

Effects Of Online Tutoring on Test Scores, Confidence, and Future Career Paths During the Pandemic

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ABSTRACT

Since the outbreak of COVID-19 in 2020, online learning has rapidly begun to replace in-person learning and demand for online tutoring has grown. The switch to remote learning has also exacerbated learning inequality, as shown by students' test scores. The paper examines the efficacy of Manhattan ACE's mathematics online tutoring model to provide a template for creating a valuable online tutoring experience.

To understand the main aspects of online learning and its effects on students' learning outcomes, an electronic survey was created and sent to the students. The survey contained both Yes/No questions and scaled 1-5 questions. Analysis of the survey responses shows that through a combination of factors such as passionate tutors and a responsive learning environment that feels like a community, online learning can boost both students' grades in math class and the effectiveness of virtual learning, while fostering students' confidence in their skills and future career choices. These three outcomes can, in turn, work to minimize educational and resource inequality.

Introduction

Online tutoring, tutoring that takes place in a virtual or online environment, has bloomed during COVID-19 (scientifically known as SARS-CoV-2). It has impacted the education of up to "94% of the world's student population, and up to 99% in low and lower-middle income countries" (United Nations, 2020). On March 15, 2020, all public schools in NYC shut down, resulting in schools transitioning to online learning (CDC, 2020). When students were unable to have in-person classes due to the pandemic, many parents turned to online tutoring to continue their child's learning. To illustrate, Chegg, an online education company, saw its 2020 total net revenue increase by 57% and subscriber rate by 67% (Chegg, 2020). Similarly, Khan Academy saw its student registrations grow by 6x and parent registrations by 20x between March and May of 2020 (Khan Academy, 2020).

COVID has caused test grades to fall dramatically. In the fall of 2021, after almost two full years of online school, students in grades 3-8 had math test scores that were 0.20-0.27 standard deviations lower compared to in fall 2019, before schools transitioned online. Math test scores seemed to suffer more losses at the beginning, compared to reading (Kuhfeld, et al., 2022). Additionally, math test scores have seen less recovery than science and social science subjects. The test scores of the highest performing students have also fallen (Gambi, et al., 2021). Moreover, the COVID-19 pandemic has disrupted learning more significantly than previous school interruptions, such as natural disasters (Kuhfeld, et al., 2022). Lastly, the COVID pandemic also exacerbated educational inequalities, especially in socioeconomic status, between students (Haack, et al., 2020). A 2020 study showed that students in disadvantaged neighborhoods had higher learning losses (Maldonado and DeWitte, 2020).

Since COVID-19 has significantly setback students' learning, it is important to pinpoint ways to get students back on track. This research aims to understand in what cases and how online tutoring can become an effective supplement to classroom learning, and what factors can result in a more functional experience. This paper contrib-

utes to existing literature on the effects of online learning on students' and how schools and tutoring services can most efficiently combat the resulting increased education inequalities.

Methods

The survey was created on Google Forms and sent out as a link to the respondents. The description detailed that all responses would be anonymous and would for a research study. The link was sent twice and collected 67 responses. The responses were collected between 7/17/2022 21:04:41 EST and 7/31/2022 10:11:06 EST. The survey contained basic information about students, such as gender and number of siblings. Students were also asked to answer questions on a 1-5 scale as well as choosing between Yes or No. The questions pertained to the tutoring service in general and specifically to their math classes. The responses can be used as a case study and the conclusions can be extrapolated to the general online tutoring environment.

Results

Following the collection of the survey responses, data treatment was performed in Python, where the non-numerical responses were mapped to a corresponding integer value in order to run the fitting statistical tests.

Through Python and a correlation matrix (Figure 1), the results show that there is a strong positive correlation between the enjoyability and helpfulness of the math team, as depicted by the dark red squares in the matrix. The next two strongest positive correlations were between attendance to the math team, and the perceived enjoyability and helpfulness of the math team.

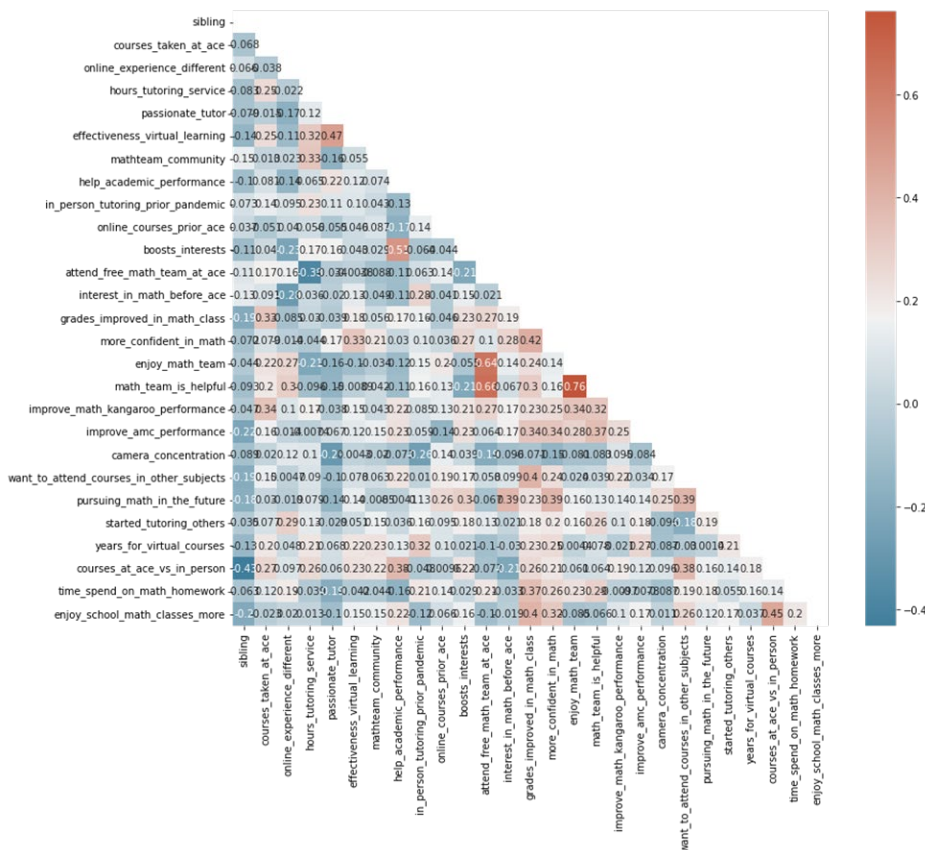


Figure 1. Correlation matrix between the variables tested. The more pigmented colors represent stronger correlations.

The results of the survey indicate that the tutors' passion while teaching the class factored strongly into the students' perceived effectiveness of virtual learning. After dropping the variables that were statistically insignificant, the two variables that showed a consistently low p-value were having a passionate tutor and taking more tutoring hours (Table 1). The model was also checked to make sure that it fitted the homoscedasticity assumption of linear models, that the error stays relatively constant in relation to the dependent variable. The residual plots created in Rstudio (Figure 2) show the unexplained variance, which mirrors the error, meaning that bias in the residuals correlates to bias in the error. The red line in the Residuals vs Fitted graph is almost completely horizontal at 0, indicating that there are no outliers or biases in the sample size that might invalidate the regression. Furthermore, the Normal Q-Q graph shows a close 1-1 relationship between the standardized residuals and theoretical quantiles. Together, these two graphs can indicate that the model meets the homoscedasticity assumption.

Table 1. Linear regression for “effectiveness_virtual_learning.” The two variables, hours_tutoring_service and passionate_tutor, are the most statistically significant.

Effectiveness of online tutoring: effectiveness_virtual_learning						
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
hours_tutoring_service	0.0876	0.0348	2.5162	0.0143	0.018	0.1572
passionate_tutor	0.8514	0.0285	29.8568	0	0.795	0.9084
No. Observations:	67.000					
F-statistic:	1363.000					
Prob (F-statistic):	0.000					
R-squared (uncentered):	0.977					
Durbin-Watson:	1.829					
Skew:	-0.346					
Kurtosis:	3.084					

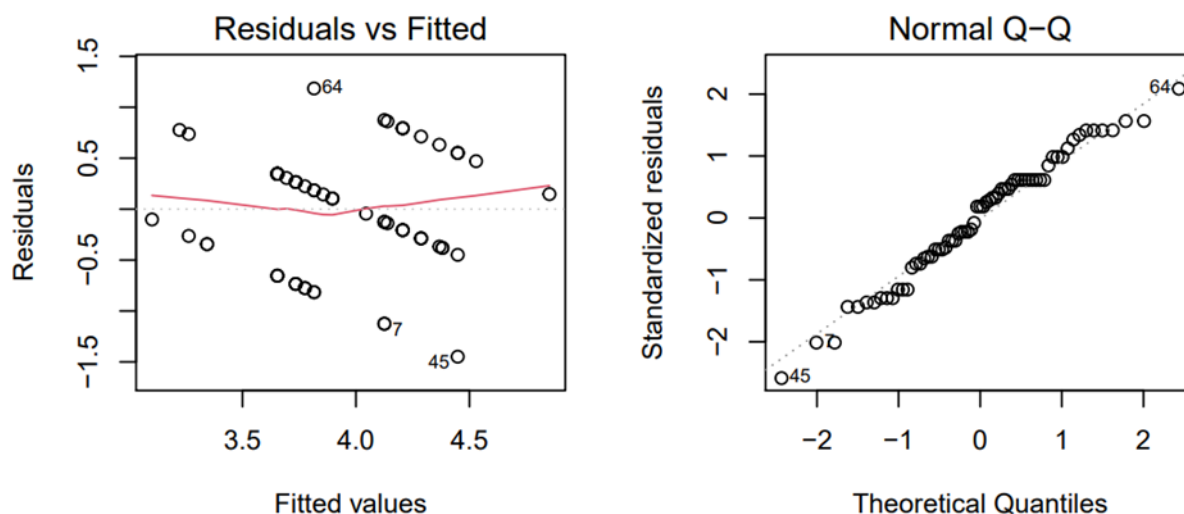


Figure 2. Residual plots run in Rstudio on “effectiveness_virtual_learning.” As seen in “Residuals vs Fitted,” the red line is mostly horizontal. The line of best fit in “Normal Q-Q” shows a 1-1 ratio. Both graphs indicate that the data fits the homoscedasticity assumption of linear regressions.

In addition to showing the possible effectiveness of online tutoring, the data from the survey also indicates that online tutoring can improve school math class grades, increased students' confidence in their math skills, and cultivate students' interest in pursuing math in the future. These three results are supported by linear regressions constructed in Python.

The two factors that explained the higher math test scores were attending the free math team ($p=0.0134$) and feeling more confident in their math skills ($p<0.0001$), as shown in Table 2. Students' confidence in their mathematical skills is a crucial element to higher test scores, as shown by its low p-value.

Table 2. Linear regression for “grades_improved_in_math_class.” “more_confident_in_math” can be seen with a p-value <0.001 , indicating its significant in improving students' grades.

Increased scores: grades_improved_in_math_class						
	Coef.	Std.Err.	t	P> t 	[0.025	0.975]
attend_free_math_team_at_ace	0.414	0.163	2.542	0.013	0.089	0.739
more_confident_in_math	0.559	0.082	6.816	0.000	0.395	0.723
No. Observations:	67.000					
R-squared (uncentered):	0.795					
Durbin-Watson:	1.799					
Skew:	-0.592					
Kurtosis:	2.714					

Students' increased confidence in their math skills can be attributed to five factors: taking more tutoring hours ($p=0.0227$), having a passionate tutor ($p<0.0001$), improved Math Kangaroo (an international math competition for students K-12) performance ($p=0.0316$), increased interest in math as a future occupation ($p=0.0001$), and higher perceived community environment in the math team ($p=0.0028$). The regression resulted in a r-squared value of 0.927, illustrating that the five factors can almost completely account for the reasons why students feel more confident in their math abilities (Table 3).

Table 3. Linear regression for “more_confident_in_math.” “pursuing_math_in_the_future” has a p-value <0.001 , showing that it has the largest influence on students' confidence.

Confidence: more_confident_in_math						
	Coef.	Std.Err.	t	P> t 	[0.025	0.975]
hours_tutoring_service	-0.068	0.029	-2.337	0.023	-0.126	-0.010
passionate_tutor	0.214	0.038	5.556	0.000	0.137	0.290
improve_math_kangaroo_performance	0.238	0.108	2.199	0.032	0.022	0.454
pursuing_math_in_the_future	0.361	0.089	4.043	0.000	0.182	0.539
mathteam_community	0.134	0.043	3.108	0.003	0.048	0.221
No. Observations:	67					
R-squared (uncentered):	0.927					

As shown in Table 4, students' interest in math as a future career field can mainly be explained by three factors: interest in math before attending math tutoring ($p=0.0055$), increased confidence in math ($p=0.0002$), and students' view that turning on cameras would increase their concentration ($p=0.0021$). Since it is mandatory that students turn on their cameras during class, increased concentration on the class led to students wanting to pursue math in the future. The Durbin-Watson value for the linear regression model is 2.225, which is between the range of

1.5 and 2.5. Such a Durbin-Watson value demonstrates that autocorrelation is not problematic in the regression model. Lastly, since the r-squared is at 0.805, it shows that there is room for further research to find another variable that may result in increased interest in math as a future occupation. Additional study on why students gravitate towards math as a career interest may minimize the gender gap in STEM fields and contribute to the general consensus.

Table 4. Linear regression for “pursuing_math_in_the_future.” The low p-values across the board for all three variables suggests their importance for pursuing a math related career in the future.

Interest in pursuing math in the future: pursuing_math_in_the_future						
	Coef.	Std.Err.	t	P> t 	[0.025	0.975]
interest_in_math_before_ace	0.258	0.090	2.876	0.006	0.079	0.438
more_confident_in_math	0.302	0.077	3.917	0.000	0.148	0.456
camera_concentration	0.328	0.102	3.200	0.002	0.123	0.532
No. Observations:	67					
R-squared (uncentered):	0.805					
Kurtosis:	2.389					
Durbin-Watson:	2.225					

Discussion

Students’ opinions on the effectiveness of online tutoring were highly dependent on their tutor’s passion. When running a simple linear regression with “passionate_tutor,” (as shown in Table 1) the r-squared was high at 0.974, showing that having a passionate tutor accounts for nearly all of why students believe online tutoring is effective. Furthermore, with a coefficient of 0.9, a 1% increase in students’ perceived tutor’s passion would result in a 0.9% increase in students’ believed effectiveness of online tutoring. Tutors’ influence on the class’s effectiveness has also been argued in previous studies, such as Baber (2020) and Alqurashi (2019). These ideas support the belief that online tutoring can be even more effective than in person learning in many circumstances (Means, Toyama, Murphy, Bakia & Jones, 2010). The kurtosis value measures the “tailedness” of a variable. A kurtosis value near 3 reflects a normal distribution. The kurtosis value for the linear regression model is 3.023, indicating that the data collected from the survey represents normal behavior in the larger population.

Finding ways to raise test scores and fill the loss of learning during the pandemic is extremely important, as drops in students’ test scores have been seen across the board during the pandemic. The National Center for Education Statistics (NCES) has shown that the COVID-19 pandemic witnessed the largest average score decline in reading tests since 1990 and was the “first ever score decline in mathematics” (NCES, 2022). Moreover, they found that lower-performing students saw greater score decreases when compared to high performing students (NCES, 2022). Thus, it can be seen that online tutoring has the potential to be helpful, especially in unexpected situations where students have to switch to remote learning. Cultivating students’ confidence and encouraging them to utilize their skills helps them to raise their test grades.

Confidence in one’s mathematical skills can be attributed to taking more tutoring hours and seeing the math team as a community would allow students to implement the concepts they learned under more informal conditions. The conclusion that students’ perception of math team as a community is an important factor to confidence fits in with the previous research. A 2009 study showed that students that could actively practice their skills in a “non-threatening environment” showed better performance and increased confidence (Roberts et al., 2009). Prior research has also found that students in an online environment work better together than independently, which is precisely how students work in the math team (Means et al., 2010). The resulting self-confidence has also been shown to aid

learning outcomes, where students who have higher confidence also have higher learning outcomes than those who had lower confidence (Sihotang, Setiawan, Saragi, 2017).

Raising students’ interest in pursuing math as a future career can work to decrease the gender gap in STEM fields and push for further changes. Previous studies have shown that introducing students to STEM subjects early on and to a variety of STEM contests has a positive influence on the students’ interest in STEM careers (Maiorca et al., 2020 and Miller et al., 2017). Thus, it is reasonable that students who had previous interest in math and now have added confidence in their skills would be more likely to see math as a possible career direction. Table 5 illustrates the gender difference in if students are more likely to pursue math in the future. Male students were more definite in their choices, being twice as likely as females to see math as a future career path. Female students were more likely to be “considering” and less likely to completely dismiss math as a future career. In addition, males saw the math team was a community more than their female counterparts (Table 6). This data shows that working to minimize the gender gap in STEM fields may be related to create a female STEM community.

Table 5. PivotTable for gender differences in “pursuing_math_in_the_future.” Male students have more extreme opinions, while females are more likely to be unsure or considering.

Row Labels	Count of pursuing_math_in_the_future	% of the Gender
Female	27	
0	3	11%
1	21	78%
2	3	11%
Male	40	
0	11	28%
1	19	48%
2	10	25%
Grand Total	67	

Table 6. PivotTable for gender differences in “mathteam_community.” Male students were more likely to see math team as a community and the female responses were more equally split between the five ratings.

Row Labels	Count of mathteam_community	% of the Gender
Female	27	
1	4	15%
2	5	19%
3	5	19%
4	10	37%
5	3	11%
Male	40	
1	2	5%
2	4	10%
3	9	23%
4	9	23%
5	16	40%
Grand Total	67	

Overall, the data shows that online tutoring can reach beyond test scores and acting as a supplement to classroom teaching. There are multiple effects that cannot be seen on the surface, such as an increased interest in pursuing math in the future and elevated confidence in students' capabilities.

Conclusion

To conclude, the factors that largely affected the effectiveness of virtual learning and its non-numerical effects were tutor's passion, increased confidence, and applying the learned concepts. Attending a math team where acquired skills were consistently utilized and becoming more familiar with the topics resulted in higher math class grades in school. Considering mathematics as a future occupation also factored towards higher math confidence. Through these aspects, online tutoring can work to guide students back to their pre-pandemic performance levels and supplement their confidence in their learning capabilities. By concentrating on finding passionate and experienced tutors and introducing a space where students can implement their skills and build a strong community, online tutoring organizations can better counter the learning difficulties and education inequalities brought on by COVID-19. Online tutoring has the potential to be a powerful resource to students and their families when conducted well.

Limitations

These conclusions should be seen as a point in time, taken specifically from the students of ManhattanACE as the responses only spanned 15 days. A longer length study would be needed to understand the long-term effects of online tutoring on students and smooth out undetected outliers. In addition, a few of the responses were submitted by elementary school students, which may be less clear than the responses by high school students.

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