Analyzing Student Performance in a College Algebra Course with Corequisite Material

Authors: Christian Ennis, Cayden Huffman, Devin Johnson, Jacob Johnston, Kennedy Jeffery, Faris Khattak, Haoxiang Lin, Bayla Patin

Abstract

In this paper, we analyze student performance in a college algebra course at a university which has corequisite material included in its instruction, rather than having preliminary materials being given in a separate course. In fall 2022, this course was treated as a single course in the university's learning management system. By fall 2024, they were separated into two courses which must be taken simultaneously. We examined student trends in these two semesters to analyze the efficacy of these respective models. In addition, we analyze student performance across both semesters to identify problematic areas of a standard fall semester. We discuss possible points where academic intervention may be most conductive to student performance.

Introduction

In Math 1020/1021 at Louisiana State University, corequisite material is presented alongside college algebra material [1]. During Fall 2022, both courses were integrated as a 5-credit combined course within Moodle, the learning management system used by LSU at the time of this study. Students engaged with prerequisite (PRQ) assignments and then College Algebra materials. By Fall 2024, the structure shifted to a co-requisite model, with Math 1020 (2 credits) and Math 1021 (3 credits) separated in Moodle, offering students flexibility in managing their workload. This co-requisite model treats these two grades as mostly independent, where the main commonality is the administration of assignments through Pearson's MyLab Math. In 2022, a student did not receive two course grades, as the assignments were coupled. In 2024, hypothetically, a student could receive a 0 in Math 1020 and a 100 in Math 1021.

Historically, student performance in college algebra is underwhelming when studying American universities. In an article by Haver et. al, in a report edited by Katz [3], the found that annually 650,000 to 750,000 college students enroll in a college algebra course. Further, more than 45% of students enrolled in a college algebra course either withdraw or receive a grade of D or F. This report further discusses certain approaches some universities have taken to replace college algebra, with the main studies cited revolving around providing mathematical modelling courses, rather than standard college algebra.

This is still a modern debate. Some universities have opted to remove the need for college algebra in curriculum [2], using an alternative approach to providing students with the necessary mathematical skills they need for their degree program. Most students who enroll in college algebra are not in disciplines which are mathematically intensive majors (such as mathematics, computer science, and engineering) [4]. Thus, such an approach for revision of curriculum should be a cross-departmental objective, determining the commonalities needed in the general education of students. However, the authors' interests are not in curriculum revision or replacement of college algebra with other courses.

Rather than remove college algebra, it is the authors' motivation to explore the problem areas of student performance and identify points in the semester which are most conductive to academic intervention. In both semesters studied in this report, there is an enrollment to the order of 700 and 800 students. This excludes students in the standard college algebra course without corequisite material. With such a large student body, the current format is favorable for efficient instruction. With this format, we aim to determine the worst areas of student performance, so that there is a measurable range for when academic intervention will be most helpful. In a paper by Boretz [5], the efficacy of a midsemester workshop for underachieving students was studied, with positive student response noted. Though this was given at a fixed point in the semester, with the workshop being dedicated to general student performance, rather than specific courses.

In addition to comparing the 2022 format and the 2024 format, we seek to determine an earlier time than midsemester to provide students with direct needed intervention. As such, we conduct an analytic study of the quantitative data available from a college algebra course. We attempt to identify a specific week that determines when a student is most at risk of not being able to succeed.

Before doing the analysis, it is important to understand how a student is evaluated in Math 1021, with or without corequisite material. A student's grade is determined by the weights in Table 1.

Comparing the Fall 2022 and Fall 2024 Formats

In both formats, a student's grade is determined by their homework assignments, quizzes, tests, class participation and lab participation. The categories of their grade are given below, along with their respective weights, and abbreviations which we will use in this article.

Category	**Weight**	**Abbreviation**
Class Participation	5%	CP
Lab Participation	5%	LP
Homework	10%	HW
Quizzes	10%	Q
Tests	45%	T
Final Exam	25%	FE

Table 1. Math 1021 grade categories, weights and abbreviations.

Thus, a student's course total (CT) is computed using the following equation:

$$CT = (0.05)CP + (0.05)LP + (0.1)HW + (0.1)Q + (0.45)T + (0.25)FE$$

For the quiz average, the lowest quiz grade is dropped at the end of the semester. For the homework average, the two lowest homework grades are dropped. There are four tests taken during the semester, excluding the final. If the final exam's score is higher than the student's lowest test score, the final exam score replaces this lowest score. The final exam score is always counted toward the student's grade in its respective category. More details on the specific lab policies, expectation of student behavior, calculator policy, etc. may be found in a current Math 1021 syllabus, available online [1]. Both formats use MyLab Math for the administration of all assignments, including tests. In general, a student will be expected to complete four homework assignments and two quizzes each week.

In fall 2022, Math 1020/1021 was instead called Math 1021 Enhanced. It was a single course in the university's learning management system. In this format, students had PRQ (prerequisite) homework assignments and quizzes. These PRQ assignments did not contribute to their grade, however they were required to be completed to gain access to their homework assignments and quizzes that did contribute to their grade. There were two class meetings each week, both of which contributed to their participation grade. Each week had a lab participation grade. Students were to begin accumulating time in the LSU Math Lab in the Main Library. Credit was given only if a student completed 3 hours during this week period. There is no partial credit for either participation grade. There were 28 homework assignments, of which the lowest two were dropped. There were 13 quizzes, of which the lowest one was dropped. Homework assignments, quizzes, and tests are all administered in

The fall 2024 format is the current format used by LSU. In this model, Math 1020 and Math 1021 are two separate courses in the university's learning management system. Each has their own assignments in MyLab, and the Math 1020 assignments do not need to be completed for a student to complete their Math 1021 assignments. Thus, it is possible (though unlikely) for a student to receive a course total of 0 in Math 1020 and a course total of 100 in Math 1021.

Initial Insights and Visualizations

The first goal of a study of two course formats should be to analyze the overview of formats. Namely, if using the same grade categories, are there stronger relationships between performance in categories using one format over another? As such, we begin our study with a large overview by taking correlation matrices and doing a direct comparison. For Fall 2022, the data referred to Test # as T #, and in Fall 2024, we removed the "(with replacement)" from the name for sake of space.

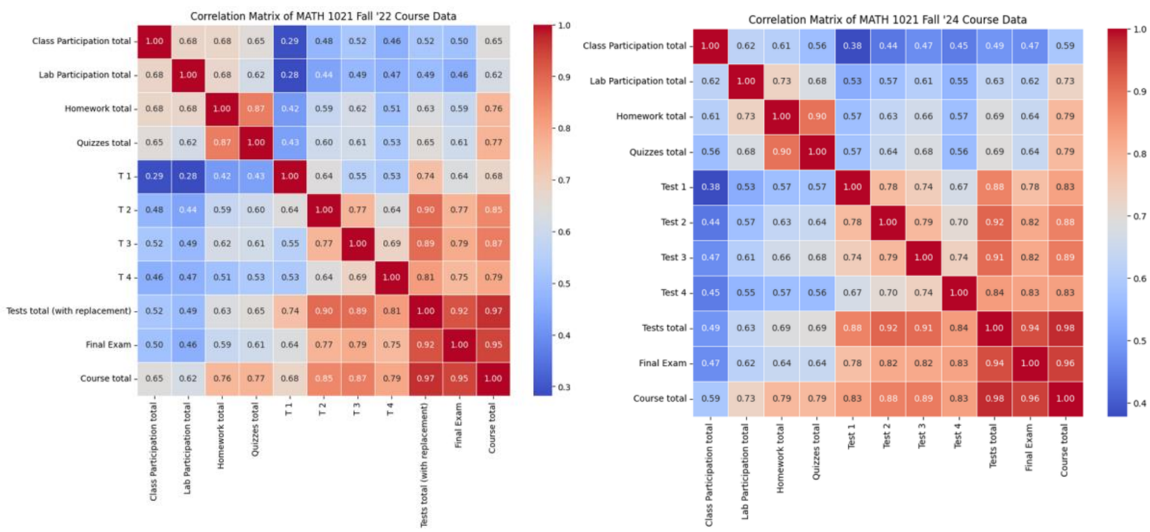


Figure 1. Correlation heatmaps of grade categories for the fall 2022 and 2024 semesters.

With weakened requirements for lab credit, we expected a minor increase in correlation between it and course total which is reflected in the charts. In general, there are noticeable increases in positive correlation between lab participation and the tests throughout the semester, with the largest increase being seen between Test 1 and lab participation. Interestingly, class participation decreased in correlation with every other category. Though, the authors believe that closer correlations would be seen if they additionally used data from Math 1020 performance.

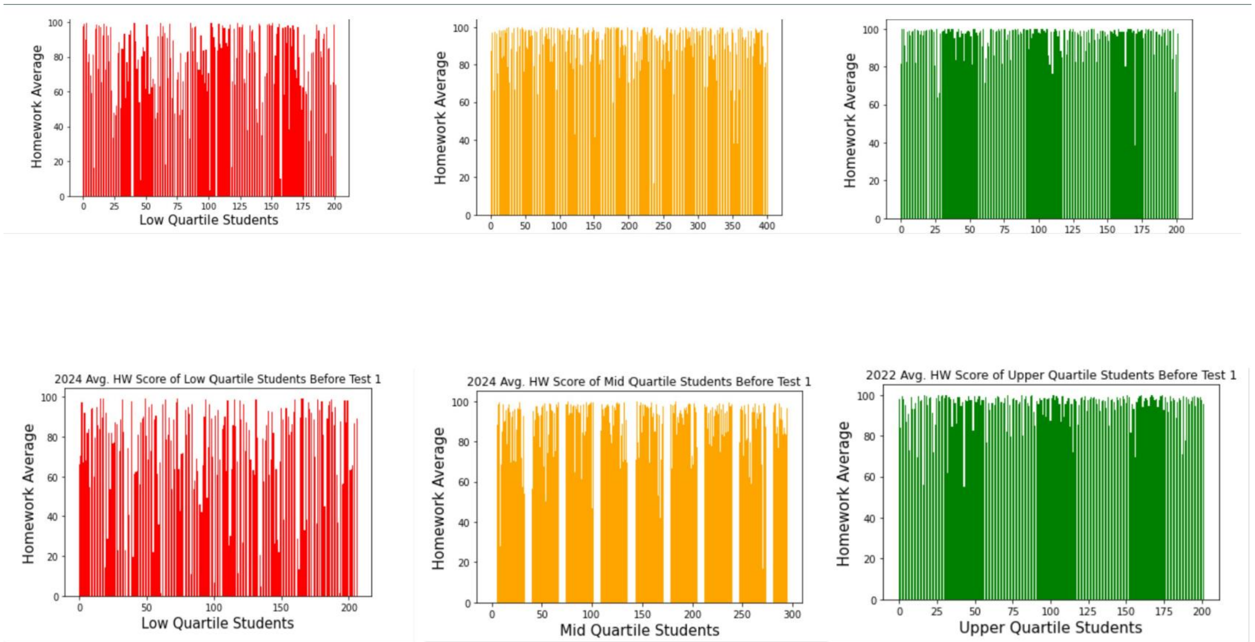


Figure 2. Average Homework Score Before Test 1 for fall 2022 and 2024 semesters

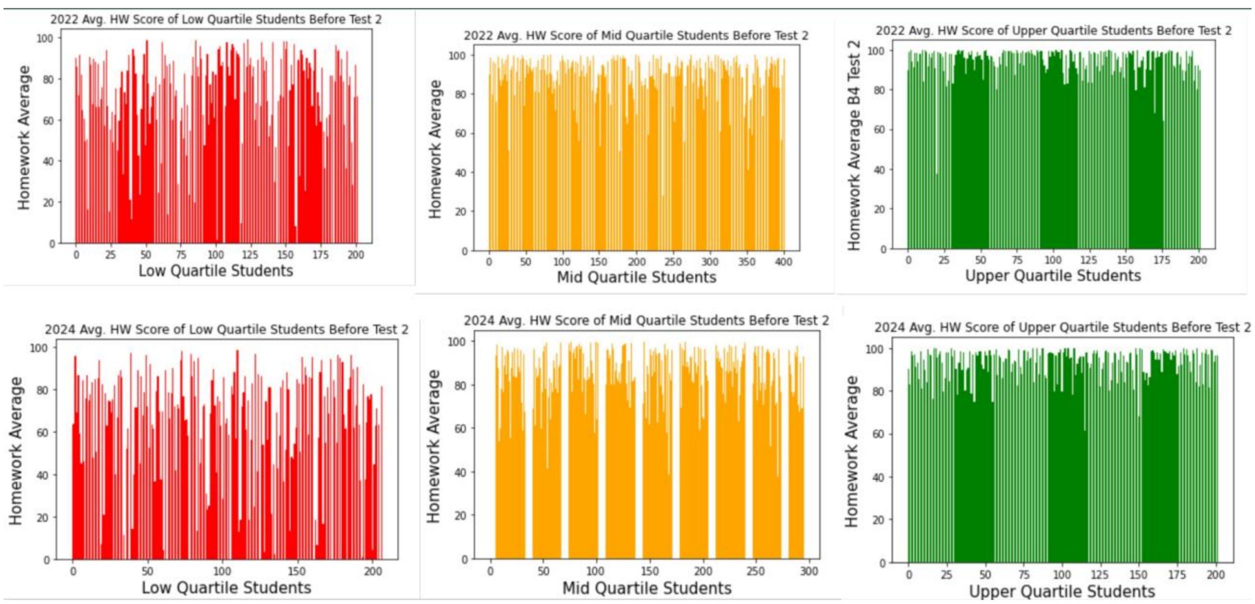
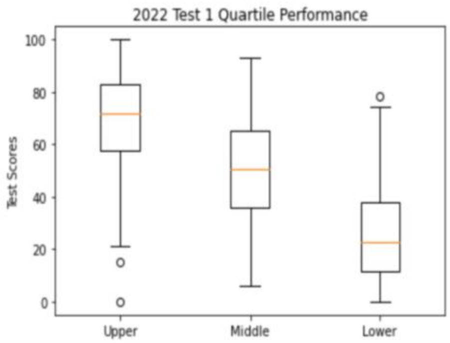
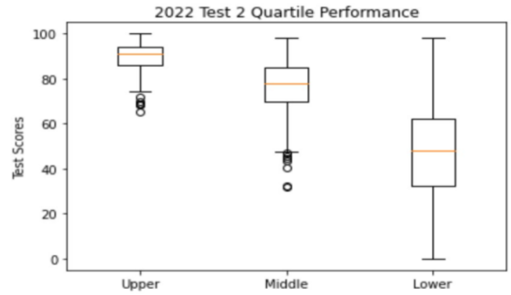
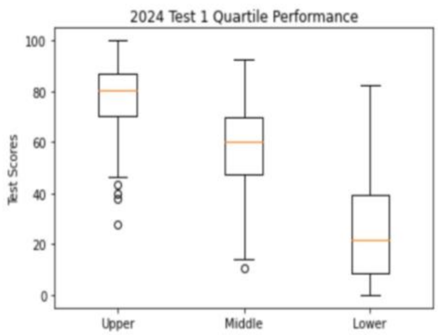
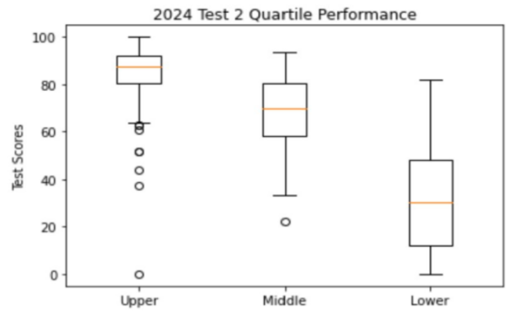


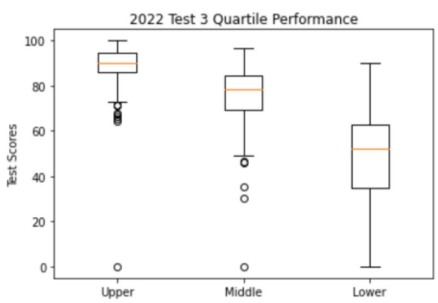
Figure 3. Average Homework Scores Before Tests 1 and 2 for fall 2022 and 2024 semesters.

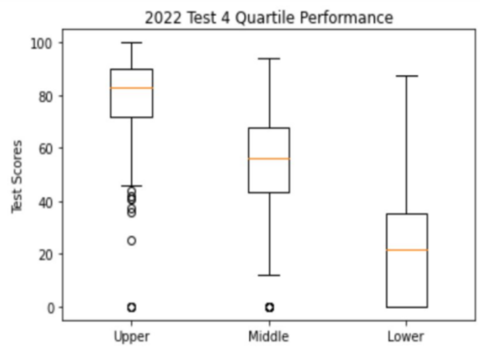

2022 Test 1 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower

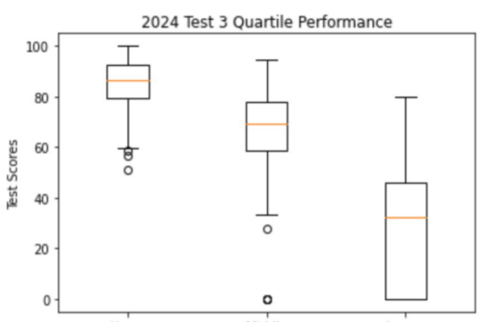

2022 Test 2 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower

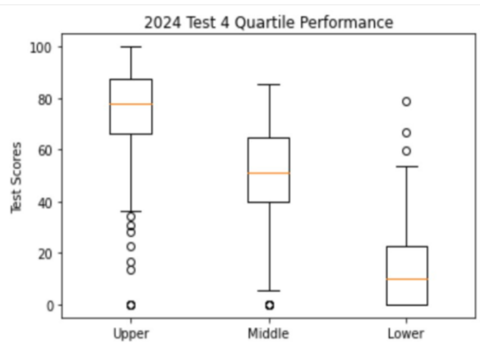

2024 Test 1 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower


2024 Test 2 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower


2022 Test 3 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower


2022 Test 4 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower


2024 Test 3 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower


2024 Test 4 Quartile Performance
Test Scores
0
20
40
60
80
100
Upper
Middle
Lower

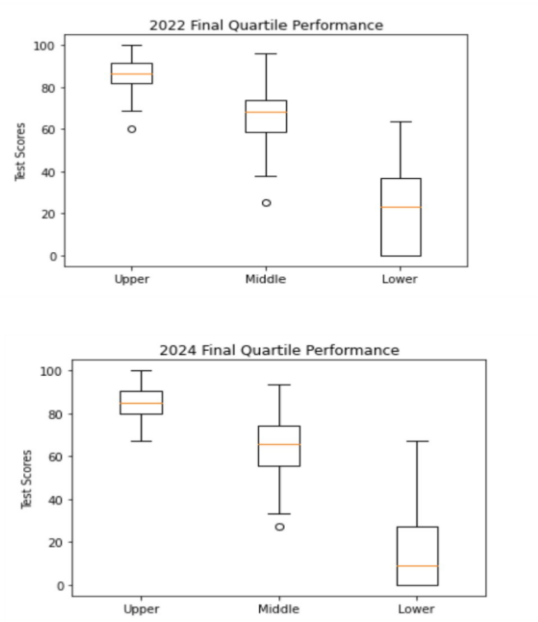


Figure 4. Boxplot of Test 1,2,3,4 and Final Exam Performance by Quartiles for fall 2022 and 2024 semesters.

Attendance Rates

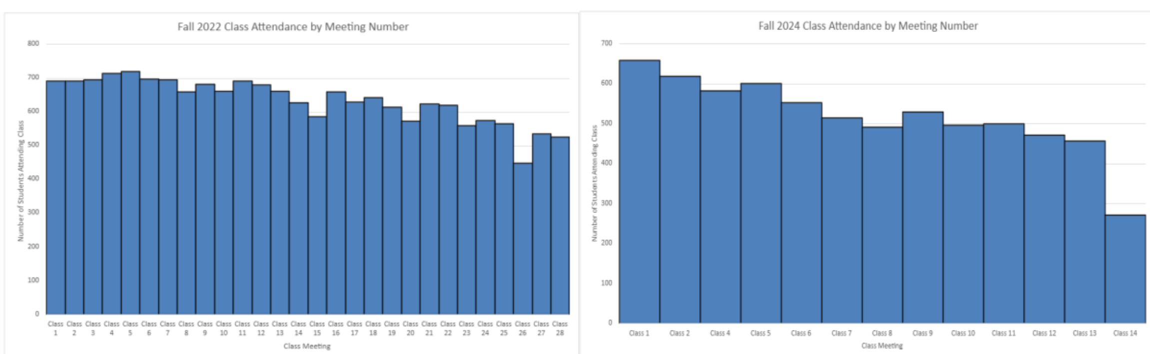


Figure 5. Fall 2022 and 2024 class attendance sorted by class meeting.

We observe that in general, attendance decreases as the semester progresses, with the lowest amount of attendance being seen in the last three class meetings. This is consistent across both semesters. However, the general decline is a bit larger in Fall 2024 than for Fall 2022. For 2022, the meeting with the largest attendance was Class 5 at 719 students (out of 806 on the roster at the end of the semester) and the smallest amount of attendance was seen on Class 26 with 448 attendees, giving a range of 271. For 2022, the meeting with the largest attendance was Class 1 at 659 students (out of 705 on the roster at the end of the semester) and the smallest amount of attendance was seen on Class 14 with 272 attendees, giving a range of 387.

While there are minor resurgences in attendance throughout the semester, the regains do not eclipse the loss seen from initial declines. For instance, in 2022, the jump in attendance at Class 15 does not reach the attendance of Class 11, which is where an initial decline can be noted. comparing to the initial decline from Class 11. A similar trend is seen between Class 16 and Class 21.

For 2024, resurgences were only seen in Class 5 and Class 9. Interestingly, the class is on a steady decline from Class 9 through the end of the semester. Using the 2024 daily schedule, Class 5 is the meeting one week after Test 1, and Class 9 is the meeting one week before Test 3. As such, there is not a discernable pattern to what causes these resurgences in attendance for current Math 1021 courses, as there are not similar attendance spikes around the second and fourth tests. However, tests happen approximately every four weeks, so resurgences are bound to be close to test dates. Using the academic calendar does not give much insight on what causes a resurgence as well, as Class 5 and Class 9 are not near any other significant dates to students (such as drop date, last day to drop with a “W”, holidays, etc.). For 2024, Class 9 is a week before the drop date, though Class 10 (a day before the drop date) was not at the same level of attendance, so the authors are unsure if there is a significant tie to this date.

It should also be recalled that the attendance figures do not include students that drop the course. Thus, this attendance rate represents only the students who made it to the end of the semester. Actual values may be higher.

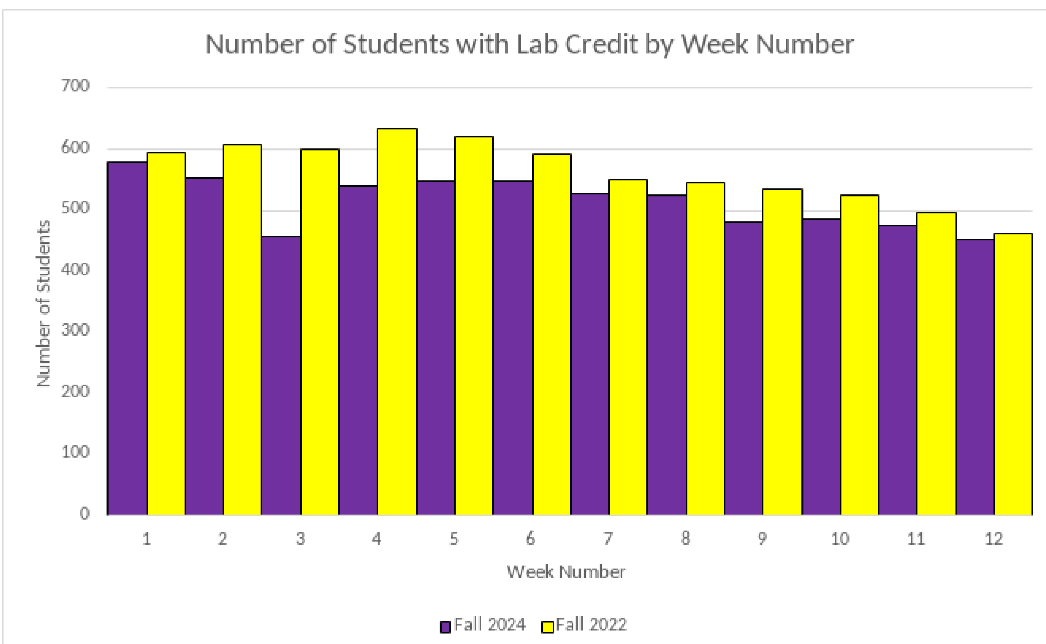


Figure 6. Number of students who got credit for full lab attendance, sorted by week number.

Lab attendance is in a general decline after the first few weeks. This is consistent across both semesters. The expectation of the authors is that the general lack of attendance in the later part of the semesters is due to academic burnout [6]. Another possibility is that students decide to dedicate their time to other courses. Using the LSU common data set for 2024 [7], approximately 86% of undergraduate students were enrolled full-time. As Math 1020 and 1021 give a total of 5 credit hours, it is a significant portion of a full-time student's enrollment. To make up for the large loss in GPA one sees upon failing a larger credit course, some students may make the decision to cut their losses and focus on other areas.

Lab attendance trends in 2022 and 2024 appear more similar than class attendance. The initial graphs may lead the reader to infer that a smaller proportion of students completed their lab attendance in 2024 than in 2022. However, when analyzing by percentage of students who received lab credit, it is clear that attendance in 2024 was generally higher.

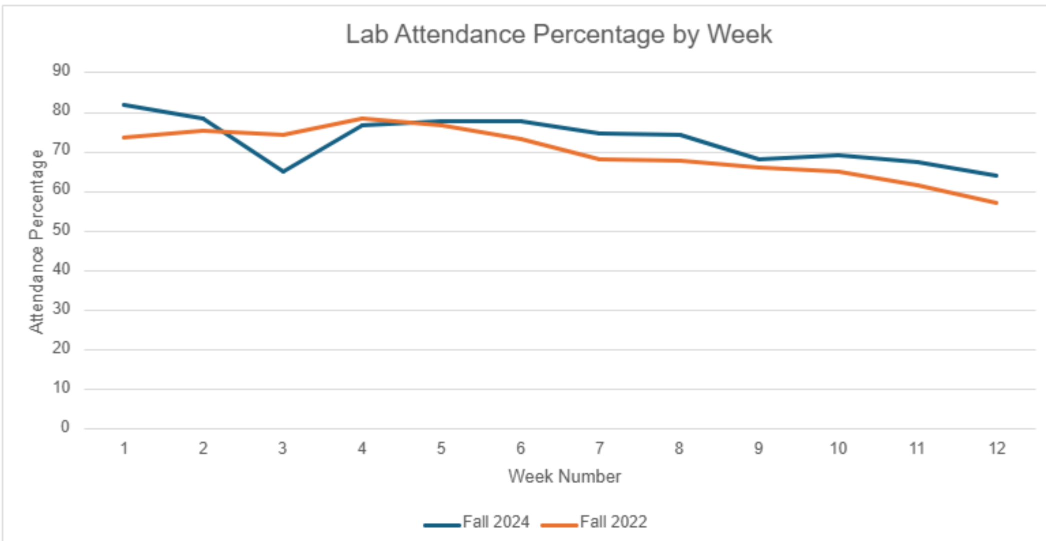


Figure 7. Line chart showing the percentage of lab attendance by week for both Fall 2022 and Fall 2024.

It is the authors' opinion that this is due to Fall 2022 requiring 3 hours of lab credit and Fall 2024 requiring only 2 hours of lab credit each week. What is not shown, of course, is whether the Fall 2024 students also received 3 hours of lab credit, so that they received lab participation credit for Math 1020 as well. In general, a student may be more likely to prioritize receiving credit for Math 1021 than Math 1020, as the latter does not count as credit toward any degree plan. Though Math 1020 performance still impacts a student's GPA.

It is reasonable to assume that participation correlates highly with student success [8]. We gather the count of students who meet specific threshold values to analyze whether this sentiment holds true for Math 1020/1021. At LSU, it is required of instructors to give their end-of-the-semester data sheet to the administration team, which includes giving the number of students who have at least a 70 for the class and lab participation grades, sorted by whether they passed (with a grade at least C) or failed/did not complete the course. We found the following counts for both 2022 and 2024.

	Counts	
Category	**Fall 2022**	**Fall 2024**
Total Number of Students	806	705
Failed	300	312
Less than 70 for Class Participation	177	220
Less than 70 for Class Participation and Failed	129	149
Less than 70 for Lab Participation	299	240
Less than 70 for Lab Participation and Failed	183	188
Less than 70 for Class and Lab Participation	147	142
Less than 70 for Class and Lab Participation and Failed	117	118

Table 2. Number of students who did not make at least 70 in participation grades for Fall 2022 and 2024, alongside those who failed the course.

Using Bayesian inference, we compare the statistics of participation across these semesters, as well as determine their influence on student success. For Fall 2022, there was approximately a 37% failure rate. 22% of students did not make at least a 70 for class participation, and of these students, 73% failed the course. 37% did not make at least a 70 for lab participation, and of these students, 61% failed the course. 18% of students received less than a 70 in both class and lab participation.

Analysis of Homework and Quiz Trends

For Fall 2022 and Fall 2024, we received the following counts from the data set. We recall that the abbreviations CP, LP, HW and Q represent the categories of Class Participation, Lab Participation, Homework and Quiz averages respectively.

	Fall 2022	Fall 2024
Category	**Count**	**Count**
Total Number of Students	806	705
Students who Passed	506	393
Students who Failed	300	312
Students with Less than 70% on HW	104	141
Students with Less than 70% on Q	141	169
Students with Less than 70% on HW and Q	83	108
Less than 70% on HW and Failed	91	126
Less than 70% on Q and Failed	113	143
Less than 70% on HW,Q and Failed	76	100

Table 3. Counts of students who meet categories relevant to homework and quiz performance for the Fall 2022 and Fall 2024 semester.

We begin our discussion of these counts by examining the fall 2024 semester. We note of the students who took Math 1020/1021, 44% failed Math 1021 in fall 2024. 20% of students had a homework average of less than 70, 24% had a quiz average of less than 70, and 15% had both their homework and quiz averages as less than 70. When examining the students who did not receive at least a “C” (70 or above) average in their homework and quiz averages, we see trends that support the advice of administrators to complete assignments when trying to succeed in Math 1021. As we see, of the students who had a homework average of less than 70, 89% failed the course. Of the students who had a quiz average of less than 70, 85% failed the course. Of the students who had both their homework and quiz averages of less than 70, 93% failed the course.

By the above counts, we can determine that there were 597 students who ended with at least a 70 average in homework and quizzes, with 212 of these students having failed the course. Thus, approximately 64% of students who end with a total of at least 70 for both their homework and quizzes pass the course. Therefore, these are moderate indicators that students will succeed in college algebra. Though, these may not be the percentages that an instructor would hope to see, as it implies homework and quiz performance is only a moderate indicator of success. Still, a student should be incentivized to perform at the level of an A grade for their homework and quiz averages. For fall 2024, only 344 students had a total homework average larger of at least 90. Of these students, 60 did not pass the course. However, these statistics make it clear that students who pass are engaging in good habits. Of students who passed the course, 96% have at least 70 for their homework and quiz averages, 93% have at least a 70 for their quiz averages, and 92% have at least 70 for their homework and quiz averages.

For fall 2022, approximately 37% of students did not pass the course with a grade of at least C-. 13% of students had a homework average of less than 70, 17% had a quiz average of less than 70, and 10% had both their homework and quiz averages as less than 70. Of the students who had a homework average of less than 70, 88% failed the course. Of the students who had a quiz average of less than 70, 80% failed the course. Of the students who had both their homework and quiz averages of less than 70, 92% failed the course. We find these trends to be mostly consistent with fall 2024, aside from minor discrepancies.

For fall 2022, there were 723 students who ended with at least a 70 average in homework and quizzes, with 224 of these students having failed the course. Thus, approximately 69% of students who end with a total of at least 70 for both their homework and quizzes pass the course. Once more, these are moderate indicators that students will succeed in college algebra. Of students who passed the course, 99% have at least 70 for their homework and quiz averages, 94% have at least a 70 for their quiz averages, and 93% have at least 70 for their homework and quiz averages. Once more, we find the general tendencies of students remaining similar across semesters. In both semesters, these markers are strong indicators of student success. We conclude this discussion by stating that we also found that the number of students which had all non-test averages at least 70 to be 352, and of these students, 281 passed the course. Therefore, a randomly selected student, who is at least satisfactory in all non-test categories, has an approximate probability of 0.8 to pass the course.

Test Trends Between Semesters

We begin our discussion on test grades by analyzing the grade distributions across these two semesters.

Relative Frequency Table of Grades by Test for Fall 2022						
Grade:	**A**	**B**	**C**	**D**	**F**	**0**
Test 1	0.03	0.08	0.11	0.12	0.62	0.03
Test 2	0.2	0.26	0.19	0.12	0.19	0.03
Test 3	0.18	0.27	0.2	0.13	0.19	0.04
Test 4	0.07	0.12	0.12	0.14	0.48	0.09

Relative Frequency Table of Grades by Test for Fall 2024						
Grade:	**A**	**B**	**C**	**D**	**F**	**0**
Test 1	0.03	0.1	0.1	0.14	0.57	0.05
Test 2	0.12	0.21	0.16	0.12	0.33	0.06
Test 3	0.1	0.19	0.19	0.13	0.32	0.08
Test 4	0.06	0.08	0.12	0.11	0.5	0.13

Table 4. Relative frequency tables for student grades by test for the fall 2022 and 2024 semesters.

We clarify that there was a test 1 retake policy in fall 2024 for students to improve their grade. However, only the first attempt was included in this relative frequency table. The tables show similar trends for the first and fourth tests. However, the second and third test relative frequencies show that there was a significant decrease in the proportion of students who met satisfactory grades (C or higher) on the second and third test. The relative frequency of students who had unsatisfactory grades for test 2 is 0.34 for fall 2022 and 0.51 for fall 2024. The relative frequency of students who had unsatisfactory grades for test 2 is 0.36 for fall 2022 and 0.53 for fall 2024. In addition, there is a slightly higher proportion of students who receive a 0 on the tests in fall 2024 against fall 2022, though not by as high of a margin as those who aren't making satisfactory grades on the tests. It is not immediately clear if the course format change had any influence on test performance for students, but there is a measurable difference in the performance across these semesters.

Looking at the raw averages of students backs up these differing trends. When removing students who had a 0 on the test, we compared the averages of students. Table 4 shows that the number of students who had a 0 on each test is a small, but not negligible value. A notable observation made by the authors is the number of students who took no test in each semester. For fall 2022, there were 12 students (approximately 1.5% of students) who did not take any test. For fall 2024, there were 23 students (3.3%) who did not take any test. In addition, it should be noted once more that this data does not include students who dropped the course.

Semester:	Fall 2022	Fall 2024
Category	**Average**	
Test 1	49.98	49.82
Test 2	74.1	65.6
Test 3	74.31	66.56
Test 4	56.98	53.03

Table 5. Averages for each test by semester, not including students who received a 0 on the test.

Once more, tests 1 and 4 mirror similar averages, up to a small difference. However, there are significant differences between the test 2 and 3 averages, given than grades are determined by a 10 point grading scale. This indeed reflects the frequencies seen in Table 4, as the grade category with the highest frequency for each test in fall 2024 was F. Thus, there was enough skew in the data to give a significant change in these averages.

With these findings, the authors were curious on whether student behaviors were significantly different by each week in their respective semesters. Thus, we conclude our initial data analysis with an analysis of course total for both semesters.

Statistical Analysis of Course Total

Time Series Analysis

For each student, we calculated their rolling course totals throughout the semester, using the end of a lab week to determine which grades are included in the calculation. This gave different formulas depending on the week, as the first three weeks had no tests to include in the average. The first three weeks' averages were calculated using the following:

$$CT = \frac{(0.05)CP + (0.05)LP + (0.1)HW + (0.1)Q}{0.3}$$

While the remaining weeks were calculated using the following:

$$CT = \frac{(0.05)CP + (0.05)LP + (0.1)HW + (0.1)Q + (0.45)T}{0.75}$$

In Excel, an example of a specific week's calculation is

```
=ROUND((0.05*U2 + AX2*0.05 + CL2*0.1 + DN2*0.1 +
AVERAGE(DQ2,DR2,DS2)*0.45)/(0.75),2)
```

here the entries U2, AX2, CL2, and DN2 are their class participation, lab participation, homework and quiz averages for the given week. Entries DQ2, DR2, and DS2 are their first three tests, which we average over to get their test total, having taken three tests at that point in the semester. The final week for each student is automatically included in the data, as it is the course total recorded in Moodle. After calculating each student's course total for each week, we averaged over the students to determine the average performance throughout the semester. These averages removed the small outlier of students who had a course total of 0 for all weeks. There were no students who scored 100 on all weeks.

The categories we plotted the time series for are

- All students (except those with 0 course total for all weeks)
- Students who attempted all homework
- Students with perfect attendance
- Students with satisfactory attendance (a final average of at least 70)
- Students with satisfactory homework and quiz averages (a final average of at least 70)

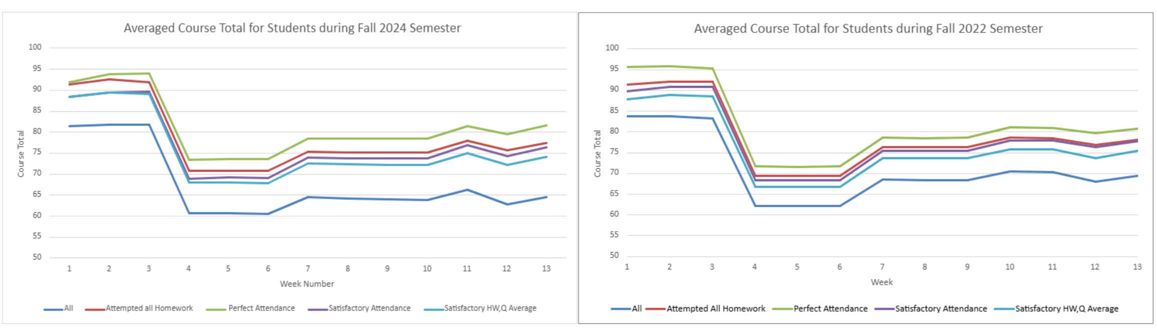


Figure 8. Time series of averaged student course totals by each week using fall 2022 and 2024 semester data separated by: all students, those who attempted each homework assignment, those with perfect attendance, those with satisfactory class and lab attendance (averages of at least 70) and those with satisfactory homework and quiz averages (of at least 70).

Notable jumps in student course totals occur at the third week, sixth week, and tenth week. These are the weeks during which the first three tests occur. We initially inferred that after the sharp decline after the first test was recorded, that the rebound in performance was not as strong as it could have been due to outliers of students who remained enrolled but stopped completing assignments. However, when analyzing students in the other categories, we observe similar trends. The main difference is that general returns in performance are better. In addition, students who are excelling or giving satisfactory levels of performance tend to start and end the semester with higher course total values. We make the note to clarify that a student who attempted all homework may not necessarily be receiving perfect scores on each assignment. This was simply a check of whether they had a non-zero score for each assignment.

Notably, while class and lab participation have weaker correlations to course total than homework and quizzes, controlling for satisfactory attendance showed better performance than controlling for satisfactory homework and quiz averages. Perfect attendance was plotted since there are a non-negligible number of students with perfect attendance (113 total) whereas there are only 4 students with perfect homework averages, 3 with perfect quiz averages, and only 1 student with perfect homework and quiz averages. Still, there is a larger sample of students who meet satisfactory homework and quiz averages at the end of the semester (503) than there are students who have satisfactory attendance (387), so the general effect of attendance on course performance should be carefully observed.

Figure 5 shows general decline with small regains throughout the semester. However, when analyzing samples of students, we see sharp regains on occasion.

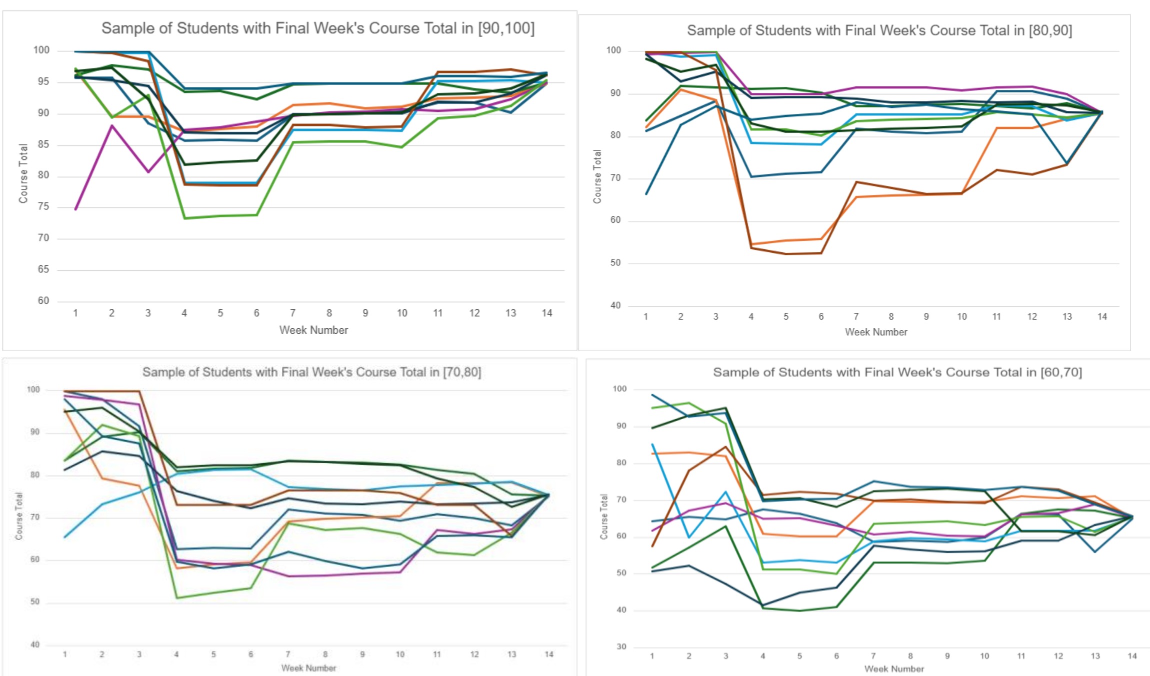


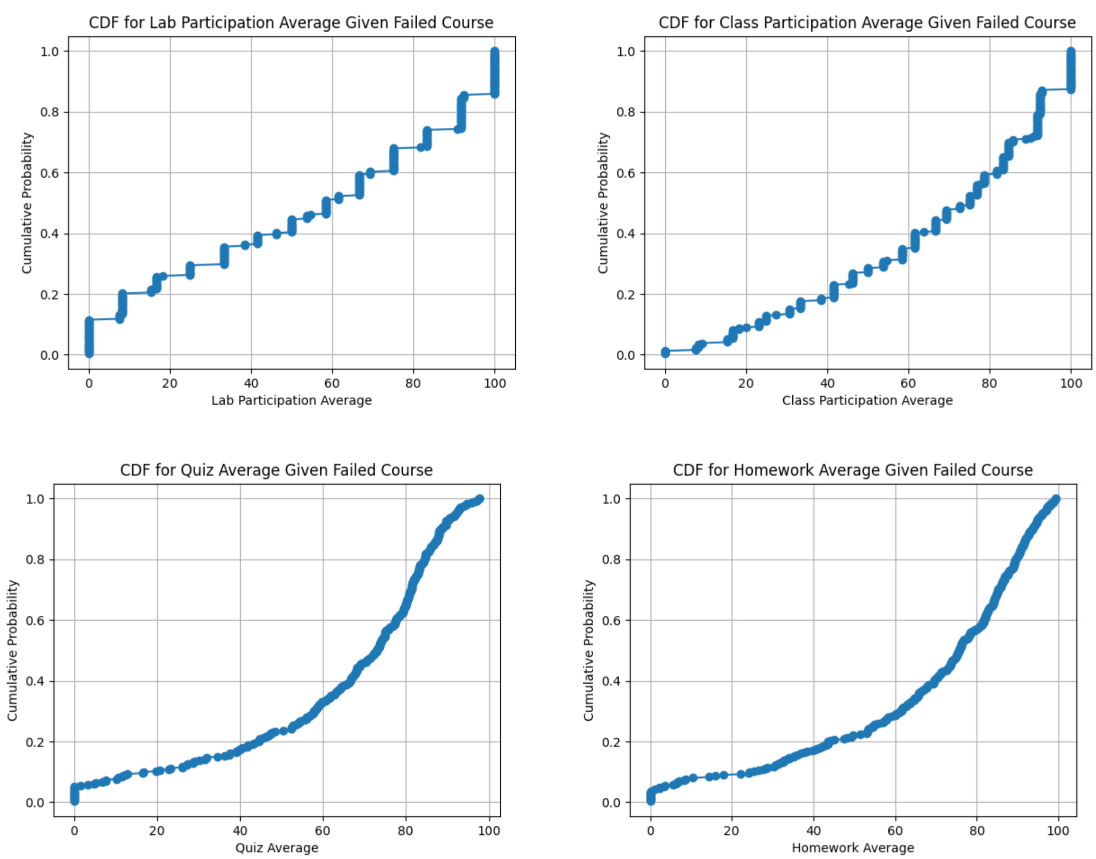
Figure 9. Sample of Fall 2024 student course totals by week number with final course total around the center of [90,100],[80,90],[70,80], and [60,70].

Most students across these samples, as well as in underperforming samples, experience significant performance drops, with a decent return, though do not reach the point of their previous score. However, there are students who rebound their scores greatly. It is unknown to the authors what the reasons for such large gains are. However, what can be discerned is that there are some thresholds which students do not rebound from based on the data.

Fitting a Probability Distribution

To better understand the behaviors and tendencies of students that failed the course, we examine the cumulative distribution functions (CDF) of grade category averages for students who failed and passed. This is in hopes to determine the conditional distribution of a students and determine the trends in good and bad behaviors. Using distributions to gain insight on course structure and student performance was previously done by Lewin [11], where he analyzed the distribution of exams to gain insight. However, we adapt such methods to instead analyze students who failed and do not limit our analysis to exam grade distribution.

A)



B)

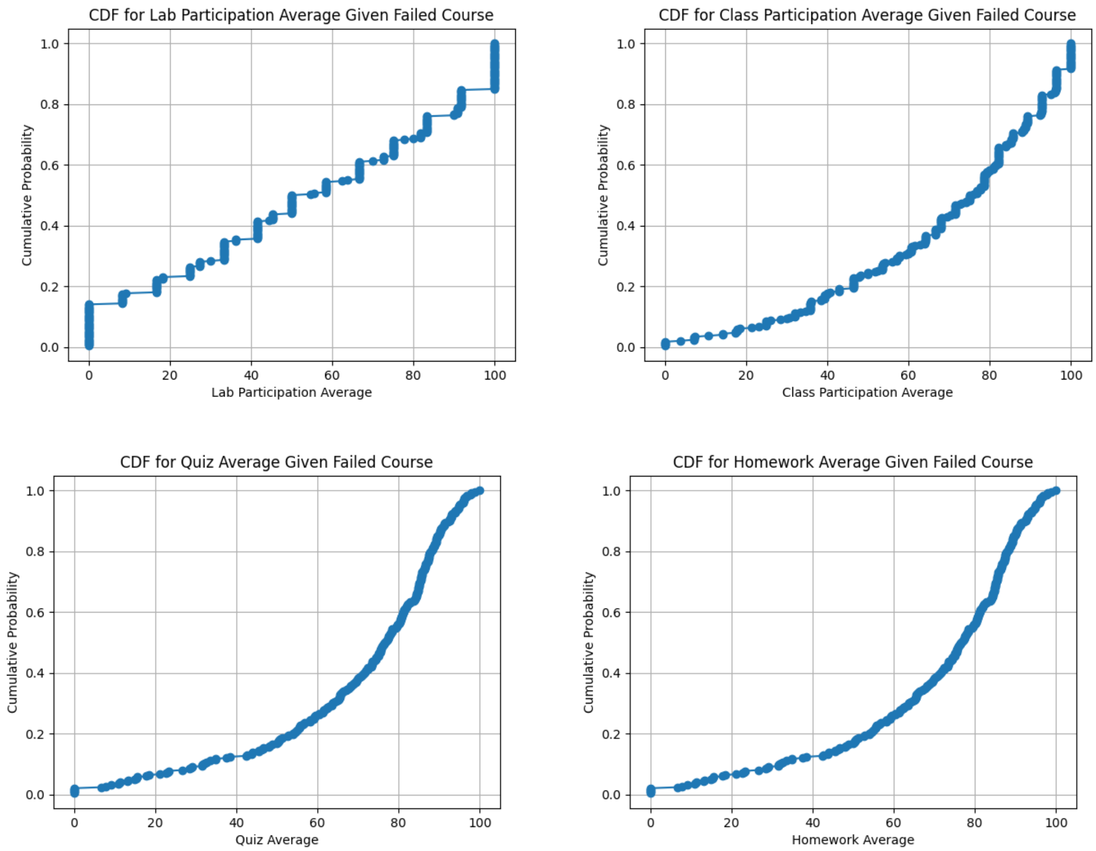
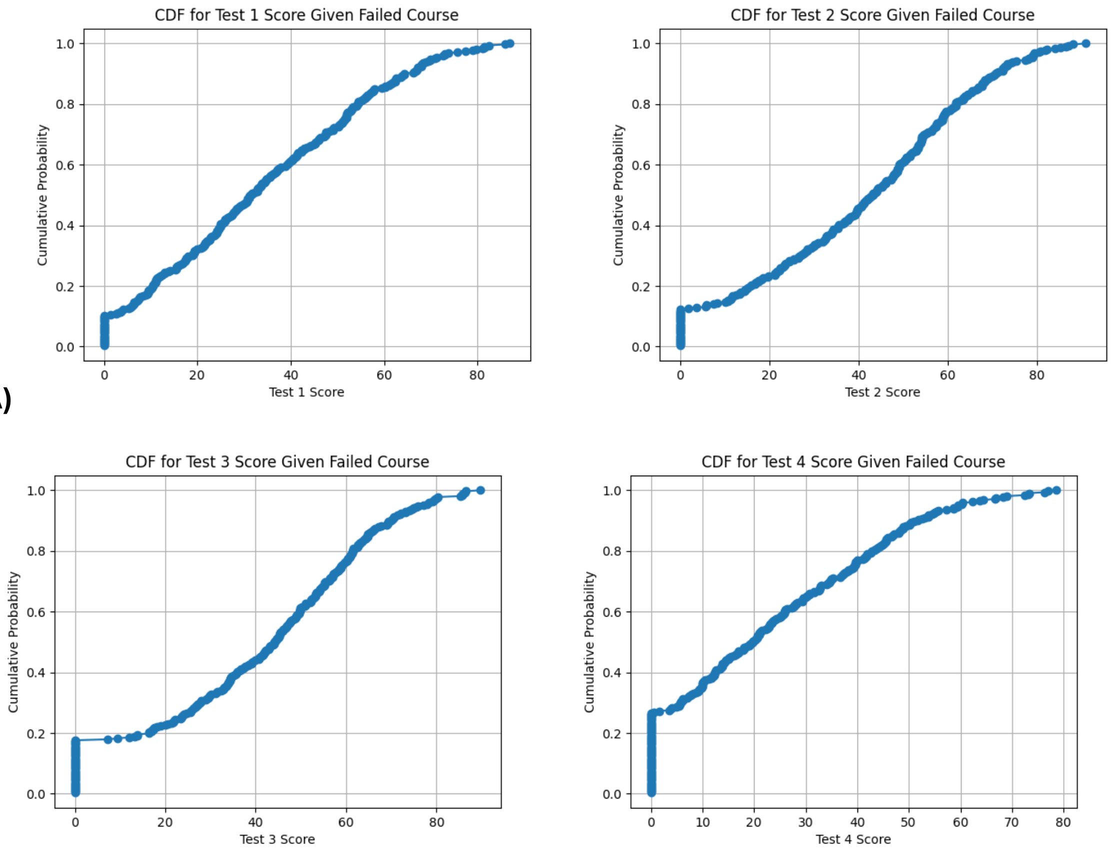
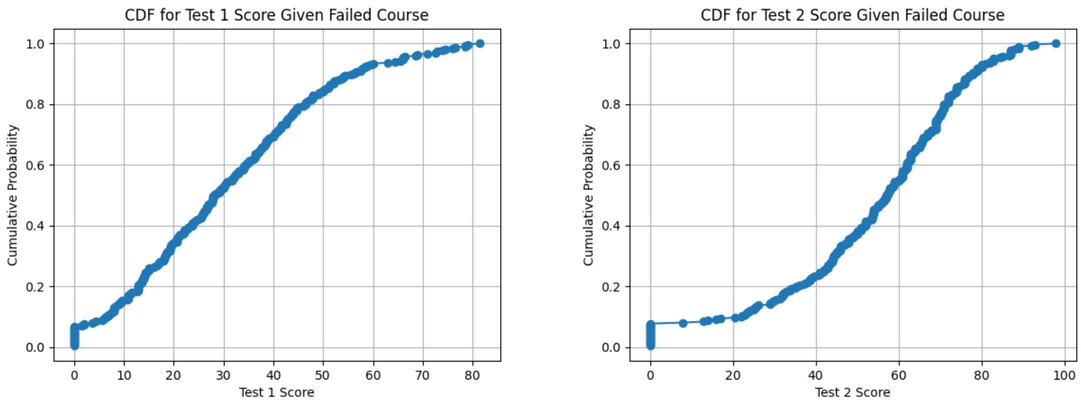


Figure. A) CDFs for the conditional distributions of non-test grade averages for students who failed using Fall 2024 data. **B)** CDFs for the conditional distributions of non-test grade averages for students who failed using Fall 2022 data.

The CDFs of continuous valued grades (homework and quizzes) resemble smoother curves. The rigidity of the participation CDFs is due to the discrete nature of the grades. These averages can be expressed as a finite set of rational values. The minor discrepancies in participation are due to the instances where a student has an excused absence, as they do not factor into the average. We can note a large number of students (though not necessarily the majority) who failed do not reach satisfactory averages (at least 70) for non-test items. The data also indicates that approximately 10 to 15% of students who failed have excelling averages (at least 90). Thus, a future motive for researchers can be analyzing this high end of failing students and the low end of passing students to discern the patterns that “make or break” the grade. Comparing the CDFs between 2022 and 2024 shows the students of each semester are similarly distributed. Across both semesters, those who failed in the course appear to have similar trends in behavior. Analyzing the conditional distribution for test scores gives similar results.

A)


CDF for Test 1 Score Given Failed Course
Cumulative Probability
Test 1 Score
CDF for Test 2 Score Given Failed Course
Cumulative Probability
Test 2 Score
CDF for Test 3 Score Given Failed Course
Cumulative Probability
Test 3 Score
CDF for Test 4 Score Given Failed Course
Cumulative Probability
Test 4 Score



B)

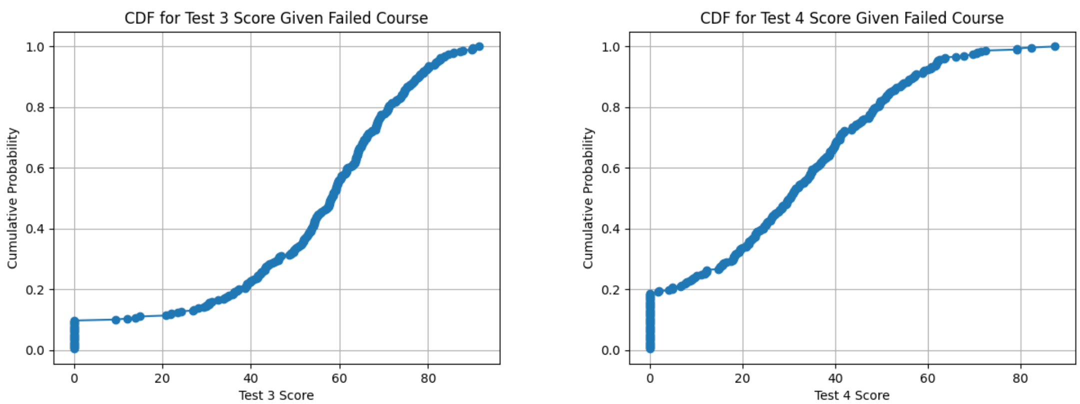
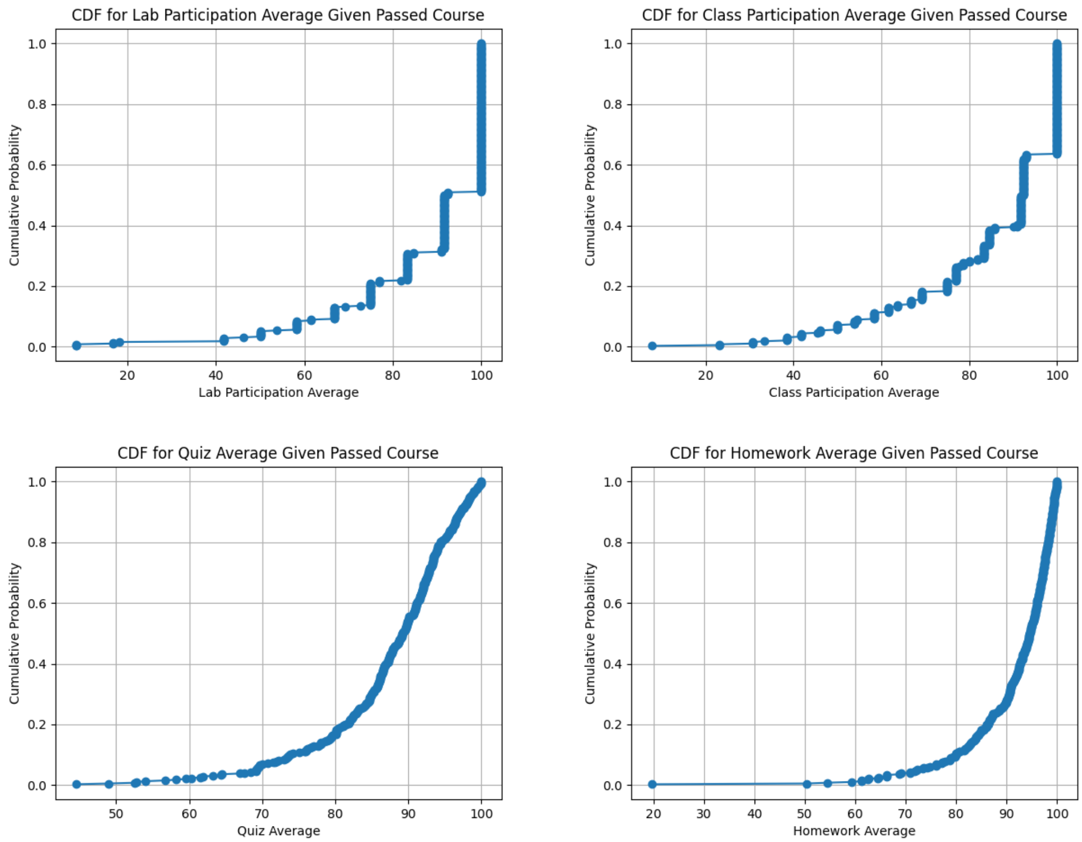


Figure. A) CDFs for the conditional distributions of test grades for students who failed using Fall 2024 data. **B)** CDFs for the conditional distributions of test grades for students who failed using Fall 2022 data.

Indeed, the CDFs are similar, though there are more noticeable distinctions between the curves. In Fall 2024, students were much more likely to simply not show (grade of 0) for tests 3 and 4 than in 2022. In addition, there are a larger proportion of students who failed with failing test scores in Fall 2024 than in 2022. For instance, test 2 shows a probability of 0.8 that a student had a score of 60 or less when using Fall 2024 data, whereas this probability is closer to 0.6 for Fall 2022 data.

It is also important to compare these results to the CDFs of the conditional distributions of the students who passed, as it is important to understand the distribution and skew of good behavior as much as it is to understand that of bad behaviors. This led us to make the following charts.

A)


CDF for Lab Participation Average Given Passed Course
Cumulative Probability
Lab Participation Average
CDF for Class Participation Average Given Passed Course
Cumulative Probability
Class Participation Average
CDF for Quiz Average Given Passed Course
Cumulative Probability
Quiz Average
CDF for Homework Average Given Passed Course
Cumulative Probability
Homework Average

B)

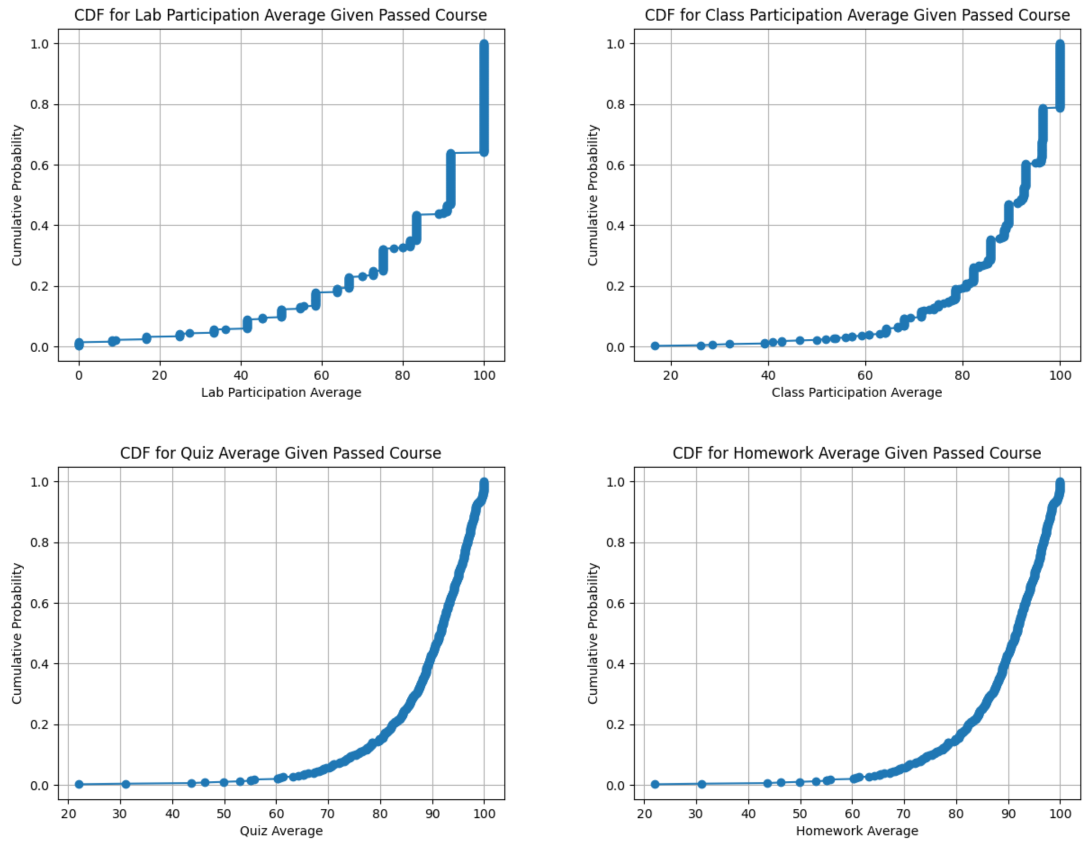


Figure. A) CDFs for the conditional distributions of non-test grade averages for students who passed using Fall 2024 data. B) CDFs for the conditional distributions of non-test grade averages for students who passed using Fall 2022 data.

For Fall 2024, the participation policy led to a larger proportion of students with perfect lab and class attendance. Of course, in Fall 2024, there are meetings which instead count as credit for Math 1020, and do not reflect in the calculation of this CDF for Math 1021. Interestingly, the proportion of students who passed with less than a 90 as their quiz average increased in 2024 but those who passed with less than 90 as their homework average decreased in 2024.

Student Behavior and Academic Intervention

Determining Criteria for Academic Intervention

The motivation of this section is to find suitable criteria for academic intervention. An initial idea of the authors was to determine the minimum course total of a passing student week by week. Thus, using the current format and more recent data should better reflect the information for instructors at LSU to take from the data. As such, the following table was made using only fall 2024 data. The following table was made by retrieving the minimal course total seen at a given week by a student who eventually passed the course in the Fall 2024 data.

Week	1	2	3	4	5	6	7	8	9	10	11	12
CT	16	37	39	30	32	33	46	47	49	50	55	58

Table 6. Minimal course total (CT) by week for students who passed the course, rounded down to the nearest integer.

Thus, in fall 2024, if a student entered the third week (going into test 1) with less than a 37 for their course total, they did not pass the course. These should not be looked at as concrete values that will be accurate predictors of student success or failure. However, they may be analyzed across semesters to determine general trends and give educators an idea on problematic thresholds what students most need immediate academic intervention.

In addition, recalling the analysis of Tables 2 and 3, we saw participation in assignments as a strong indicator of student success. If a student is not participating in assignments at the beginning of the semester, the student has a strong likelihood of not passing the course if the behavior propagates through the end of the semester. In general, whether analyzing a select non-test category, or examining course total, there are thresholds that instructors are aware of, which signals when a student is need of academic help.

Averages by Test Block

Figure 8 indicates a stark drop off in student course total in the third week, with regains being present at the week of tests. This is consistent with Figure 2, which analyzes students who completed all homework assignments. We analyzed student non-test averages by test block (the period between tests) to determine where student performance is lackluster. So, for instance, the test 1 block is the time up to test 1, the test 2 block is the time after test 1 and before test 2, and so on. Using the heatmaps seen in Figure 5, homework has a moderate positive correlation with test averages. As such, the authors expected homework performance that relates to a given test to be higher if that test average were higher. However, this assumption does not reflect the data seen across both semesters.

	Averages							
Category	**Test 1 Block**		**Test 2 Block**		**Test 3 Block**		**Test 4 Block**	
Year:	**2022**	**2024**	**2022**	**2024**	**2022**	**2024**	**2022**	**2024**
Homework	94.34	92.31	90.22	86.49	92.52	88.07	91.79	86.03
Quizzes	91.91	87.85	86.91	83.71	86.69	82.81	90.04	86.1

Table 7. Averages of homework and quizzes by test block, separated by semester.

As the data shows in Table 5, the test with the lowest score across both semesters is test 1. However, the highest homework and quiz performance is seen on the material related to the first test. Initially, the authors assumed that this was due to less students participating in the assignments. However, Table 7 removes any assignments that were recorded as 0. Therefore, these averages are computed from students who attempted the assignments in the test block. Across both semesters, the lowest quiz averages were found in the blocks with the best test performance (test 2 and 3 blocks). The lowest homework averages were seen in the test 2 and test 4 blocks for both semesters. Thus, interestingly, while homework has a positive correlation with test performance, isolating each test and comparing performance on its related homework and quizzes does not reflect the performance. Still, the averages are relatively close, so this likely does not infer much beyond students are consistently participating in assignments, but have the strongest performance in the beginning of the semester. Students may be simply doing less questions on later assignments, rather than getting problems incorrect.

Test 1 Retake Policy

For Fall 2024, the administrative team for Math 1021 at LSU decided to provide students the opportunity to retake test 1 in an effort to improve their score. This retake did not replace a student's first attempt if they performed worse on their second attempt. The utility of frequent testing as it relates to student retention has been studied [7] with Paff noting most previous studies reported positive effects from frequent testing. For a specific study on optional retakes, Davidson [8] studied an introductory psychology course and noted improved student performance after the retakes. In addition, he found findings from students indicating decreased anxiety when offered a retake.

We determine whether the policy was beneficial and conductive to student success. As such, we retrieved counts relevant to whether such a policy was beneficial to students. At the minimum, such a survey gives insight into the trends seen in students who take advantage of such opportunities for score improvement.

Students who Participated in the Optional Test 1 Retake	
Category	**Counts**
Total	365
Saw Improvement	292
Passed the Course	195
Saw Improvement and Passed	154
Less than C- on First Attempt	322
Less than C- and Saw Improvement	269
Less than C- on First Attempt and Passed	161

Less than D- on First Attempt	268
Less than D- and Saw Improvement	232
Less than D- on First Attempt and Passed	116

Table 8. Number of students who participated in the test 1 retake option offered in fall 2024, along with counts of relevant categories.

Using Tables 3 and 8, we can note that approximately 52% of students on the roll sheet partook in the test 1 retake. Of these students, 80% saw improvement in their score and 53% passed the course. Of the students who took the retake and passed the course, 79% saw improvement in their test 1 score. Of the students who failed, 54% took the retake option. Most students who took the retake (approximately 88%), had a less than satisfactory score for their first attempt. In fact, 73% of students who took the retake originally failed test 1. Approximately 92% of students who saw improvement originally had a less than satisfactory score for their first attempt.

From these statistics, the authors conclude that the test 1 retake policy was beneficial to student performance, and that it served a good purpose. Most students who took the retake improved their score, and the large majority of these students had subpar performance for their first attempt. Still, the number of students who increased their score by at least a letter grade's worth of points (10 points) is much less. For students who made less than a C- on their first attempt and saw improvement, we found that only 167 of them had an improvement of 10 or more points, 96 of them had an improvement of 20 or more points, 36 of them had an improvement of 30 or more points, 17 of them had an improvement of 40 or more points, and 5 of them had an improvement of 50 or more points. Thus, while most students who had a subpar test 1 score did not see a large improvement of their score, approximately 13% of students who had a subpar test 1 score improved their score by a significant amount (at least 30 points). We also found that of the students with a subpar test 1 score who improved it by at least 30 points, 27 of them passed the course, meaning 75% of students in this category. Overall, these findings support the continuation of an optional retake in future semesters, if the goal is to give the opportunity for students who had subpar test 1 scores to improve their performance.

In fall 2022, there was no test 1 retake option. We found the average improvement among students who improved their score was 16.16. We simulated what this policy would have done for student performance in 2022 if the option were available. Our method was to apply this average increase to each test 1 score of the students who failed, recalculate final grades with this replacement, and determine the number of students who now passed. We found that 13 (out of 300) previously failing students in 2022 would now attain a passing course total of at least 69.5 after this hypothetical test 1 score increase. This is roughly 4.3% of the originally failing group, which is a non-negligible amount. In addition, we applied this same method to the students in 2024 who did not take the retake and failed the course. We found that 6 (out of 142) failing students in 2024 with no test 1 retake would cross the 69.5 course total threshold and pass the course with this improved test 1 score. This is only about 4% of that subgroup, which is still a non-negligible number of students.

Future Work

While analyzing these patterns in student performance showed general trends remained similar between semesters, there was a notable improvement in lab attendance in the fall 2024 semester. Further analysis of what causes the differences in averages seen in Table 5 and Figure 8 using qualitative student data and external circumstances to these semesters would be the next step in discussing the reasons behind the differences. This study used only quantitative data and is treated as an exploratory descriptive study, rather than a study on examining the meanings behind the trends. For the test 1 retake analysis, the projection was restrictive, with the only change being a hypothetical increase in their test 1 score. To further analyze the effect that an optional retake had on students, we plan to analyze the improvement in other grade categories as the semester progressed. Upon determining the general increase in performance, these can then be simulated in fall 2022, to determine if the number of students who pass would be a significant amount. This study also did not use the data of students who dropped Math 1020/1021. It would be interesting to conduct a study similar to McKinney, et. Al. [12], which analyzes why students drop courses in a community college, instead in the context of an R1 flagship, such as LSU.

Another component of this project was to use machine learning to speculate pass or failure of students, rather than give a simple threshold to examine week-by-week. Our initial findings are currently being collected in a separate report. We mention that this project inspired us to use both datasets simultaneously when testing and training the model, as we see similar patterns in course total among both semesters, even though actual averages vary. We hope that this will provide a more substantial method to classify at-risk students, who may benefit from academic intervention, early in the semester.

Lastly, this study examined students who were in Math 1020 and 1021, rather than solely in Math 1021. Each student in the data set also had grades for Math 1020 items. The authors believe it would be of value to examine the performance of students in Math 1020 and determine if it relates with their performance in Math 1021. There is anecdotal evidence observed by the instructors and administration of Math 1021 to indicate that there is not as strong of a relationship between performance as one would expect. It would be a worthwhile study to determine if the data reflects these observations. If a stronger relationship is shown than expected, it could justify creating an even stronger tie between the two components. Otherwise, if the relationship between the two courses is weaker, then it may spark a motivator to increase the course relation, (such as possibly reverting to the original PRQ assignment system).

Acknowledgements

The authors thank Dr. Nadejda Drenska for acting as the PI for this study, which was approved by the LSU Institutional Review Board. In addition, the authors thank the Math 1021 administration, especially Phoebe Rouse and Stephanie Kurtz for their approval, cooperation, and support for this study.

References

1. https://www.math.lsu.edu/precalcprogram/1020
2. Perez, S. (2022). Who needs college algebra? Kansas Universities May Rethink Math Requirements. *KMUW*. https://www.kmuw.org/news/2022-12-12/who-needs-college-algebra-kansas-universities-may-rethink-math-requirements
3. Katz, V. J. (2007). *Algebra: Gateway to a technological future.* The Mathematical Association of America (MAA). http://www.maa.org/algebra-report/Algebra-Gateway-Tech-Future.pdf
4. Herriott, S. R., & Dunbar, S. R. (2009). Who takes college algebra? *PRIMUS*, 19(1), 74–87. https://doi.org/10.1080/10511970701573441
5. Boretz, E. (2012). Midsemester academic interventions in a student-centered research university. *Journal of College Reading and Learning*, 42(2), 90–108. https://doi.org/10.1080/10790195.2012.10850356
6. Liu, Z., Xie, Y., Sun, Z. *et al.* Factors associated with academic burnout and its prevalence among university students: a cross-sectional study. *BMC Med Educ* **23**, 317 (2023).
7. Paff, Bradley. *Effect of test retakes on long-term retention*. Diss. 2012.
8. Davidson, William B., William J. House, and Thomas L. Boyd. "A Test-Retest Policy for Introductory Psychology Courses." *Teaching of Psychology* 11.3 (1984): 182-84.
9. https://www.lsu.edu/data/common-data-set/index.php
10. Randy Moore, Murray Jensen, Jay Hatch, Irene Duranczyk, Susan Staats, Laura Koch "Showing Up: The Importance of Class Attendance for Academic Success in Introductory Science Courses," *The American Biology Teacher*, 65(5), 325-329, (1 May 2003)
11. Lewin, Daniel R. "What Can We Learn from Exam Grade Distributions?." *International Journal for the Scholarship of Teaching and Learning* 15.2 (2021): 7.

12. McKinney, L., Novak, H., Hagedorn, L.S. *et al.* Giving Up on a Course: An Analysis of Course Dropping Behaviors Among Community College Students. *Res High Educ* **60**, 184–202 (2019).