Measuring Success in Mathematics Trailer Sections

Deana B. Olles M.S., Helen Timberlake M.S., Rebecca Daggar M.S., Elizabeth Davis
Rochester Institute of Technology School of Mathematical Sciences

INTRODUCTION

An analysis of the success of students in selected trailer and non-trailer general education mathematics courses is conducted. It is assumed that trailer students are typically less successful in sequential courses and, based on the results of the data analysis, we will be able to make recommendations and implement policies and procedures that will assist them in completing their coursework effectively. The failure rate in these types of courses is high enough to warrant concern for those students requiring better resources, adequate review of prerequisite concepts, or enhance student motivation and persistence.

THE COURSES

	Calculus B	Calculus C	Statistics I
Non-trailer Section	Spring Semester	Fall Semester	Does not apply to this course.
Trailer Section	Fall Semester	Spring Semester	
Non-trailer Student	Student is taking the course either in the semester recommended in their timeline or before (credit by examination).		Based solely on whether or not they are repeating the course.
Trailer Student	Repeating the course Repeated one or more prerequisite courses Began in lower level than recommended by program of acceptance		

STATISTICAL ANALYSES

The samples of trailer and non-trailer students are independent of one another so it is sufficient to make some inferences concerning the difference between their means. Assuming the populations of trailer and non-trailer students have normally distributed success rates with means μ_T and μ_N respectively, the null hypothesis is that no difference in the means exists and, alternatively, there is enough of a difference to warrant some concern about the success rate of one of the populations.

$$H_o: \mu_N - \mu_T = 0$$
$$H_a: \mu_N - \mu_T \neq 0$$

Using a 0.05 level of significance, the hypothesis tests for the difference of the mean success rates of trailer and non-trailer students for each of the learning outcomes, regardless of semester course offering, were conducted and confidence intervals constructed. Below are the estimated differences of the means and standard errors.

| LO	Statistics I				Calculus B				Calculus C			
	1	2	3	4	1	2	3	4	1	2	3	4
$\bar{x}_N - \bar{x}_T$	0.68	-3.4	10.5	16	2.83	4.27	15.2	-0.2	10.1	4.08	13.1	17.1
$\sigma_{\bar{x}_N - \bar{x}_T}$	10.2	6.73	11	12	6.9	4.31	5.38	6.58	2.89	4.03	4.54	12.1

Further analyses will be conducted on the differences of the success rates of trailer and non-trailer students from semester to semester and over each exam in the course. A deeper look into the success rates on exams might be an interesting way of determining where the students who fall into the trailer classification may need more remediation in order to perform at the same level as their non-trailer counterparts. Since the Spring semester has not yet come to a close, the collection of data and analyses mentioned cannot be finalized, at this time.
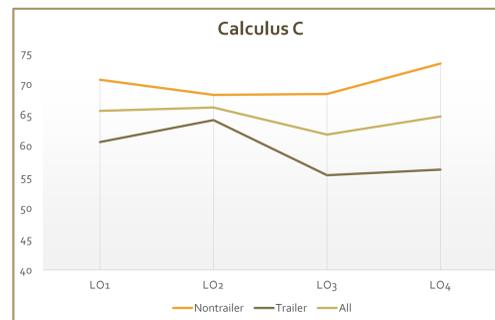
PLOT ANALYSES
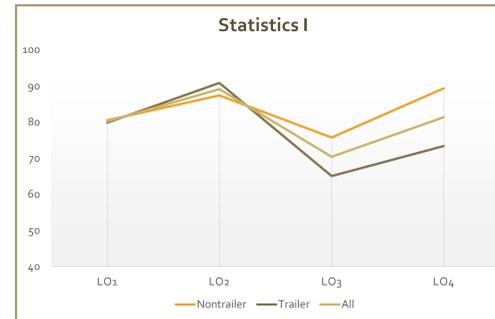
Examination of the line graph to the left and comparing learning objectives, we observe that the trailer and non-trailer students are about equal for LO1 and LO2. However, as the course becomes more complex and we move into the higher learning objectives, the trailer students' scores drop. LO3 has the lowest success rate for both groups. The *p*-value obtained from the hypothesis performed on LO3 is 0.058, so we fail to reject the null. This indicates that there is not a significant difference in the mean success rates. Focus needs to be placed on all students, regardless of classification, in the area of LO3.

Testing the hypothesis that there is no difference in the mean success rates of trailer and non-trailer students in LO4 yields a *p*-value of 0.016 so we are to reject the null hypothesis. We are 95% confident that the interval of differences ranges from 4.02% to 27.98%. The bar graph which compares scores from semester to semester, shows the scores for each of the learning objectives are about the same. This is to be expected because the proportion of trailer to non-trailer is roughly the same every semester.
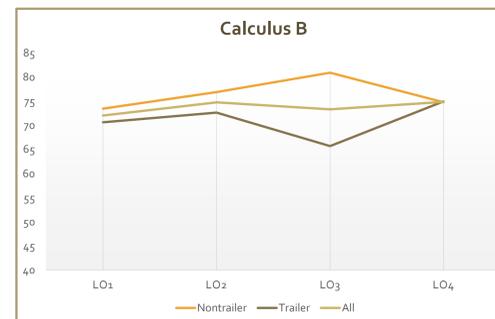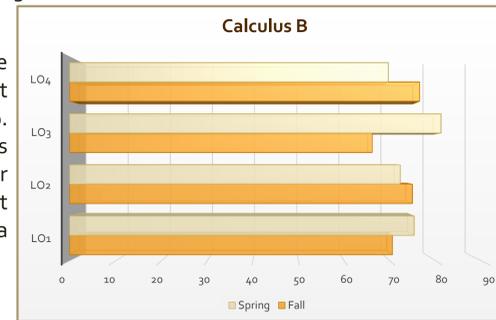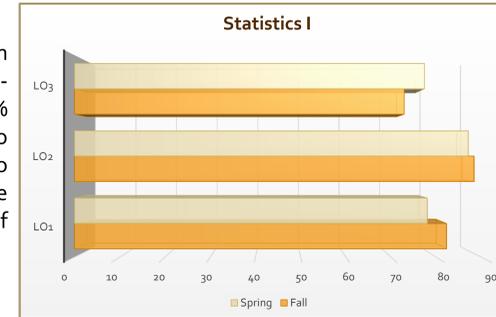

To the left is a line chart describing the success rates of trailer and non-trailer students in Calculus B. The two samples seem to be able to grasp the concepts in three of the four learning objectives, but the third learning objective seems to be where the trailer students begin to falter. Though the trailer students are as successful in LO4, their ability to *set up* an integral to solve a problem, they are unable to *evaluate* that integral, as seen in the results of LO3.
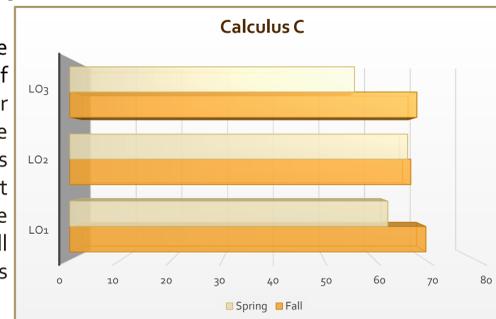
Calculus B results indicated an immediate cause for concern in the success rates of learning objective 3. We can be 95% confident that the difference of the means is between 9.84% and 20.59%. With a *p*-value of zero, we reject the null hypothesis that there is no difference in the mean success rate of trailer and non trailer students in LO3 in Calculus B. In all other objectives we do not have sufficient evidence to suggest that there is enough of a difference between the success rates of these two populations.

The figure to the left displays the student success rate in each learning objective for the Calculus C course. Trailer and non-trailer students from both Fall and Spring semesters were grouped together to determine if the individual's classification would be a good predictor for their success in each objective. The bar chart below represents the success rates of students in trailer and non-trailer sections of Calculus C. The Fall semester is a non-trailer course offering Spring is a trailer course offering. Both displays indicate a significant difference in the students' abilities.

In both diagrams, it is apparent that the trailer students are able tighten the gap at LO2, as this objective is tested by repetition of procedures and methods. The 95% confidence interval for difference of the mean success rates in the first learning objective in Calculus C is between 7.17% and 12.95%. This range decreases when examining the results for the second learning objective, but in the third (8.58% to 17.65%) and fourth (4.96% to 29.25%), the difference is clear. All *p*-values are small enough to reject the null hypothesis that there is no difference in the means of the success rates of trailer and non-trailer students in Calculus C.

THE LEARNING OBJECTIVES AND DATA COLLECTION

	Calculus B	Calculus C	Statistics I
LO1	Define basic concepts and notations of calculus	Define basic concepts and notations of calculus	Demonstrate a working knowledge of definitions, concepts, rules, vocabulary, and notation of statistics
LO2	Demonstrate the manipulative skills required to solve problems in calculus	Demonstrate the manipulative skills required to solve problems in calculus	Perform basic statistical calculations
LO3	Integrate algebraic and transcendental functions	Apply calculus to physical problems	Describe data sets, statistical measures and displays
LO4	Examine, discuss and apply definite integrals	Represent functions by infinite series ad determine convergence and divergence of the series	Formulate simple hypothesis tests and state conclusions

Exams administered in each course were designed with questions which could all be mapped to one or more of the learning objectives for that course. The students success in each learning objective they were tested on was recorded (as a percentage) and used to determine the overall success in that learning objective, each exam, and the course in general.

CONCLUSIONS

The statistics course housed a very low number of trailer students each semester which leads to speculation about the strength of our analysis. What has been found is that the weaknesses lie in different subsamples than what we are discussing in this study. Further analysis may need to be conducted to determine if that is in fact the case. Calculus B seems to be a course worth continued examination. In the case of the sections analyzed during this academic year, the proportion of trailer students in a non-trailer section, was higher than desired. This may account for some of the interesting differences in expectation for the success of students in the Spring semester versus the Fall semester. However, it is still evident that the trailer student sample has not performed at the level of the non-trailer student in this course for three of the four learning objectives. The course that stands out the most with reasonable differences in means is the Calculus C course. There are several reasons why this may be, but most significant is the students who are considered trailer in this course have more possible reasons for being classified as such. These students could be repeating Calculus C, but even weaker trailer students may have had to repeat prerequisite courses, may have gone a semester without a mathematics course from their sequence, or may have begun in an algebra or pre-calculus course, indicating their preliminary skills were lower than should have been.

RECOMMENDATIONS

If we are able to determine, prior to the beginning of a semester, what the proportion of trailer to non-trailer students in any given course, preliminary action (course design, presentation, academic resources, etc.) could be taken in order to ensure the students that are targeted as weaker get the best chance at succeeding in the course. The academic resources and programs provided on campus are well designed and implemented to assist struggling students of all backgrounds, but most are not mandatory for students in this group.
Suggested programs in existence to make mandatory for credit:
• Weekly visits to the Bates Study Center or the Academic Support Center
• Weekly standing appointment to review materials, exams, quizzes, etc. with professor or TA
Suggested programs to be designed, revised, or implemented:
• TAs hold one office hour a week in lieu of one hour of grading
• LAs introduced into lower level courses deemed "at risk" due to proportion of trailer students
• Online supplemental, remedial, work to be completed for credit in the course
• Implementation of group work (with mixed abilities) in the Statistics courses

References: [1] *Predicting Mathematics-Related Choice and Success Behaviors: Test of an Expanded Social Cognitive Model*; Robert W. Lent, Frederick G. Lopez, Kathleen J. Bieschke; Journal of Vocational Behavior v42 i2, 1993