

Currents

In Teaching and Learning

ACADEMIC
JOURNAL



VOLUME 13 NUMBER 1 SEPTEMBER 2021



WORCESTER
STATE
UNIVERSITY

PROGRAM REPORT

Mathematics Tutoring in Higher Education: Impact on Students and Student Tutors

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Abstract

This paper discusses the current literature of mathematics tutoring in higher education and examines the effectiveness of the Math Center at a mid-sized University in the northeast region of the United States of America. Two surveys were developed, one for students who visited the math center and one for tutors who worked in the math center. The goal of these surveys was to assess the impact that tutoring has on each group's academic performance, as well as their attitude toward mathematics. The findings were that both the students and the tutors were positively impacted by the tutoring in the center in both areas. A quantitative analysis was also completed and found significant results in the effectiveness of the math center. The findings were that students who visited the math center five or more times were more likely to pass math courses than students who visited less than five times. The conclusion is that institution-based math tutoring services are a valuable resource for students in mathematics courses.

Keywords

tutoring, tutoring center, math center, student academic support services

Mathematics Tutoring in Higher Education: Impact on Students and Student Tutors

The goal of this study is to examine the effectiveness of tutoring across a range of classes and a range of students. This article examines the impact and effectiveness of a mathematics tutoring center in a higher education setting. Two phases were used in this study: a survey of students and tutors and then a quantitative analysis of student grades. After a brief review of current literature on tutoring in higher education, the survey is discussed. The survey asks both students and tutors to evaluate the impact and effectiveness of the mathematics tutoring center, called the Math Center in this report, from their own perspectives. Following the survey discussion, a quantitative analysis of student grades is presented to determine the effect of tutoring on student grades from the official college transcript. The paper concludes with a discussion of the findings and recommendations for further study.

The Need for Mathematics Competency

Many colleges and universities have developed programs through which any student can receive free tutoring (Menz & Jungic, 2015; Robinson et al., 2005; Xu et al., 2001). Robinson et al. (2005) noted that there is a need for tutoring in mathematics because competency in mathematics content is a priority for the United States of America, specifically because the United

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States lags behind its global counterparts like Singapore, Korea, Australia, and Canada. The United States ranked 19th out of 38 countries in the Third International Mathematics and Science Study-Repeat (TIMSS-R). The TIMSS-R compared mathematics and science competencies of eighth grade students internationally in 1999 (Gonzales et al., 2001). The U.S. ranked 40th out of 70 countries in the Program for International Student Assessment (PISA) study in 2015 (Kastberg et al., 2016). Not only is there a desire to produce students of the highest quality, but as Robinson et al. (2005) asserted, there is a need because the United States is a part of an increasingly global and technological world.

The need to produce students of the highest quality, along with the limited resources in higher education, often leads universities to invest in peer tutoring. Kim (2015) affirmed that employing student tutors for the growing student population was a cost-effective way for universities to provide these services. Studies that have examined tutoring for students in higher education found that university students benefited from tutoring and that the tutoring programs varied to fit the needs and goals of the institution (Kim, 2015; Topping, 1996; Menz & Jungic, 2015).

Peer Tutoring in Higher Education

Research into the effectiveness of peer tutoring programs in math, especially in calculus, is emerging. The Mathematical Association of America (MAA) conducted a study on College Calculus finding 97% of the institutes surveyed had a tutoring center (Bressoud et al., 2015). The set up and reporting structure varied with some centers being housed within the mathematics department, others within a school under the dean and still others housed within the general learning support center. The study also found 60% of calculus students never attended the tutoring center and 50% never attended their professor's office hours.

Regarding the impact of tutoring on students' achievement, one community college study found a 19% higher average grade among students who visited the math center than students in the control group who did not visit the center (Jaafar et al., 2016). Additionally, 48% achieved a grade of B or higher compared to 36% in the control group, fewer withdrawals at 0% compared

to 8% in the control group, and finally 25% achieved an F compared to 42% in the control group. Another study at a large, public, mid-western university studied a voluntary tutoring program for first year students and used an applied case-control matched-pairs analysis (Walvoord & Pleitz, 2016). The study found students who attended tutoring had a GPA 0.29 higher than students who did not.

One study involving Calculus 1 students at Oklahoma State University found the tutoring center benefited both high- and low-achieving students (Rickard & Mills, 2018). Additionally, the study found low-achieving students needed to attend tutoring more often to see significant grade improvements. Another study at Colorado State University also targeted calculus students (Byerly et al., 2018). Students who reported increased visits to the tutoring center had a higher likelihood they would pass their Calculus 2 course. This study also pointed out the need to account for self-selection bias on the ability to determine if increased scores and grades were the result of tutoring or if other factors, such as motivation, accounted for the increase.

Other literature has focused on the benefits of tutoring on the peer tutor. A 2019 meta-analysis of the literature on this topic focused on 16 studies (Leung, 2019). The analysis revealed that a greater effect was found for math tutors and same-age nonreciprocal peer tutoring than for cross-age tutoring. Cross-age tutoring is defined as age differences between tutors and tutees (Hänze et al., 2018).

Research Overview

Most prior research has focused on specific core mathematics courses, like calculus. The goal of the present study is to address the gap by examining the effectiveness of tutoring across a range of undergraduate courses. This study examined the effect of tutoring college freshmen through seniors in a variety of mathematics classes, with the goal of determining the broader benefits (and shortcomings) of math tutoring in a higher education setting.

The research centered on the Math Center at a four-year state university in the northeast region of the United States of America. Classes that were supported

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in the Math Center ranged in difficulty from Arithmetic Developmental Math, which re-examined concepts initially taught in the elementary grades, through Calculus II. Undergraduate peer tutors were recommended by their professors for the courses for which they tutored and have demonstrated their tutoring ability to the Math Center Director. Student tutors tended to be approximately the same age as students they tutored.

The mission of the Math Center is to enhance student learning and success in any course that contains mathematical components in an effort to increase student retention. The Math Center is a hub for mathematical learning and dialogue and it allows students to find help from a knowledgeable, friendly tutor who may not evoke the feelings of pressure or judgment that students may experience when interacting with their professors. The literature shows the majority of students prefer peer tutors to staff tutors because peer tutors were more likely to understand the students' problems and show more interest in their lives while assessing the students' learning in a less authoritarian way (Topping, 1996). According to Topping, students' mathematics knowledge and competencies are expanded, as well as attitudes are shifted and improved. The Math Center plays an integral role in the community by helping students succeed in their mathematics classes, ultimately fulfilling graduation requirements.

The following research questions were constructed to determine if tutoring through the Math Center has a positive effect on both the students' and tutors' academic performance and attitudes toward mathematics:

1. Do students report that Math Center tutoring had a positive effect on their academic performance?
2. Do students report that Math Center tutoring had a positive effect on their attitude toward mathematics?
3. Do tutors report that working as a tutor in the Math Center had a positive effect on their own academic performance?
4. Do tutors report that working as a tutor in the Math Center had a positive effect on their own attitude toward mathematics?

Methods

Research Site and Participants

In the academic year 2016-2017, the full-time student body of 4,033 freshmen consisted of 59% female students and 41% male students. The percent of minority students was 26.4%. Students were predominantly in-state residents at about 95% and less than 1% were international students. The average age of incoming freshman is 21.9. Our Math Center offers tutoring that is on a walk-in basis. Therefore, tutoring may be one on one or in small groups, depending on the number of students attending. Tutoring takes place during business hours in the same building that houses the math department. The Math Center has specific blocks of time dedicated to each class that depends on the availability of the tutor. The center reports to dean of the college including all STEM, Health Sciences and Education departments. The Math Center director is a faculty member of the mathematics department. Tutoring is offered in any class with mathematical content. In the 2016-2017 academic year, more than three hundred students visited the Math Center, with a total of almost one thousand visits for the year.

The two targeted samples for this study were the students who visited the Math Center for tutoring and the tutors who worked in the Math Center. The researchers drew the participant pool from the population of all students who used the Math Center in Fall 2016 or Spring 2017. In the Fall of 2016, 220 students visited the Math Center and 116 visited it in the Spring of 2017, totaling 336 students for the academic year. There may be some overlap between students who visited the math center in the Fall and then again in the Spring. At the conclusion of the academic year, a request to complete the survey was sent twice to all 336 students who used tutoring services at the Math Center in the 2016-2017 academic year. Of the 336 students, 42 chose to participate in the survey, yielding a response rate of 12.5%. Students' responses to each of the questions were recorded.

The participant pool of tutors included all students who worked in the Math Center in Fall 2016, Spring 2017, or both. In Fall 2016, 16 tutors worked in the Math Center. In Spring 2017, two left and three additional tutors were hired. This brought the total tutors employed for the Spring semester to 17 and the

Mathematics Tutoring *continued*

total for the academic year to 19 tutors. Of the 19 tutors, one excluded herself as a co-author of the study, and 15 of the remaining 18 tutors responded, giving a response rate of 83.3%. The survey began with a question about how long the tutor had worked in the Math Center. Responses ranged from one to four semesters, with six tutors responding four semesters, two tutors responding three semesters, four tutors responding two semesters and three tutors responding one semester.

Tutors hired in the Math Center are recommended by the faculty who teach the course and are based on their demonstrated ability in the course, their communication skills and their future plans, with preference given to those pursuing the field of education. All tutors are interviewed by the Math Center Director and if hired tutors undergo training. For Fall 2016, all tutors attended a four-hour training session, which included both administrative tasks and tutoring skills. Administrative tasks cover human resources systems, and the data collection system for students and tutors. Tutoring skills training included a review of the mission and goals of the Math Center, tutoring guidelines, a presentation and discussion led by experienced tutors, and concluded with mock tutoring sessions.

Survey Instruments

For this study, two survey instruments were created and used by the researchers. The first is the student survey, which gathered information from students on their experiences at the Math Center. Student survey questions can be divided into four categories: background, academic effect, attitude effect, and other. Table 1 (see page 29) contains all the questions for the student survey.

The second survey is the tutor survey, which collected information from the tutors on their experience as employees of the Math Center. This survey also included questions that can be divided into four categories: general background, academics, attitude, and general feedback questions. Table 2 (see page 30) contains all the questions for the tutor survey.

Data Collection Procedures

Data collection for the survey was through Qualtrics,

a survey platform. The web-based platform supported survey creation, platform independent deployment, data collection, and data analysis. Results were stored and can be retrieved in a number of formats for further analysis. Data analysis of this study was based on descriptive statistics using a five-point Likert scale of strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree and strongly disagree.

Results

Student Survey Results

All reference to survey questions refer back to Tables 1 and 2 by S# for the student survey and T# for the tutor survey, respectively. In question S2, as shown in Table 3, students reported which specific class or category of classes for which they attended tutoring. Most students came to the Math Center for assistance with developmental mathematics courses or courses for math elementary education. It is important to note that many students do not take advantage of tutoring, especially those who could most benefit from these resources.

Table 3
Course for which Student Visited the Center

Course Group Visited	Count (n)	Percent
Developmental	11	26.19%
Liberal Arts Math	1	2.38%
Math for Education Courses	8	19.04%
Statistics	4	9.52%
STEM Track	7	16.66%
Placement Test Prep	4	9.52%
Non-Math Courses	7	16.66%
TOTALS	42	99.97%

In Question S3, students reported which tutor they met with most frequently. Students reported that they met with one of the 23 specific tutor-course pairings between

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Table 1
Student Survey Questions

Number	Question	Type of Response	Question Category
S1	Are you 18 years of age or older	yes/no	Background
S3	Which tutor did you meet with	list selection	Background
S4	How did you learn about the Math Center	list selection	Background
S5	Math Center hours met your needs	Likert Scale	Background
S6	Tutor hours met your needs	Likert Scale	Background
S7	Tutor demonstrated a firm grasp of the material	Likert Scale	Academic effort
S8	The tutoring session(s) met my expectations	Likert Scale	Academic effect
S9	The tutoring session(s) helped me grasp the material	Likert Scale	Academic effect
S10	The tutor and tutoring sessions helped me complete assignments	Likert Scale	Academic effect
S11	The tutor and tutoring sessions helped me prepare for exams	Likert Scale	Academic effect
S12	I will return to the Math Center for additional tutoring sessions	Likert Scale	Academic effect
S13	I will recommend the Math Center to my friends and peers	Likert Scale	Other
S14	The Math Center provided a comfortable, welcoming learning environment	Likert Scale	Other
S15	The tutoring session(s) improved my confidence in math	Likert Scale	Attitude effect
S16	I feel more positive about math than I did before tutoring	Likert Scale	Attitude effect
S17	If tutoring was not offered at the Math Center, I would hire and pay a private tutor	Likert Scale	Other
S18	Comments and Suggestions	Text	Other

Mathematics Tutoring *continued*

Table 2
Tutor Survey Questions

Number	Question	Type of Response	Question Category
T1	Are you 18 years of age or older	yes/no	Background
T2	When did you begin tutoring	list selection	Background
T3	Tutoring increased my understanding of math concepts outside of what I tutor	Likert Scale	Academic effect
T4	Tutoring increased my understanding of the material	Likert Scale	Academic effect
T5	I feel I am better able to explain the material after working as a tutor	Likert Scale	Academic effect
T6	Working in the Math Center increased my academic performance	Likert Scale	Academic effect
T7	Working in the Math Center improved my attitude toward mathematics.	Likert Scale	Attitude effect
T8	I know and understand the mission of the Math Center	Likert Scale	Background
T9	I would benefit from more training on tutoring students.	Likert Scale	Other
T10	I would benefit from more training on administrative processes.	Likert Scale	Other
T11	The Math Center is a good working environment	Likert Scale	Other
T12	I would work in the Math Center again.	Likert Scale	Other
T13	I would recommend working in the Math Center to my friends.	Likert Scale	Other
T14	Comments and Suggestions	Text	Other

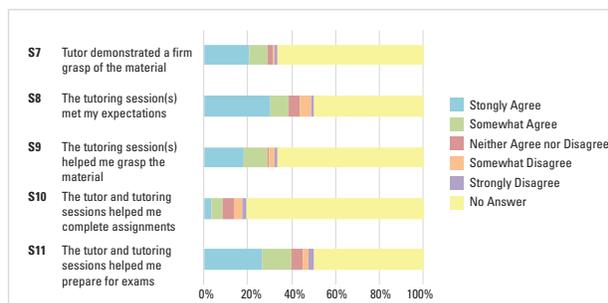
Mathematics Tutoring *continued*

zero and ten times, where zero means the student failed to report the pairing. In Question S4, students reported how they learned of the Math Center, with 78.6 % of students reporting that they learned about the Math Center from their professor, 4.8% from a friend, 4.8% from a current tutor, and 11.9% from another source, including their advisor, the Math Center Director, and the website.

The next two questions dealt with the Math Center hours and availability. Question S5 asked students if the Math Center hours met their needs and 48.8% of students responded that they strongly agreed that the Math Center hours met their needs, 29.3% somewhat agreed, 2.4% neither agreed nor disagreed, 17.1% somewhat disagree, and 2.4% strongly disagreed. Question S6 asked students if the tutor hours for their class met their needs and 40.0% of students responded that they strongly agreed nor disagreed, 20% somewhat disagreed, and 5% strongly disagreed.

Effect on Students' Academic Performance. Questions S7 to S11 asked the students to assess the outcome of tutoring on their academic performance. The responses are summarized in Figure 1. This outcome of academic performance will be revisited in the follow up data analysis.

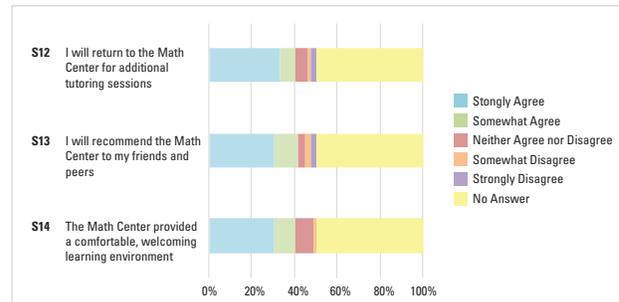
Figure 1
Student Report of Math Center Impact on Academic Performance



Questions S12 to S14 addressed the Math Center experience, including would the student return to the Math Center, would the student recommend the Math Center to others, and did the student find the Math

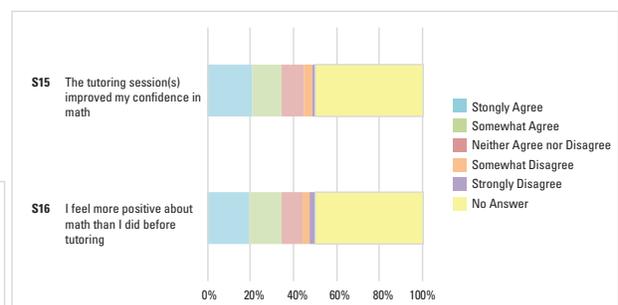
Center to be a welcoming learning environment. These findings are shown in Figure 2.

Figure 2
Student Perception of the Math Center



Effect on Students' Attitude toward Mathematics. Figure 3 addresses questions S15 and S16. These questions asked the students to assess the impact of their visits to the Math Center on their attitude toward mathematics and their level of confidence with the subject.

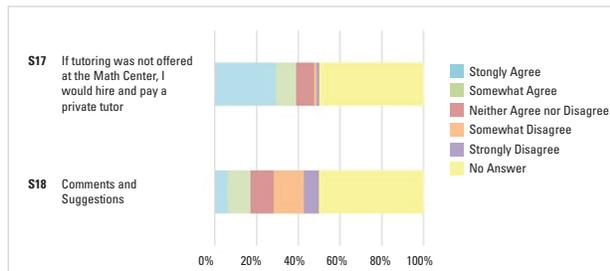
Figure 3
Student Report of the Overall Effect of the Math Center



The last two questions, S17 and S18, shown in Figure 4 addressed the use of student tutors and if the students would seek paid, private tutors if the Math Center did not exist. These questions assessed the students' perceived need for tutoring.

Mathematics Tutoring *continued*

Figure 4
Student Preference for Tutors

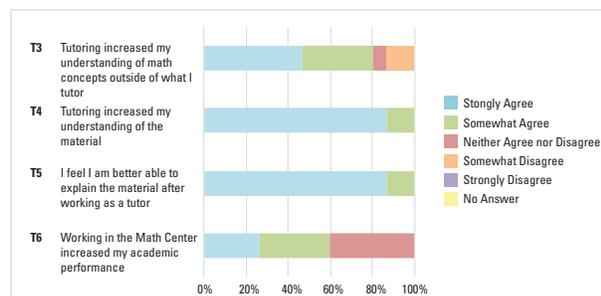


Tutor Survey Results

The tutor survey collected information from the tutors on their experiences as employees of the Math Center. The data collected helped to answer the research questions related to the Math Center effect on tutor academics and attitude toward mathematics.

Effect on Tutors' Academic Performance. Questions about the effect of tutoring on the tutor's academic performance, mathematical understanding, ability to communicate mathematical concepts, and academic performance followed. Figure 5 shows the data illustrating the responses to each of these questions.

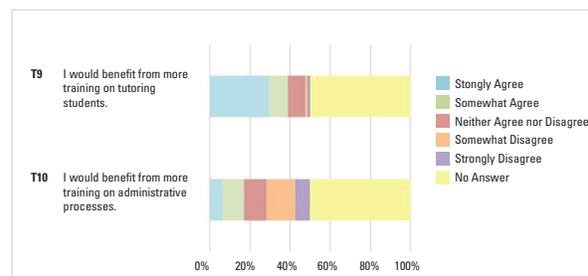
Figure 5
Tutors on Effect of Tutoring



Effect on Tutors' Attitude toward Mathematics. Question T7 asked tutors to assess the impact of tutoring on their attitudes toward mathematics by noting whether their attitude toward mathematics improved by working

in the Math Center. The data found the majority, 73.33% of tutors agreed that working in the Math Center improved their attitudes and 26.67% reported they neither agreed nor disagreed. None of the tutors disagreed with this statement. Question T8 focused on the mission of the Math Center. All tutors responded that they understood the mission, with 66.7% responding strongly agree and 33.3% agree. Questions T9 and T10 examined the process and training for tutors. Tutors responses are summarized in Figure 6 below.

Figure 6
Tutors on the Need for Training



Questions T11 to T13 addressed the overall experience of working in the Math Center. Question T11 asked tutors to respond to the statement The Math Center is a good working environment. Of the tutors, 100.0% strongly agreed. Question T12 asked tutors to respond to the statement I would work in the Math Center again, with 100.0% of the tutors responding that they strongly agreed. Question T13 asked tutors to respond to the statement I would recommend working in the Math Center to my friends. Of the tutors, 80.0% strongly agreed with the statement and 20.0% somewhat agreed. Finally, the survey solicited open-ended student comments and suggestions.

Analysis of Student Grade Data

To follow-up the survey questions from the 2016-2017 academic year, specifically the questions addressing students' academic performance after visiting the Math Center, an analysis of student grade data was performed after the Spring semester of 2018 using the most current grade data and Math Center data available at that time. This quantitative analysis uses data from the Spring of

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2018 and is not the same population of students that participated in the 2016-2017 survey.

In the Spring of 2018, a total of 1,238 students were enrolled in a mathematics course and 118 (9.53%) visited the Math Center. Passing and failure rates for the total number of students in a mathematics course and total number of students who visited the Math Center follow in Table 4; however, we believe tutoring is most effective when students attend multiple times, as it helps to reinforce the material. Therefore, it is beneficial to consider students who have made repeated visits of five or more in the Spring 2018 semester to the Math Center. Visiting the center 5 times would imply that a student visited the center, on average, every other week during the semester. This seemed like a reasonable amount of time to expect a student to visit the center, while still allowing for a large enough sample size to analyze the data. The passing rates for students enrolled in a math class in Spring 2018 are included in Table 5. The final grade in the math class of the students who visited the Math Center 5 or more times is shown in Table 6. Most students who visited more than five times were C level students in their math course, who may have been at risk of failure without the tutoring from the Math Center. A chi-square test revealed that there is a significant association between visiting the Math Center five or more times and passing mathematics courses. ($\chi^2=4.0842$ with a p-value=0.043285 and critical ($\chi^2_{0.05, df=1}=3.841$) The data from the chi-square test is given in Table 7.

Table 4

Pass Fail Rates for Students

Spring 2018 All Students Enrolled in a Math Course		
	Number of Students	Percentage
PABCD	971	78%
FW	267	22%
Spring 2018 All Students Visiting the Math Center		
	Number of Students	Percentage
PABCD	94	80%
FW	24	20%

Note: PABCD refers to grades of Pass, A, B, C, D, while FW refers to grades of Failure or Withdrawal.

Table 5

Pass Fail Rates for Students with repeated visits

Students with 5+ Visits to the Math Center		
	Number of Students	Percentage
PABCD	34	92%
FW	3	8%

Table 6

Grades earned in Math Class by Students who attended the Math Center Five or More times

Grade	Number of Students
Passes (P)	1
A range	3
B range	6
C range	17
D range	7
Failures (E and F)	2
Withdrawals (W)	1

Table 7

Math Center Visits by Student Grade

Chi-Square Table		
	PABCD	FW
5+ Visits to the Center	34	3
< 5 Visits to the Center	937	264

$\chi^2=4.0842$ with a p-value=0.043

Mathematics Tutoring *continued*

Discussion

The results of the survey study contained interesting findings from both the student and tutor perspectives. The discussion first focuses on how the student survey findings relate to the current literature. The discussion concludes with suggestions for future studies.

Discussion of Student Results

The student survey evaluated the effects of tutoring from the Math Center tutors, and on students' academic performance and attitudes towards mathematics and towards the Math Center. Of the 336 students who used the Math Center and who were asked to complete the survey, 42 participated. The majority of these students had positive experiences in the Math Center. This was evident to the investigators because all questions regarding the Math Center had over 75% agreement from the students. The availability of the Math Center met the students' needs with 79% of the students in agreement. Eighty percent of students felt comfortable and welcomed while learning from a tutor in the Math Center. Eighty percent of students stated that they would return to the Math Center and 83% said that they would recommend the Math Center to a friend or peer. The students' overall comfort with and favorable responses to a Math Center employing peer tutors agrees with Kim's (2015) assertion that students prefer a less authoritarian, fellow student-tutor over their professors. The students' survey responses confirmed that the Math Center and its tutors had a positive effect on the students' academic performances and attitudes toward math.

Students had positive experiences with the tutors. Seventy-eight percent of students felt the tutoring session(s) met their expectations and preferred tutors who were fellow students. Eighty-eight percent thought the tutor had a firm grasp of the material and that the tutor and the tutoring session(s) helped the student grasp the material. Seventy-three percent believed the tutor and the tutoring session(s) helped the student complete assignments and 80% stated the tutor and tutoring session(s) helped prepare the student for an exam. These findings agreed with the literature as Cohen et al. (1982), Robinson et al. (2005), and Kim (2015) reported similar improved academic performance with tutored students.

After coming to the Math Center, 68% of students

felt improved confidence in mathematics and a more positive attitude towards math. This finding supports the mission and goals of the Math Center and thus, the tutors were successful in implementing and practicing the Math Center's mission and goals.

Discussion of Tutor Results

The tutor survey, which had a response rate of 83%, assessed the impact of tutoring on the tutors' understanding of the material tutored, understanding of mathematical concepts beyond the tutored subject, and on the tutors' attitude towards mathematics. The length of time tutors were employed by the Math Center ranged from one to four semesters. Of the fifteen tutors who responded to the question, six worked four semesters, two worked three semesters, four worked two semesters, and three worked one semester. Thus, there was a mixture of new and veteran tutors. The tutors have varying majors, but the majority are mathematics majors.

One hundred percent of the tutors agreed that the Math Center was a good working environment and that they would work there again; however, only 80% agreed and 20% somewhat agreed that they would recommend working at the Math Center to a friend. The investigators think this may be because the tutors would like more tutoring hours and hiring new staff could lower the current tutors' hours. Another reason for this result could be that the tutors see themselves as having a particular set of skills suitable to tutoring, but that their friends do not.

Sixty percent of tutors felt tutoring had a positive effect on their academic performance. This concurs with the literature that the study of the foundations of mathematics improves a person's mathematics capabilities in higher level mathematics courses (Cohen et al., 1982) and their achievement in the field (Leung, 2019). At the time of the survey, each of the tutors was enrolled in a mathematics class of a higher level than the one for which they were tutoring. Nevertheless, 60% of tutors reported that tutoring for the lower level class improved their performance in the higher-level class. Eighty percent reported that tutoring increased their understanding of mathematics concepts outside of what they tutored; however, about 13% somewhat disagreed with that statement. Unsurprisingly, 100% of tutors

Mathematics Tutoring *continued*

agreed that tutoring increased their understanding of the tutored subject. In addition, 100% agreed that they were better able to explain material after having been a tutor. From the tutors' responses of self-evaluation, the investigators confirmed that tutoring helped the tutors' academic performances. These academic improvements agree with the findings of Cohen et al. (1982) and Robinson et al. (2005).

About 73% of tutors agreed that tutoring improved their attitude towards mathematics. Cohen et al. (1982) found similar improvements in the attitudes of tutors towards mathematics. From the tutors' responses of self-evaluation, the investigators confirmed that tutoring helped the academic performances and improved their attitudes towards mathematics of the tutors.

Questions regarding the need for additional training were included on the survey. Only 33% of tutors somewhat agreed that they would benefit from more training on administrative processes, which includes logging hours worked in the Math Center tracking system and reporting hours worked through an online payroll system. Due to the low perceived need, the investigators concluded that in the future, Math Center staff can continue to conduct training on administrative processes and that there is no need to have the payroll department or Human Resources perform the training. On the other hand, 60% of tutors agreed that they would benefit from more training on how to tutor students. The remaining 40% of tutors neither agreed nor disagreed with the need for more training on how to tutor, indicating that there were no strong feelings against additional training. In the future, the investigators will create a tutor training program, as we currently do not have a formal training approach. The investigators will survey the tutors to determine the particular aspects of tutor training needed, but the investigators will also research more formal training programs for tutors.

Limitations of the study

One large threat to internal validity of this study is the small sample size and the potential for skewed results due to the self-selection of participation, as identified by the research of Byerly et al. (2018). Another threat to internal validity is that the researchers also serve a supervisory role to the tutors. Threats to external validity

include generalization of the results to mathematics tutoring centers in different educational settings whose tutoring models differ significantly. To address the level of external validity, additional studies could be conducted at other types of institutions such as community colleges or private institutions. For this study, the tutoring model was drop-in with students choosing when to seek tutoring. Other studies could evaluate tutoring models that require faculty recommendations or group tutoring models that obtain similar results. Additional studies could examine larger populations of students.

Conclusion

This study showed that tutoring from the University Math Center benefits both students and tutors. The data showed the majority of students who used the tutoring services felt it helped them improve their academic performance, which was verified in a follow-up quantitative analysis, as well as their attitude toward the subject of mathematics. Tutors reported that working in the Math Center also benefited them in these two areas. Based on these findings, the investigators were able to conclude that both the tutors and students being tutored showed improved academic performance and improved attitude toward mathematics. Additionally, the investigators concluded that mathematics tutoring is a valuable service at the University deserving of further studies. The strong link between the investigators findings and the related literature supported the assertion that mathematics tutoring in higher education is needed and valuable for all students.

Mathematics Tutoring *continued*

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Mathematics Tutoring *continued*

Appendix A Data Tables

Table A1
Students' Report

Question	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree	No Answer
S7 Tutor Demonstrated a firm grasp of the material	62.50%	25.00%	7.50%	2.50%	2.50%	2
S8 The tutoring session(s) met my expectations	60.98%	17.07%	9.76%	9.76%	2.44%	1
S9 The tutor and tutoring session helped me grasp the material	55.00%	32.50%	2.50%	7.50%	2.50%	2
S10 The tutor and tutoring session helped me complete assignments	60.00%	12.50%	12.50%	10%	5%	2
S11 The tutor and tutoring session helped me prepare for exams	53.66%	26.83%	9.76%	4.88%	4.88%	1
S12 I will return to the Math Center for additional tutoring sessions	65.85%	14.63%	12.20%	2.44%	4.88%	1
S13 I will recommend the Math Center to my friends and peers	60.98%	21.95%	7.32%	4.88%	4.88%	1
S14 The Math Center provided a comfortable, welcoming learning environment	60.98%	19.51%	17.07%	2.44%	0.00%	1
S15 The tutoring session(s) improved my confidence in math	41.46%	26.83%	21.95%	7.32%	2.44%	1
S16 I feel more positive about math than I did before tutoring	39.02%	29.27%	19.51%	7.32%	4.88%	1
S17 I prefer that the tutors employed in the Math Center are fellow students	58.54%	19.51%	17.07%	2.44%	2.44%	1
S18 If tutoring were not offered I would hire an a private tutor	12.20%	21.95%	21.95%	28.86%	14.63%	1

Mathematics Tutoring *continued*

Table A2

Tutors' Report

Question	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree	No Answer
T3 Tutoring increased my understanding of math concepts outside of what I tutored.	46.67%	33.33%	6.67%	13.33%	0.00%	0
T4 Tutoring increased my understanding of the material.	86.67%	13.33%	0.00%	0.00%	0.00%	0
T5 I feel I am better able to explain the material after working as a tutor	86.67%	13.33%	0.00%	0.00%	0.00%	0
T6 Working in the Math Center increased my academic performance.	26.67%	33.33%	40.00%	0.00%	0.00%	0
T7 Working in the Math Center improved my attitude toward math	40.00%	33.33%	26.67%	0.00%	0.00%	0
T9 I would benefit from more training on administrative processes including payroll and tracking	0.00%	33.33%	66.67%	0.00%	0.00%	0
T10 I would benefit from more training on tutoring students	13.33%	46.67%	40.00%	0.00%	0.00%	0

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Currents in Teaching and Learning is a publication of Worcester State University, Worcester, Massachusetts, U.S.A. ISSN: 1945-3043 © 2011, Worcester State University