Evaluating the Impact of Math Drop-In Tutoring

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Abstract

The objective of this study is to compare tutored and non-tutored students enrolled in math courses in fall 2017 at Mount San Antonio College (Mt. SAC) using course success rates, course completion rates, and grade distributions, which are common metrics used to evaluate the academic performance of tutored and non-tutored students. Additionally, we will perform an exploratory analysis to investigate whether there is a relationship between time spent in the math tutoring centers and success rates using various data visualizations. Results show that students who participate in tutoring attain higher course success and completion rates as well as a higher proportion of the passing letter grades compared to non-tutored students. We also found that students who dedicate more time in the math tutoring centers tend to achieve higher success rates.

Background

The Math Activities Resource Center (MARC) and Transfer Math Activities Research Center (TMARC) are tutoring centers that combined, offer tutoring for all levels of math at Mt. SAC. The MARC lab offers tutoring in Prealgebra (Math 50) to Intermediate Algebra (Math 71), and the TMARC lab serves students enrolled in college level math courses. Both math labs offer free tutoring, study spaces, and a variety of resources including textbooks, solution manuals, calculator rentals, and handouts. Tutoring staff at the MARC and TMARC is mostly comprised of Mt. SAC student workers and four-year university students of which more than half have earned an associate's degree or higher.

Math students interested in using the math tutoring centers must sign up every semester to access free tutoring services and resource materials. Once students sign up to use the services for the semester, they are required to check in using their Mt. SAC student ID card every time they want to access the services. The math labs then keep track of students' total lab hours as well as the time contributed for any given lab usage session. This information is stored in a database and can later be retrieved for analysis after grades are submitted about a week after the semester ends.

Definitions

In this analysis, a student is classified as *tutored* if the student accumulated lab hours at the MARC or TMARC labs. Those regarded as *non-tutored* are students who did not use the MARC or TMARC services; however, these students may have received tutoring at different campus locations such as Tutorial Services, which offers tutoring in many subjects including chemistry, physics, writing, and math. Although students can receive tutoring for math at other campus locations, a considerable amount of the tutoring or lab usage takes place in the MARC and TMARC math labs. For example, when comparing math tutoring that takes place in the MARC labs to Tutorial Services in terms of lab hours, Tutorial Services accounted for at least 5% of the tutoring in fall 2017, with the majority of students receiving help in lower level math courses such as Math 50, Math 51, and Math 71 at 62.2%. Here, we say at least 5% since Tutorial Services categorizes students who receive tutoring in Math 280 and 285 under a general tutoring CRN; that is, Tutorial Services uses lab CRNs for each math course from Math 50 up to Math 181 but excludes Math 280 and 285. With respect to student head counts, Tutorial Services serves about 9% of tutored math students. However, keep in mind that a subset of these students also use the MARC labs as well. As noted previously, students who use the MARC labs may also accumulate hours in Tutorial Services; this analysis is restricted to math lab hours accumulated in the MARC and TMARC labs only. It is also important to note that when a student is classified as tutored in this report, it is entirely possible that the student was never actually tutored when

using a math lab; such students may come in to use the math lab for study space or to possibly borrow resources such as textbooks, solution manuals, and calculators.

In this report, we will follow the Research & Planning Group for California Community Colleges (RP Group) definitions of *course success rate* and *course completion rate*, respectively defined as the percentage of students who receive a passing/satisfactory grade and the percentage of students who do not withdraw from class and who receive a valid grade (The Research & Planning Group for California Community Colleges 2011). The RP Group is a non-profit, non-partisan team whose work focuses on increasing the success of California Community Colleges through research and planning in various areas such as learning outcomes assessment, completion and transfer, and institutional effectiveness.

Data Set Description and R Programming Language

Argos reports was used to generate fall 2017 course grade distributions for all math courses along with tutoring attendance data for the MARC and TMARC tutoring centers. All columns were renamed using descriptive variable names and extraneous columns were omitted from the dataset. The course grade distribution dataset includes course IDs, CRNs, and letter grades for each math course. The tutoring attendance dataset includes CRNs, course IDs, grades, and lab hours for each student who signed up to use the math tutoring centers. Once the datasets were obtained, the R statistical programming language was used to merge course grade information with tutoring attendance data as well as to perform all analyses in this report. R is a free software environment used for statistical computing and graphics (R Core Team 2016). A variety of R packages were used extensively for data manipulation and visualizations.

Summary of MARC and TMARC Level Courses

Table 1 provides a summary of all the math courses offered at Mt. SAC, including the number of students tutored, the enrollment number, total lab hours contributed, number of math sections offered, and lab usage expressed as a percentage for each math course. In this report, the terms lab usage, lab participation, and lab utilization rate will be used interchangeably. Lab usage is simply the ratio of the number of tutored students to the total number of students enrolled in a math course. The total number of students who enrolled in a math course in fall 2017 was 8,979 (duplicated). A total of 2,702 students (unduplicated) used the MARC and TMARC math labs, contributing a combined total of 46,058.7 math lab hours. A total of 1,220 MARC students contributed 18,532.9 hours while 1,504 TMARC students contributed 27,617.8 hours. Overall, about 31% of all students enrolled in a math course in the fall 2017 semester signed up to use either the MARC or TMARC math labs, i.e. one in three math students in fall 2017 used either the MARC or TMARC math labs. When examined separately by math lab, lab utilization at the TMARC was about 40% while for the MARC it was 25%. A total of 5,165 were enrolled in MARC level math courses and 3,814 in TMARC level courses, yet the utilization rate was higher for the TMARC lab compared to the MARC lab. These results suggest the need to increase our outreach efforts for MARC level math courses. Past results have shown that Math 50 has one of the lowest participation rates among all the math courses offered at Mt.SAC, yet a substantial number of Math 50 sections are offered every semester compared to other math courses. In addition, past participation rates for Math 51 have been in the 30-40% range and for the fall semester it was at 23.1%.

Table 1: Course Data for MARC and TMARC Level Courses

CourseID	NumTutored	TotalEnrolled	TotalLabHrs	NumSections	LabUsage
MATH100	11	31	73.7	1	35.5
MATH110	526	1228	7287.7	35	42.8
MATH110S	16	67	110.7	2	23.9
MATH120	2	15	59.0	1	13.3
MATH130	224	747	2817.9	22	30.0
MATH140	66	150	1154.5	4	44.0
MATH150	126	335	2772.9	9	37.6
MATH160	81	228	1540.4	6	35.5
MATH180	177	391	3363.3	10	45.3
MATH181	160	306	5224.9	8	52.3
MATH280	103	224	2355.1	6	46.0
MATH285	41	92	790.1	3	44.6
MATH50	226	1332	2778.5	38	17.0
MATH51	315	1362	4158.4	38	23.1
MATH51A	15	69	236.8	2	21.7
MATH51B	16	44	526.9	2	36.4
MATH61	38	74	452.2	2	51.4
MATH70S	31	154	299.8	5	20.1
MATH71	578	1801	9385.8	49	32.1
MATH71A	23	144	254.4	5	16.0
MATH71B	22	79	215.7	3	27.8
MATH71X	17	106	200.0	3	16.0

Figure 1 shows math course lab usage in increasing order. Math 181 had the highest lab utilization rate at 52.3% with Math 61 (Geometry) the second highest at 51.4% and Math 280 the third highest at 46%. Observe that TMARC level courses tend to have higher participation rates compared to lower level math courses. These results are not surprising since overall, the TMARC lab utilization rate was 40% while at the MARC it was 25%.

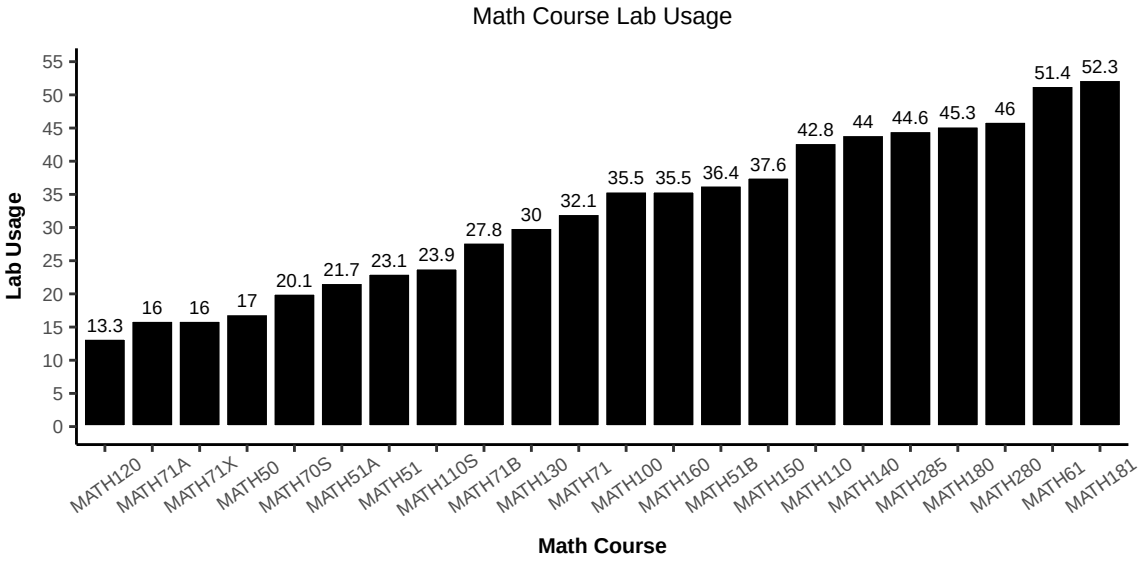

Figure 1: Math Course Lab Usage

Figure 2 displays course success and completion rates for all math courses. The course completion rates are presented in the red background in increasing order while the bars correspond to course success rates. It appears that course completion rates tend to be higher for MARC level courses compared to TMARC level courses. Math 70S and 110S attained some of the highest success and completion rates, which are courses offered to non-STEM majors; Math 285 attained the highest success rate at 69.6%. Courses with the lowest success rates include Math 100, 71X, 71B, and 120. Math 100 and 120 are math courses offered in fall semesters only and the math department typically offers one section of each course.

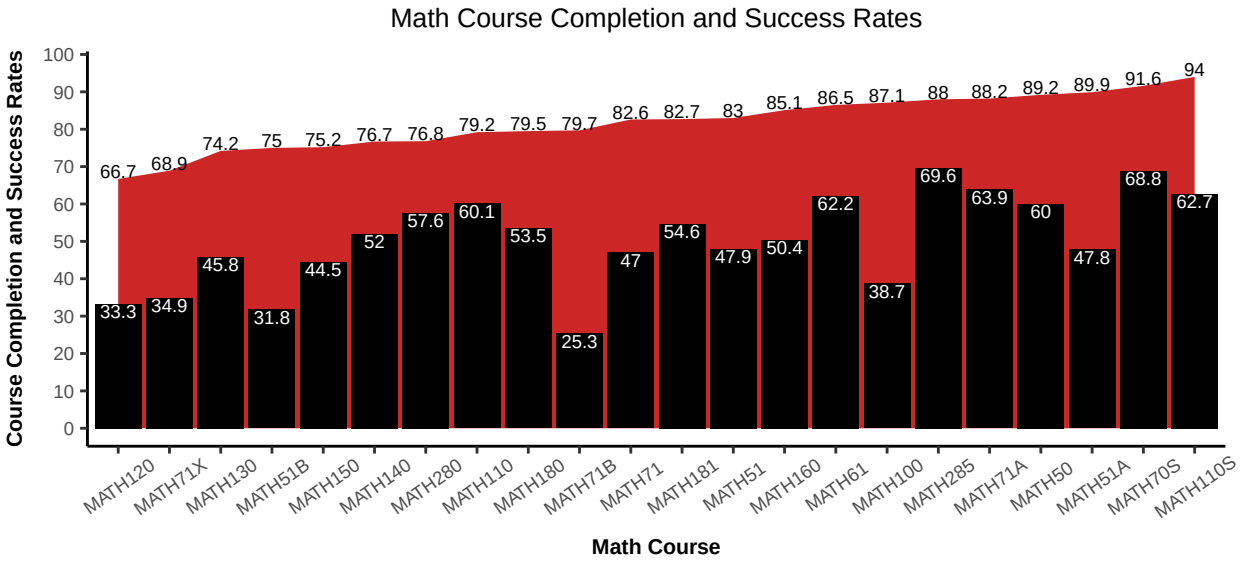

Figure 2: Math Course Retention Rates with Success Rates

Tutoring Lab Hour Analysis

In this section we will perform a lab hour analysis to ascertain whether there is a relationship between time spent in the math lab and course success rates. We will also examine math lab hour distributions based on course grades and success status to identify differences, if any, that exist between categories.

Figure 3 shows the distribution of lab hours for students who used the MARC and TMARC labs for the fall 2017 semester. About 950 students accumulated less than 5.0 lab hours, with the second highest number of students accumulating between 5.0 and 15.0 lab hours at 870. Combined, these two time ranges account for 65% of students who used the math labs, or equivalently, two out of three tutored students in the fall 2017 semester accrued less than 15 lab hours in the math labs.

Summary statistics for tutoring lab hours by success status are presented in Table 2. In what follows, successful students are those who passed a math course with a C or better. The median amount of time spent in the lab for students who were successful was 11.6 hours compared to 7.5 hours for the unsuccessful group. In other words, successful students spent an average of 4.1 more hours in the lab than the unsuccessful students. We can also see that the mean amount of time spent in the lab for successful students is higher than those who were not successful; however, the median is the preferred measure of central tendency when there are several outlying lab hour observations in the dataset. Finally, the variability in labs hours among the successful group is much higher compared to the other group.

Table 2: Lab Hour Summary Statistics by Success Status

	Min	Q1	Median	Mean	Q3	Max	SD
Successful	1.5	4.2	11.6	19.68	25.65	234.3	23.90348
Not Successful	1.5	3.2	7.5	13.45	17.42	157.8	16.25566

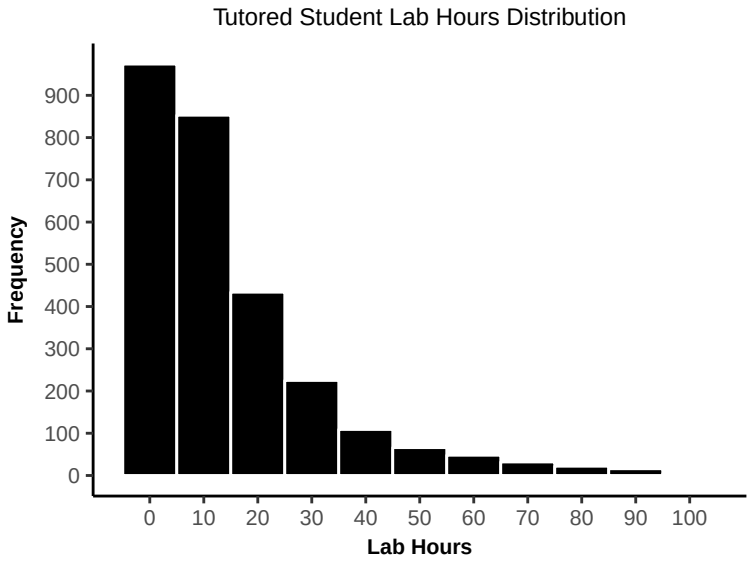

Figure 3: Lab Hours Distribution

One of the goals of this study was to identify a minimum amount of lab hours or time range that produces the highest success rate. In our attempt to answering this question, we found that students who dedicate more time in the math lab tend to achieve higher success rates. This relationship is captured in Figure 4, where the x-axis represents mutually exclusive time ranges and the y-axis represents success rates among students who participated in tutoring. Note that the time ranges are labeled in interval notation, where $[x, y)$ means at least x hours but less than y hours. For example, students who spent at least 15 hours in the math lab but less than 18 hours attained a success rate of 67.3%. Similarly, students who spent at least 24 hours in the math lab attained a 77.1% success rate, which is the highest success rate amoung all the time ranges. For most students, spending 24 hours or more in the math lab may not be feasible because as we discussed earlier, 65% of tutored students spend less than 15 hours in the lab. Therefore, only a small percentage of tutored students dedicates a minimum of 24 hours in the math lab.

Figure 5 shows plots similar to Figure 4 by math lab. For the MARC lab plot, the success rates for the initial time ranges remain relatively constant at around the 50% success level. Once we reach the 15-18 hour time range or higher, there is a considerable increase in success rates compared to the initial time ranges spanning less than 15 hours. It appears that the 15-18 hour time range serves as the point where students start achieving higher success rates. This pattern is not observed when examining the TMARC plot, however. Nevertheless, the overall pattern shows that the more time students spend in the lab, the higher the success rates.

To further explore the relationship between time spent in the math lab and success rates, we examined ten semesters of tutor attendance data from fall 2012 to spring 2017. This dataset included nearly 31,000 student lab hour observations, which allowed us to extend the time ranges up to 90 hours due to the large number of students that could be categorized for each time range. For instance, the number of students who

fall under the first category of more than zero hours but less than 3 hours was 5,299 students. The number of students placed in subsequent categories generally decreases as the time ranges increase. As seen previously when considering only one semester of tutor attendance data, a similar pattern emerges when we extend time ranges from 24 hours up to 90 hours or beyond for multiple semesters. That is, more time spent in the lab is associated with higher success rates (see Figures 6 and 7).

Another factor that may have an impact on success rates is the frequency of visits to the tutoring center and the time points during the semester that students use the math tutoring labs. Some students are regular math lab users while others tend to visit the math labs during exam time. In some cases, some students sign up for tutoring some time after the middle of the semester, possibly even close to the end of the semester. Currently, Argos reports does not provide information on number of visits to the tutoring center. Tracking such information may provide greater insight as to the relationship between frequency of visits to the tutoring centers and success rates while also taking into account when students used tutoring during the semester.

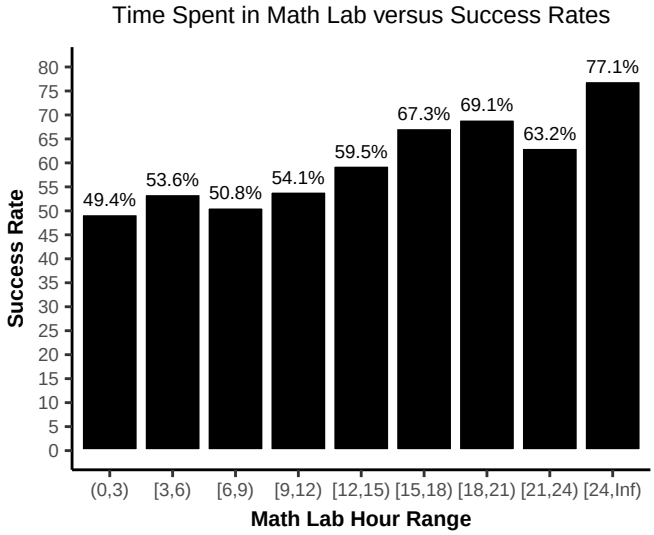

Figure 4: Time Spent in Math Lab versus Success Rates

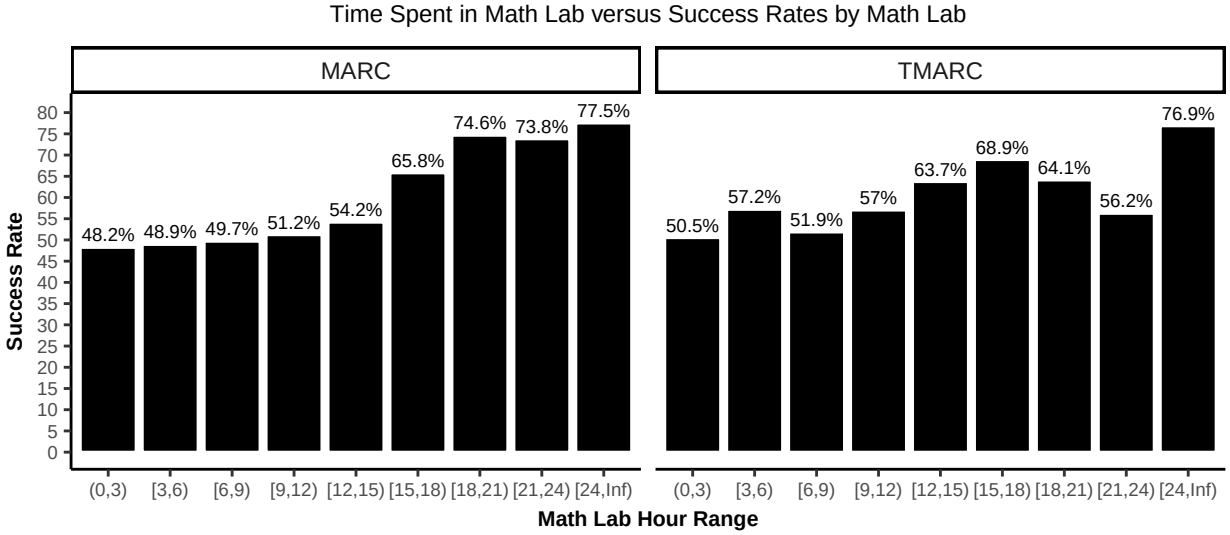

Figure 5: Time Spent in Math Lab versus Success Rates by Math Lab

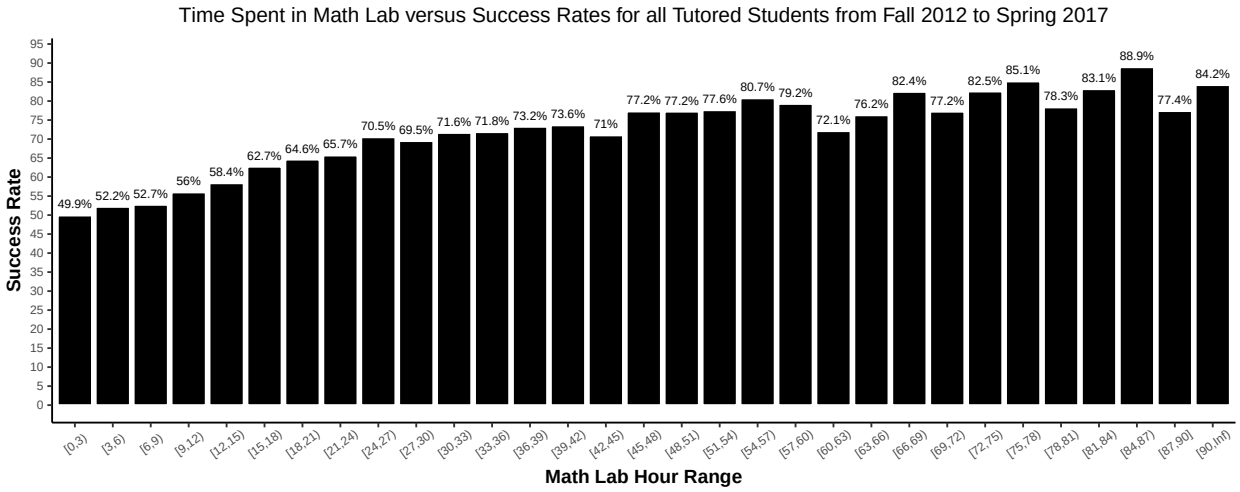

Figure 6: Time Spent in Math Lab versus Success Rates

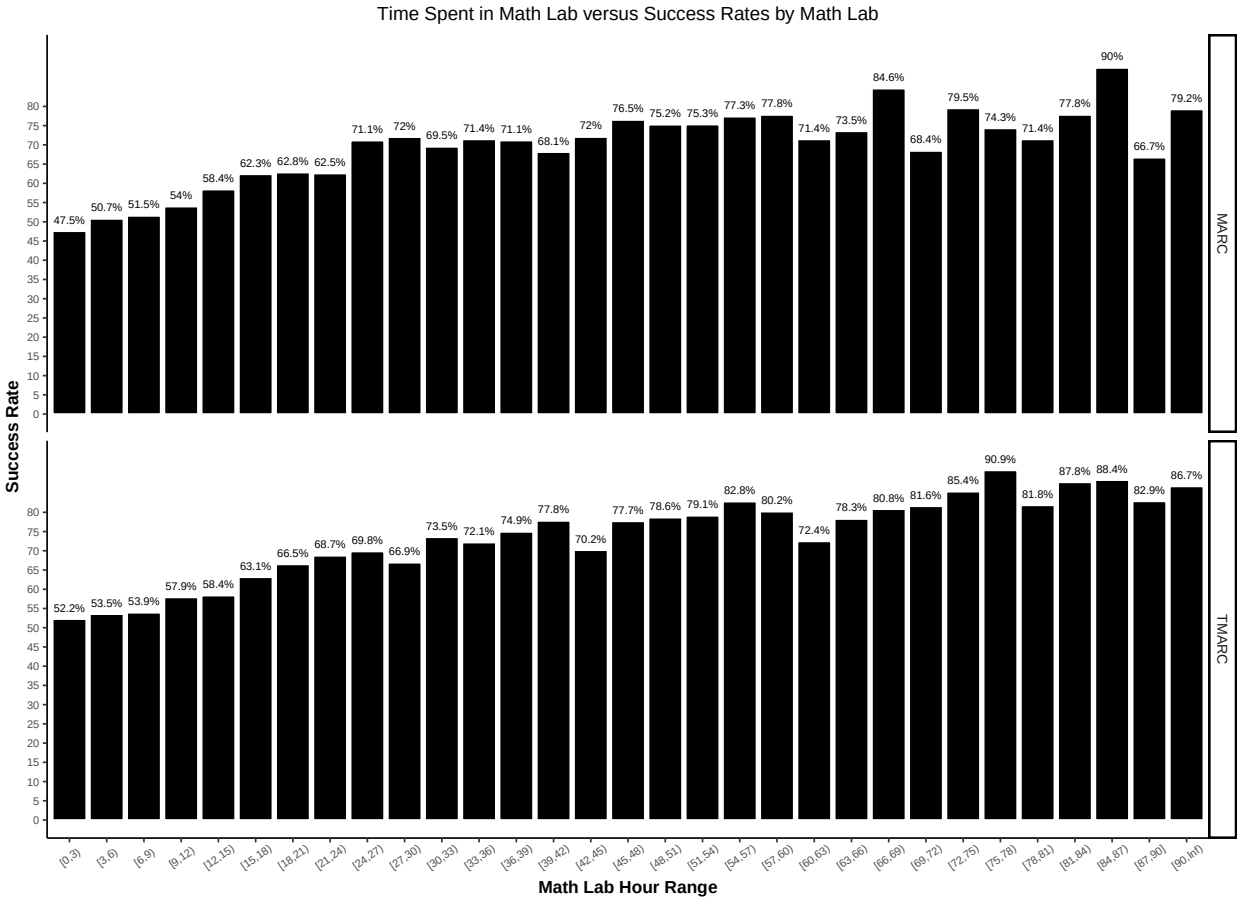

Figure 7: Time Spent in Math Lab versus Success Rates by Math Lab

Now we investigate whether a relationship exists between letter grades and time spent in the math labs. Figure 8 displays a jittered plot and parallel boxplots, where the x-axis represent letter grades and the y-axis math lab hours. Each point corresponds to the amount of time a math student spent in the lab. Both plots depict the same information; however, due to the amount of overplotting of outlying points that occurs in the parallel boxplots, the jittered plot provides a better view of the density of the outlying points. Such plots allow us to compare the distributions of math lab hours corresponding to each letter grade and show the minimum, maximum, median, and quartile values. Note that passing letter grades appear to have similar distributions or characteristics and are therefore quite similar. When comparing passing grades (successful students) to failing grades as shown in the bottom two figures where the horizontal axis is categorized by success status, however, we can see that successful students tend to spend more time in the math lab compared to unsucessful students. Students who received W's should not be considered in the comparison as students stop using the lab at some point after withdrawing from their math course.

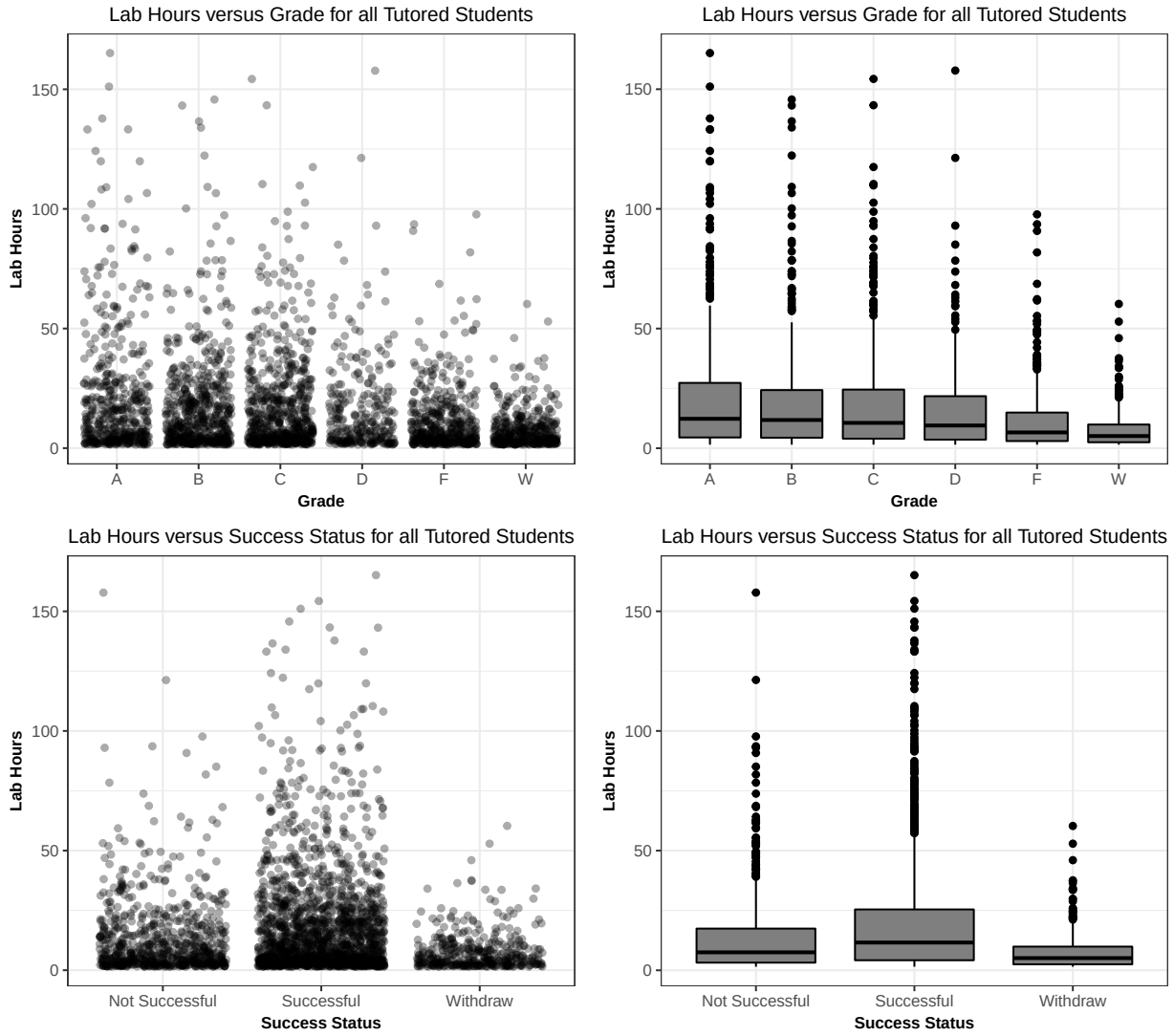

Figure 8: Jitter Plot and Boxplots of Lab Hours versus Grades for all Tutored Students

Grade Distributions

In addition to using course success and completion rates, we can also evaluate the academic performance of tutored and non-tutored students using grade distributions. Figure 9 shows the distribution of letter grades by tutored status for all math courses. The x-axis represents the letter grades and the y-axis represents the proportion of students who received an A, B, C, and so on for both tutored and non-tutored students. We see that tutored students attained a higher proportion of the passing letter grades compared to non-tutored students. Also note that the percentage of withdrawals is higher among the non-tutored student population compared to tutored students. These results are consistent with results observed in prior semesters; that is, tutored students are more likely to pass a math course and less likely to withdraw.

Letter grade distributions are also presented separately for the MARC and TMARC math labs in Figures 10 and 11. Once again, tutored students attained a higher proportion of the passing grades over the non-tutored students. The grade distribution for TMARC level courses show that tutored and non-tutored students have similar passing (and failing) rates. This suggests that tutored students are performing as well or better than students who are not using the math tutoring labs.

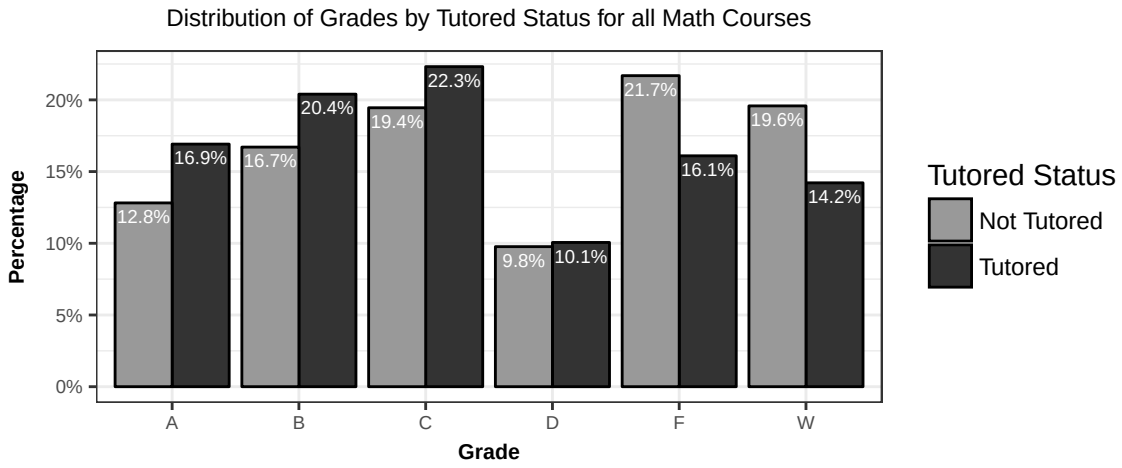

Figure 9: Distribution of Grades by Tutored Status

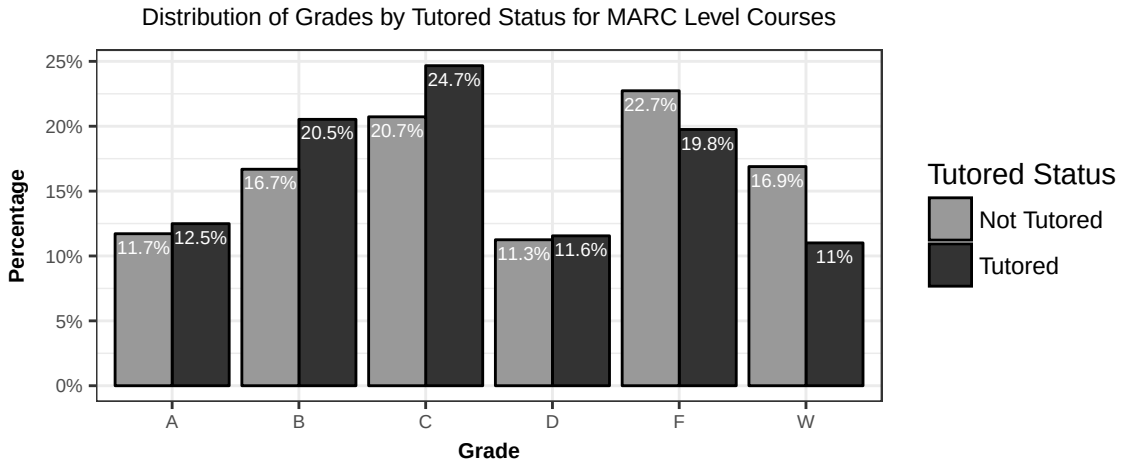

Figure 10: Distribution of Grades by Tutored Status

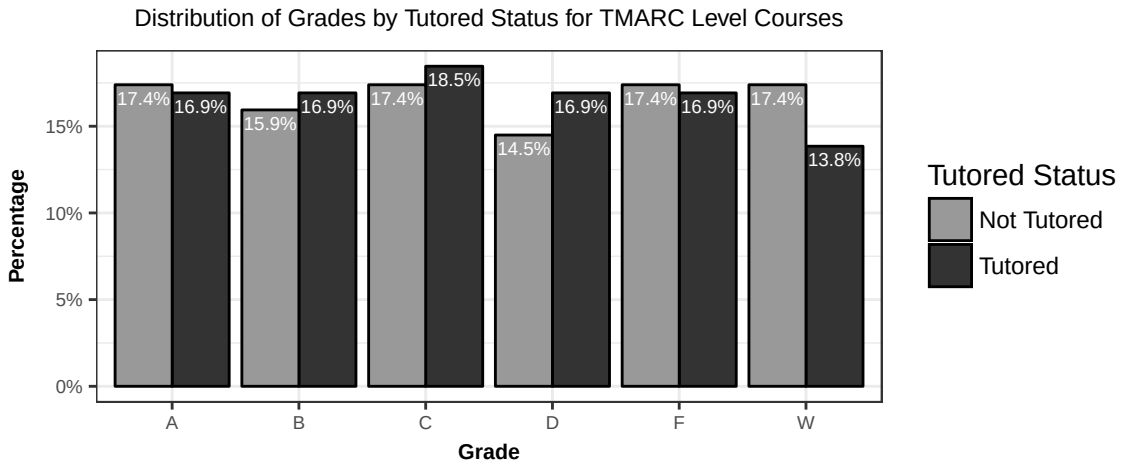

Figure 11: Distribution of Grades by Tutored Status

Math Course Success and Completion Rates by Tutored Status

Table 3 presents math course success and completion rates for each math course offered at Mt. SAC. The table is divided into three sections, which includes course success and completion rates for all math students, tutored students, and non-tutored students. Each section also includes the enrollment number, the number of students who passed the math course, and the number of students who did not withdraw from the course. Column names that begin with the letter "T" denote tutored students while columns that begin with the letters "NT" denote the non-tutored group. Displaying the course success and completion rates in this format allows us to easily make side-by-side comparisons between the tutored and non-tutored groups and then compare these results to the overall success and completion rates for all students. The overall success rate for tutored students across all math courses was 59.6% whereas for the non-tutored group it was 48.9%. In other words, **tutored students had an overall success rate of 10.6% higher than the non-tutored students**. Overall course completion for the tutored group was 85.8% while for the non-tutored group it was 80.4%, which is a difference of 5.4%. These findings are consistent with results from prior semesters and therefore serve as a snapshot of what is typically observed semester-to-semester.

Table 3: Success and Course Completion Rates: Overall, Tutored, and Non-Tutored

Course	Enrolled	Passed	Retained	Success	Completion	TEnrolled	TPassed	TRetained	TSuccess	TCompletion	NTEnrolled	NTPassed	NTRetained	NTSuccess	NTCompletion
MATH100	31	12	27	38.7	87.1	11	3	11	27.3	100.0	20	9	16	45.0	80.0
MATH110	1228	738	972	60.1	79.2	526	351	435	66.7	82.7	702	387	537	55.1	76.5
MATH110S	67	42	63	62.7	94.0	16	9	16	56.2	100.0	51	33	47	64.7	92.2
MATH120	15	5	10	33.3	66.7	2	2	2	100.0	100.0	13	3	8	23.1	61.5
MATH130	747	342	554	45.8	74.2	224	121	179	54.0	79.9	523	221	375	42.3	71.7
MATH140	150	78	115	52.0	76.7	66	42	53	63.6	80.3	84	36	62	42.9	73.8
MATH150	335	149	252	44.5	75.2	126	61	101	48.4	80.2	209	88	151	42.1	72.2
MATH160	228	115	194	50.4	85.1	81	40	71	49.4	87.7	147	75	123	51.0	83.7
MATH180	391	209	311	53.5	79.5	177	104	146	58.8	82.5	214	105	165	49.1	77.1
MATH181	306	167	253	54.6	82.7	160	101	138	63.1	86.2	146	66	115	45.2	78.8
MATH280	224	129	172	57.6	76.8	103	70	83	68.0	80.6	121	59	89	48.8	73.6
MATH285	92	64	81	69.6	88.0	41	35	39	85.4	95.1	51	29	42	56.9	82.4
MATH50	1332	799	1188	60.0	89.2	226	154	212	68.1	93.8	1106	645	976	58.3	88.2
MATH51	1362	653	1130	47.9	83.0	315	179	279	56.8	88.6	1047	474	851	45.3	81.3
MATH51A	69	33	62	47.8	89.9	15	7	12	46.7	80.0	54	26	50	48.1	92.6
MATH51B	44	14	33	31.8	75.0	16	6	14	37.5	87.5	28	8	19	28.6	67.9
MATH61	74	46	64	62.2	86.5	38	24	34	63.2	89.5	36	22	30	61.1	83.3
MATH70S	154	106	141	68.8	91.6	31	23	29	74.2	93.5	123	83	112	67.5	91.1
MATH71	1801	847	1487	47.0	82.6	578	315	513	54.5	88.8	1223	532	974	43.5	79.6
MATH71A	144	92	127	63.9	88.2	23	15	18	65.2	78.3	121	77	109	63.6	90.1
MATH71B	79	20	63	25.3	79.7	22	8	17	36.4	77.3	57	12	46	21.1	80.7
MATH71X	106	37	73	34.9	68.9	17	8	12	47.1	70.6	89	29	61	32.6	68.5

The final graph (Figure 11) shows a series of plots of success rates for each math course by tutored status. Overall, tutored students attained higher success rates compared to non-tutored students across most math courses. For courses where at least five sections were offerred, the success rates for tutored students ranged between 1.6% and 28.5% higher than non-tutored students.

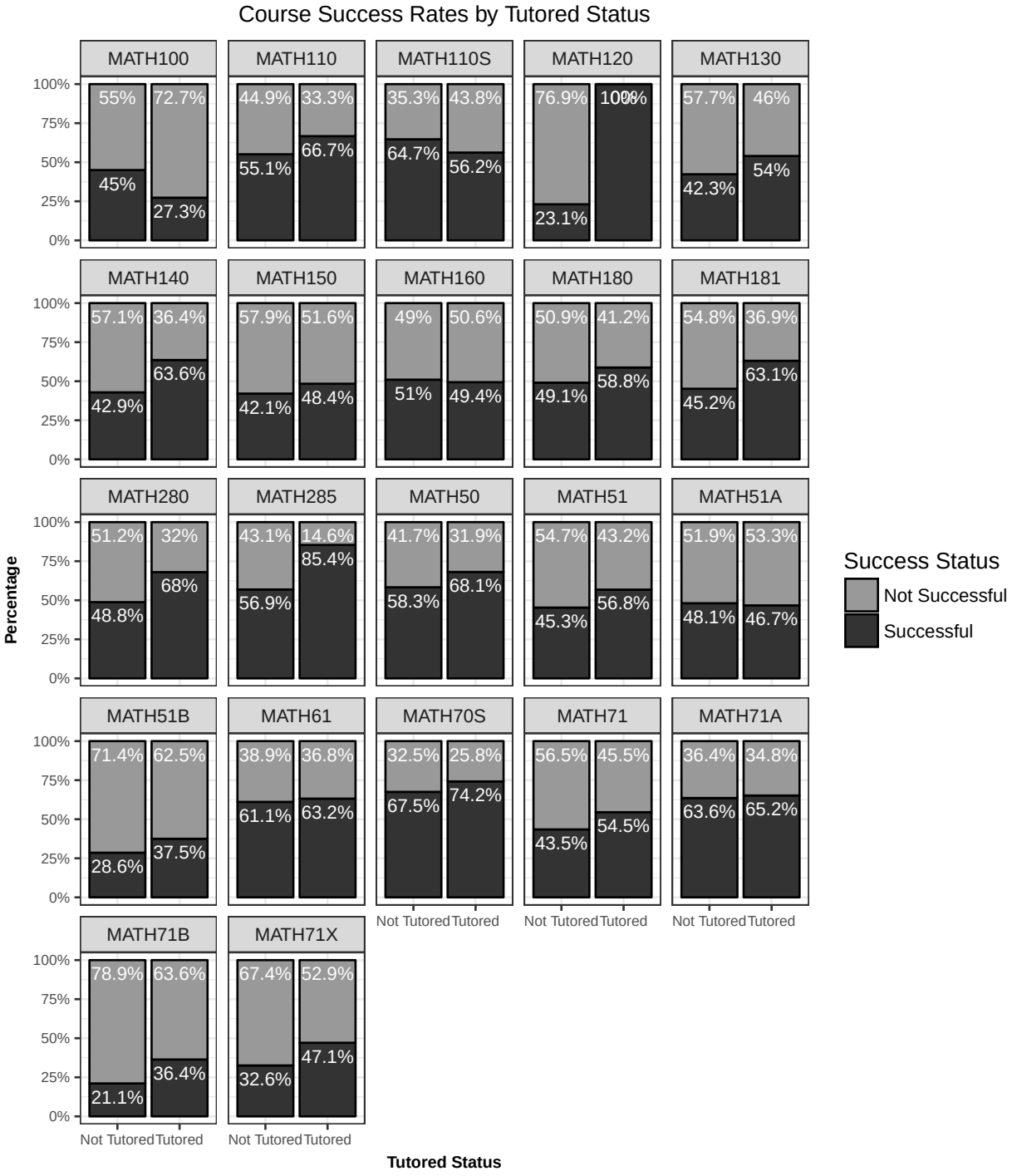

Figure 12: Course Success Rates by Tutored Status

Conclusion

The results of this study show that tutored students were more likely to pass their math courses, less likely to withdraw, and attain a higher proportion of the passing grades compared to non-tutored students. Additionally, we also found that students who dedicate more time in the math tutoring centers tend to achieve higher success rates; this relationship also holds when examining ten semesters of tutoring attendance data. While these findings are only applicable to the fall 2017 semester, these results are representative of what is usually observed in prior semesters.

Future Work

There are several factors that impact student success. Such factors include academic preparedness, use of academic support programs, student course load, age group, gender, financial aid status, and ethnicity/race. Future work will incorporate demographic and academic factors associated with course success. This will involve carrying out a variety of hypothesis testing procedures as well as regression analyses that will help us evaluate the extent to which tutoring is associated with course success statistically controlling for confounding variables.

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