, and we may conclude that age does not affect AIM. The R^2 value for the regression test is only 0.0066, which indicates that the linear model does not fit the data well.

4.4 Age, Sex, and AIM

A multiple regression test was performed on age, sex, and AIM of respondents to determine if there was a relationship between the three variables. To perform this test, a dummy variable for male respondents was created. For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no relationship between age, sex, and AIM.
H_a: there is a relationship between age, sex, and AIM.

The test yielded a t test statistic of -1.3715 and a P-value of 0.1724 for the age variable, which again is not statistically significant and indicates that there is insufficient evidence that there is a relationship between age and AIM. There is a t test statistic of 2.0127 and a P-value of 0.046047734 for the sex variable. This result is statistically significant. The coefficient of the sex variable is 1.0420, which suggests that, if someone is male, they are predicted to have a 1-point higher rating of mathematics than their female counterparts, given that age is fixed. The R^2 value for this test is low—only 0.0344—but higher than that of the age-AIM regression test.

4.5 Age, Sex, Grade, Method of Schooling, Math Course, and AIM

To determine if demographic characteristics (age, sex, etc.) affected respondents' AIM scores, multiple regression analysis was performed on sex, grade, method of schooling, and math course. In order to perform the test, dummy variables were assigned to each of the respondent traits. For this test, α is 0.05. The relevant hypotheses for this test are:
H_0: there is no relationship between AIM and any of the other variables.
H_a: there is a relationship between AIM and at least one of the other variables.

None of the variables yielded statistically significant P-values except for sex. The dummy variable for female respondents yielded a coefficient of -0.9591 and a P-value of 0.04217. These results indicate that the only demographic characteristic that affected the respondents AIM was sex. .

5. Results and Discussion

5.1 Analysis of SRCC Results

The difference in the results of the SRCC tests between respondents taking math online and in-person suggests that the method of learning mathematics has an effect on students' AIM and ATM. Online schooling could possibly establish a more predictable relationship between AIM and ATM for students as opposed to in-person learning, which has positive implications for the educational system during this period of the new normal.

5.2 Analysis of Regression Results

Regression analysis illustrates that, largely, demographic characteristics, such as age, do not affect students' AIM. However, sex does appear to have a relationship with AIM, where female respondents generally had a less favorable view of mathematics. This may reflect upon the systemic discrimination that women continue to face in STEM fields and the misogyny that female students are confronted with in classrooms. Other factors, such as race, may have an affect on AIM, and further testing is necessary to the influence of such aspects.

5.3 General Analysis of Results

The sample size for respondents taking math in-person was much smaller than that for respondents taking math online, which may have affected the results of the statistical tests. Most respondents are female, and they are likely to be Asian or white. The majority of respondents are older students taking challenging math courses. Some respondents commented that social factors, such as their interactions with their teachers and peers, impacted their ATM.

6. Conclusion

While a relationship between achievement in math and attitude toward math was found for all respondents, when comparing online and offline math learners, this relationship only appeared to exist for respondents taking math online.

These findings may encourage more schools to shift their method of teaching mathematics to an online method, which may produce more consistent results of achievement. The lack of association between AIM and ATM for students taking math in-person corroborated previous research investigating this relationship (Ma and Kishor, 1997). The statistically significant result for the first SRCC test is likely due to the relationship between AIM and ATM for respondents taking math online. Regression analysis highlights the need to ensure that female students are given the same treatment as their male peers in the math classroom. Overall, further sampling and testing are required to clarify the discrepancy in results for respondents taking math online versus those taking math in-person.

References

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Biography

Alina Zhong is a rising senior at Stanford Online High School. In school, she plays an active role in student life as the president of her school's Gender and Sexuality Alliance, a leader of the Literature Club, and a member of student government. Outside of academics, she acts as the executive director of Activism Impacts, a youth-led activism organization. She is also a regional director at Innoverge International, a non-profit dedicated to making STEM education accessible for all. In her free time, she enjoys reading, writing, and playing the guitar. Ultimately, she plans to study ecology and environmental science in hopes that her future research will help better society.