Overview Statistics Spring 2008 – Summer 2014 for Classes MAC 2281 and 2311

FAU
Mathematics Learning Center
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Executive Summary:

The goal of this project is a descriptive study assessing what factors affect student success in the MAC 2281 and 2311 calculus classes. Results from this study should be further investigated using inferential statistics; however, this has not been completed at this time. We hope to do this in the future. After some analysis, prior to this study, it was decided that 2281 and 2311 should be studied as a combined class due to similar grade distributions and a better sample size (see Appendix for the Grade Distribution of 2281 and 2311 separately).

The factors considered were primarily concerned with

- o   Student grades in prerequisite courses
- o   Where they took the prerequisite course
- o   Aleks Scores
- o   How long ago they took Aleks
- o   If they are repeating the course
- o   Term of enrollment for the calculus course
- o   With which instructor had they taken the course
- o   Major
- o   Midterm grades

The data for the study were taken from spring 2008 – summer 2014. As an addendum to the study, a math "boot camp" was conducted prior to fall 2014. Nine students from the boot camp enrolled in the fall 2014 and their result were compared with the class as a whole. In addition, two experimental Learning Assistant (LA) classes and one control class (not LA but same exams, quizzes and pacing) were conducted for fall 2014.

What was found is that the strongest factor in predicting student success is a passing midterm grade. It was found that students that passed at midterms had about an 85% chance of passing the class, compared with a 58% pass rate for the class as a whole. It should be noted, however, that from spring 2008 to summer 2014 only about 25% of the students have midterm grades, and about 60% reporting for spring – summer 2014. It can also be stated that midterm grades are conservative predictors of final grades in the sense they underestimate passing grades and overestimate failing grades. The next most effective indictor was Aleks Score. As discussed below, students that have an Aleks Score of 60, have an expected pass rate of 63 and students with an Aleks Score of 70 have an expected pass rate of 67. It was also found that students who had taken their Aleks test within the past 5 to 10 months had a pass rate of around 60%. Beyond this point the passing rate drops, which makes sense, since after 5 months scores are no longer valid, and other prerequisites qualifying people for the class and result in lower success rates. Historically, 30% of the class are students that got into the class via Aleks or override. For spring and summer 2014 this number was about 17%.

Students who took a prerequisite class at FAU tend to perform better compared with other universities. After FAU, the universities which account for the majority of the prerequisite classes are Palm Beach State and Broward, however, their contribution to the class is not enough to make any significant impact. For students that took the prerequisite more than a year prior, their expected pass rate is about 10% lower than those students that took the prerequisite class less than a year prior. It should also be noted that the pass rates tend to follow a cyclic pattern with fall being lower than spring, and summer tending to be irregular. The pass rate for the entire class was about 58% from spring 2008 – summer 2014. The most populous major is pre-engineering. Since 2011 it has accounted for about 40% of the class with some seasonality and a pass rate of 60%. However, in spring and summer 2014 the overall passing rate for this group was about 40%. It should be noted that pre-engineering was not coded as its own major in the database until 2010.

Added to the report is a section with data from fall 2014. Nine of the students in the fall 2014 semester had participated in a math boot camp prior to taking the course. The pass rate for these students was 56%. The two Learning Assistant (LA) classes had pass rates of 68% and 83%, while the control had a pass rate of 48%, which was comparable to the overall pass rate for fall 2014 of 46%.

A major point that should be taken away from this study is that there is seasonality present in student success data, and any predictive modeling or further study needs to consider this.

From the above discussion of the results for the study the following actions items should be considered:
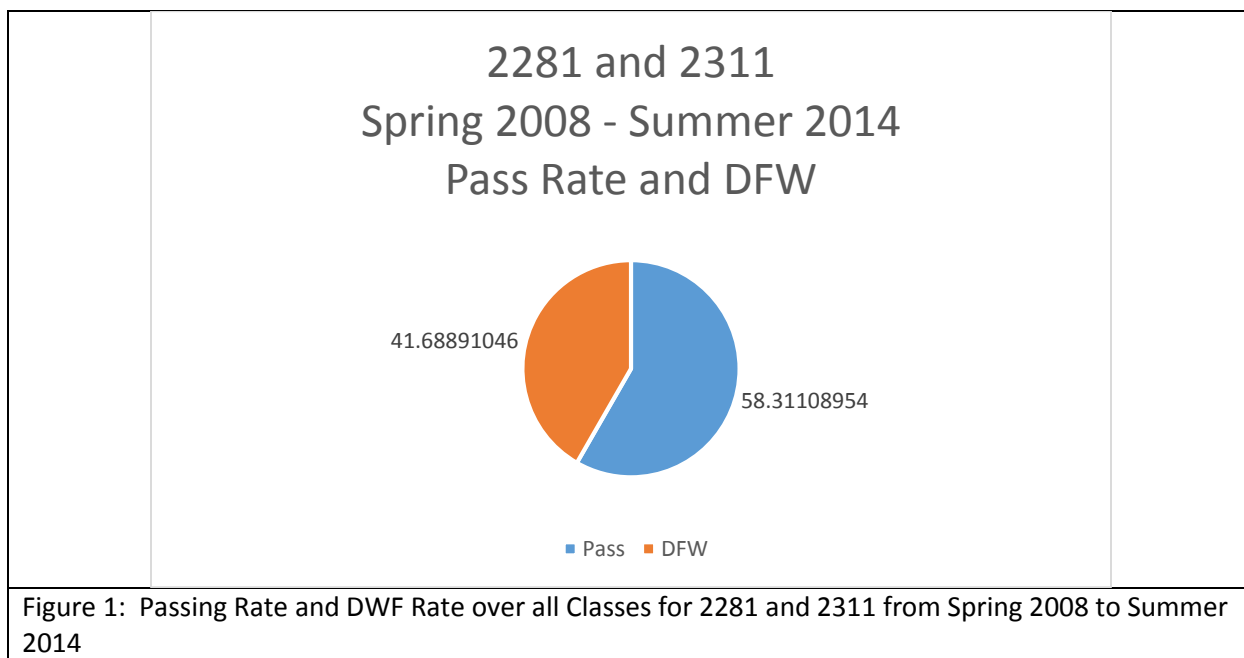
Action Items

1. Improve reporting of mid-term grades
2. Institute reporting of 1st quarter grades
3. Reach-out to students at risk
4. Require attendance at MLC
5. Do not give permission for students to take prerequisite courses elsewhere
6. Do not let time lapse in math course sequence
7. Require boot camp and retake Aleks if over 1 year
8. Work with PBSC and BSC to help them improve student performance in prerequisite courses
9. Require students who take prerequisites elsewhere to take Aleks and attend Aleks review (boot camp)
10. Expand Learning Assistant (LA) program to all sections of calculus
11. Require attendance at boot camp
12. Explore additional course redesign alternatives to improve student motivation
13. Further data analysis that can impact student success
14. Seasonal variability, instructor variability
15. Time series of success

Pass Rates and Grade Distributions

Considering both 2281 and 2311 from spring 2008 to summer 2014 with a total of 4121 students in the study, the overall pass rate for the class was found to be about 58% (see Figure 1 below). For the most recent semesters when this data was collected (spring and summer 2014) the passing rate was found to be about 53% (see Figure 2) with a total of 349 students.

To have an idea of how these number vary over time, the pass rates are plotted as a function of the Academic Period below for spring 2008 - summer 2014 for 2281 and 2311(Figure 3). It should be noted that summer 2008 was removed from the plot since this term has a pass rate of 90%, which distorted the plot. What can be noticed from the plot is that there is a somewhat cyclic tendency, with, in general, fall terms having low pass rates, spring terms having higher pass rates and summer terms being variable.

Figures 4 and 5 show that that the distribution of grades for spring and summer 2014, matches the historical data fairly well.

2281 and 2311
Spring 2008 - Summer 2014
Pass Rate and DFW

41.68891046

58.31108954

■ Pass ■ DFW

Figure 1: Passing Rate and DWF Rate over all Classes for 2281 and 2311 from Spring 2008 to Summer 2014

2281 and 2311
Spring - Summer 2014
Pass Rate and DFW

47.27793696   52.72206304
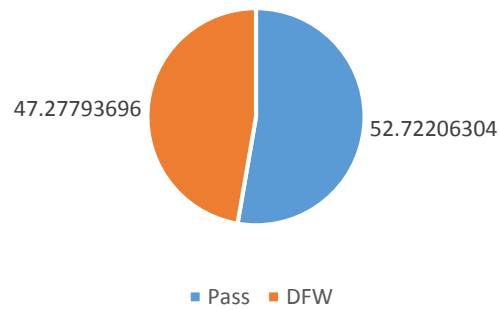
■ Pass ■ DFW

Figure 2: Passing Rate and DWF Rate overall Classes for 2281 and 2311 from Spring 2008 to Summer 2014
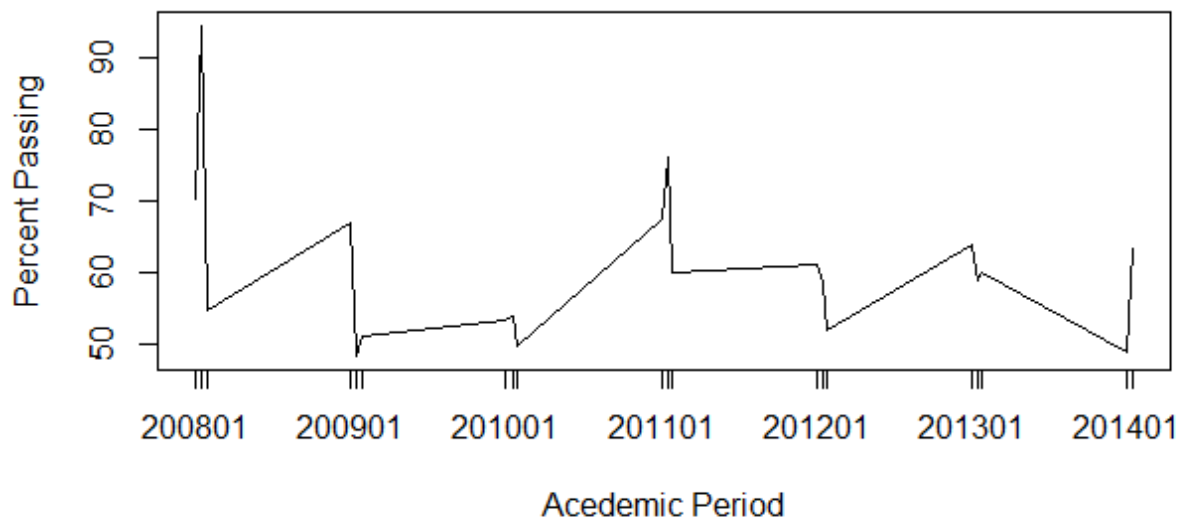

Figure 3: Pass Rate as percent of class as a function of Academic Period. The value for summer 2008 was not plotted in the figure since the pass rate was abnormally high at 90% and distorted the graph. Note that "01" following each year indicates spring.
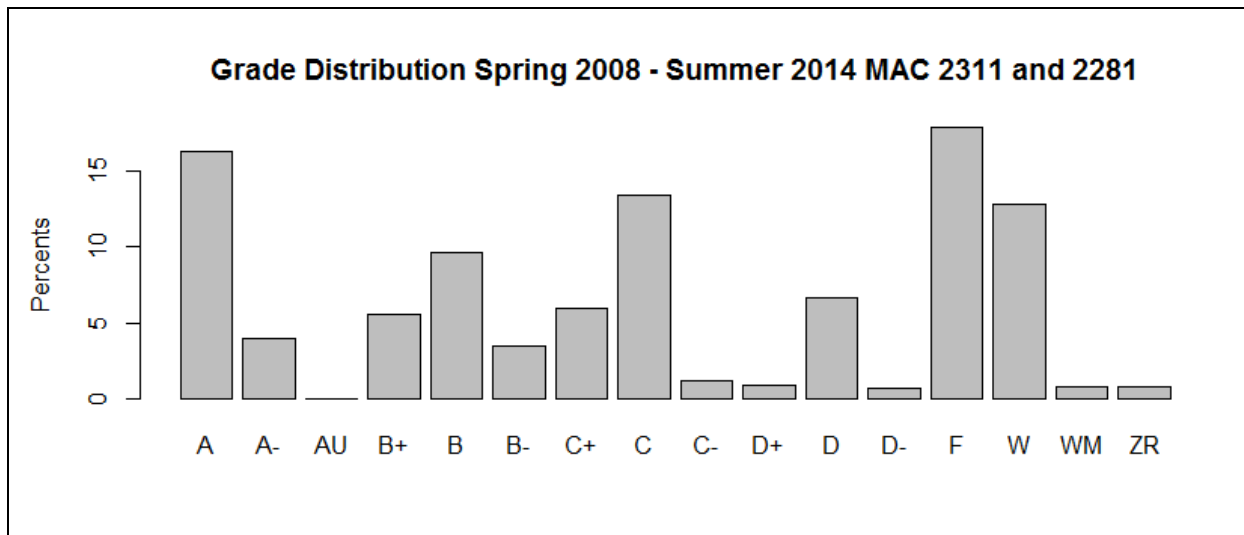
Figure 4: Grade Distribution overall classes of Mac 2311 and 2281 from
Spring 2008 to Summer 2014
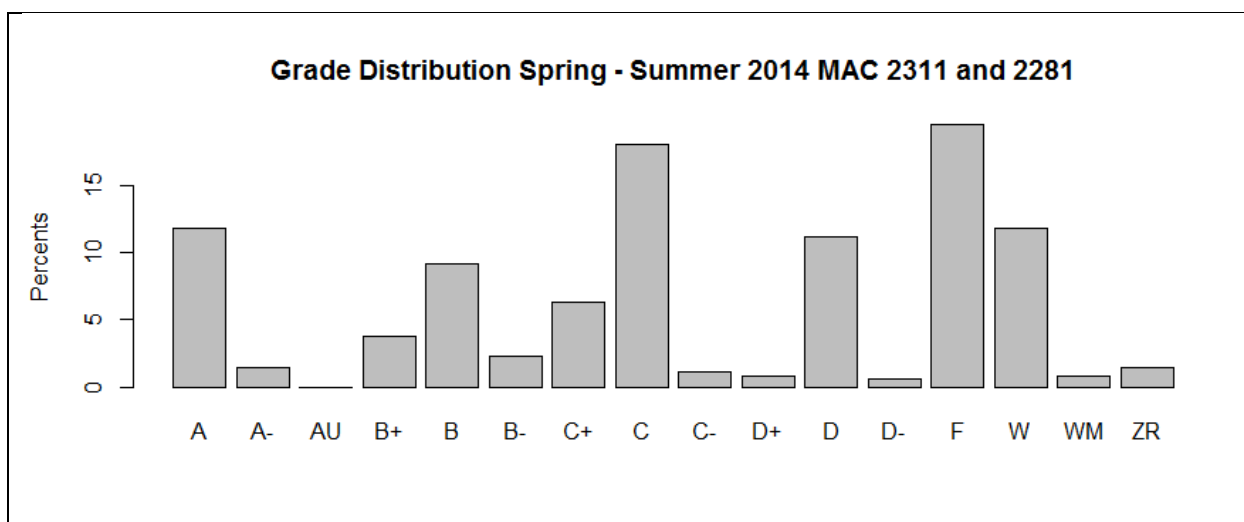
Figure 5: Grade Distribution over all classes of Mac 2311 and 2281 from Spring to Summer 2014

Midterm Grades

Grades are the best predictor of whether or not a student will pass or fail 2281 or 2311. Over all semesters from spring 2008 to summer 2014 with a total of 1143 midterm grades being reported (about 25%), students that have a passing grade at their midterm have an 85% chance of passing the class, while for the spring and summer 2014 semesters, with a total of 206 (about 60%) midterm grades being reported, these students have an 80% chance of passing. Figure 6 shows the pass rates for students that have passed their midterms as a function of academic period. As demonstrated, since 2011, midterm grades consistently predict success at least 80% of the time. Also, as can be seen from Figures 7 and 8, we see that midterm grades are conservative estimators of final grades in the sense that they underestimate passing grades and over estimate failing grades.

Figure 6: Percent Passing vs Academic Period for students that have passed their midterms. Spring 2011 to Summer 2014 for Mac 2311 and 2281. Note that "01" following each year indicates spring.

Midterm Grades Compared with Final Grades
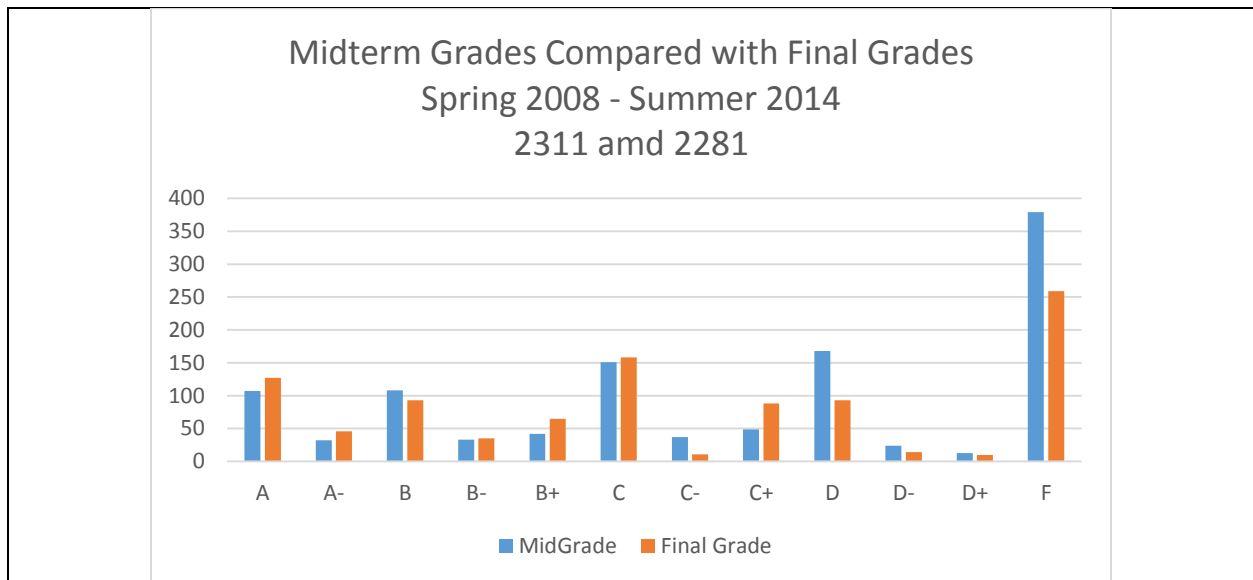**Spring 2008 - Summer 2014**
2311 amd 2281
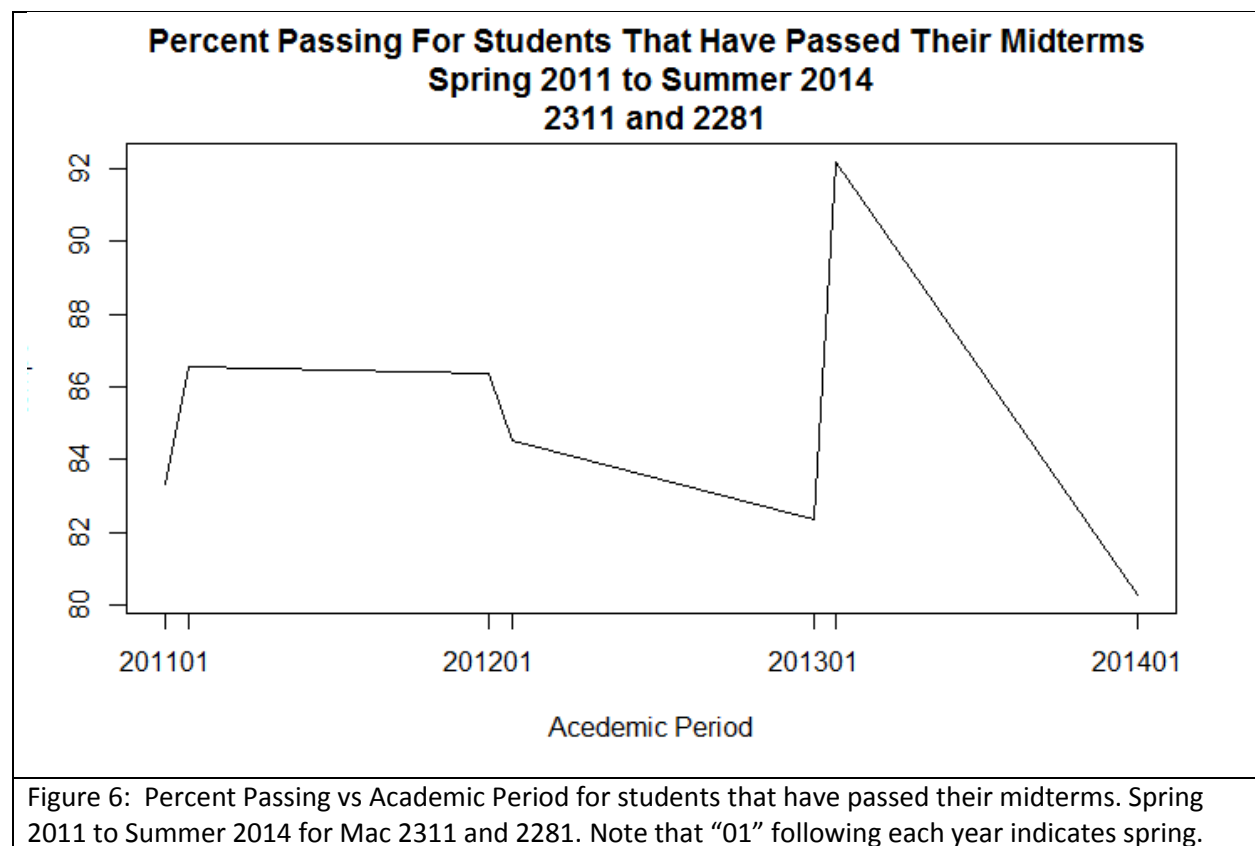
Figure 7: For students that have midterm grades, the distribution of midterm grades is compared with final grades for students from Spring 2008 to Summer 2014. The data is presented as frequency.
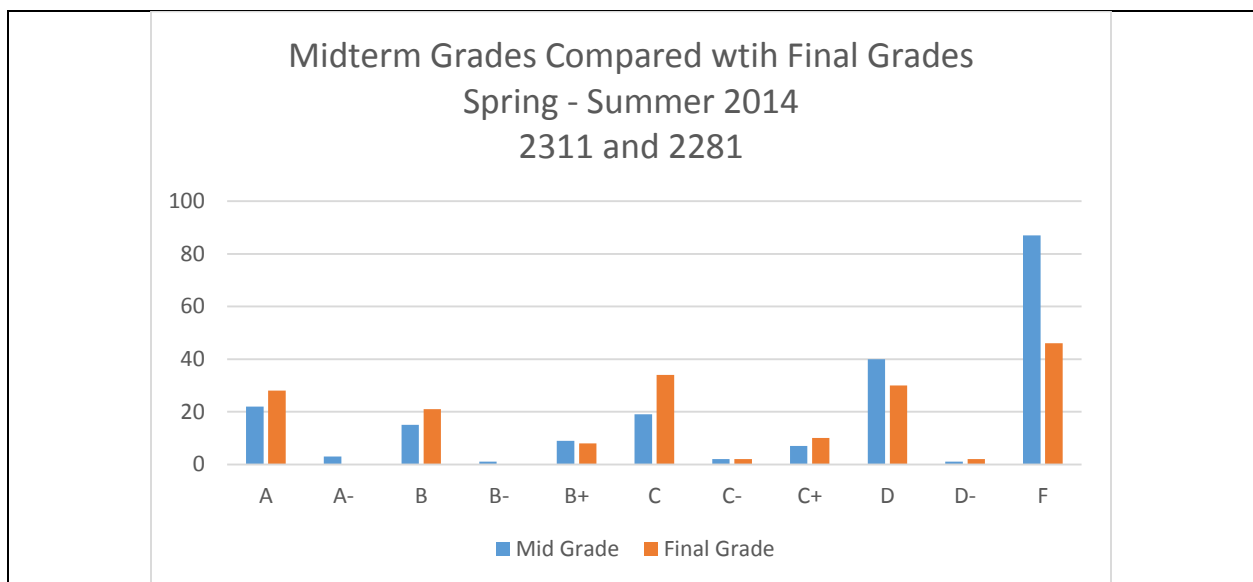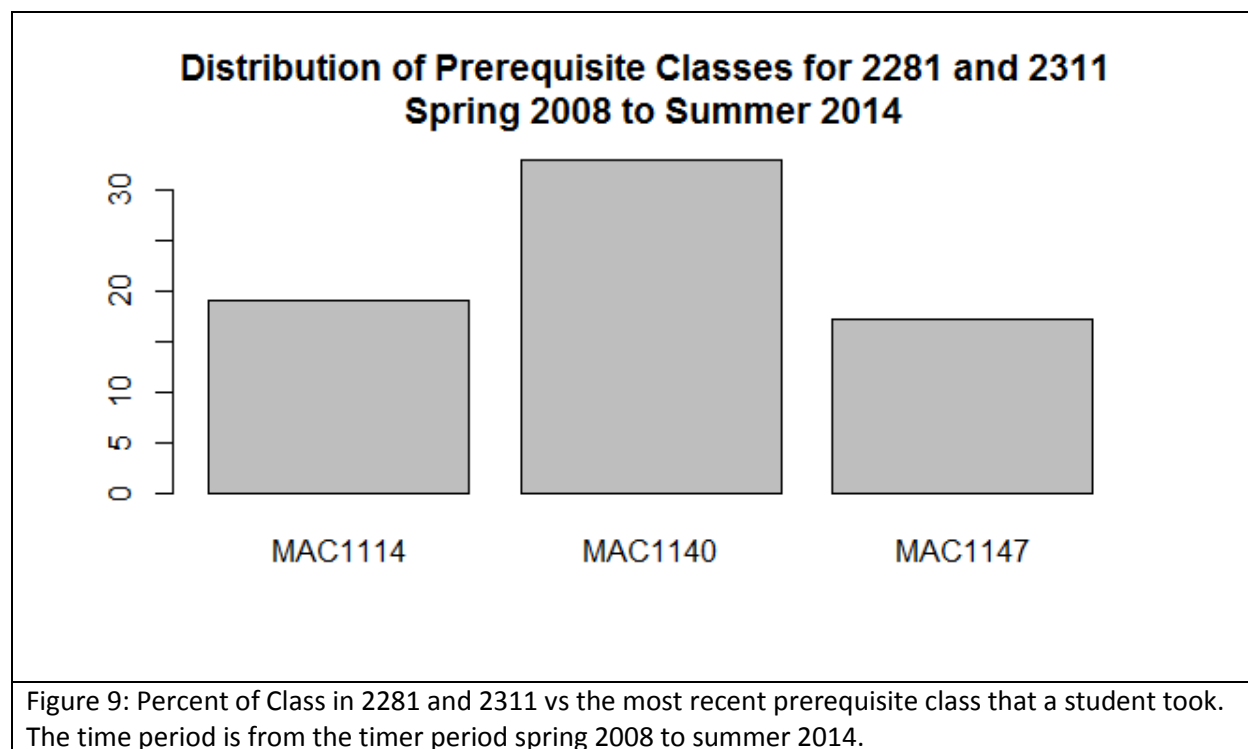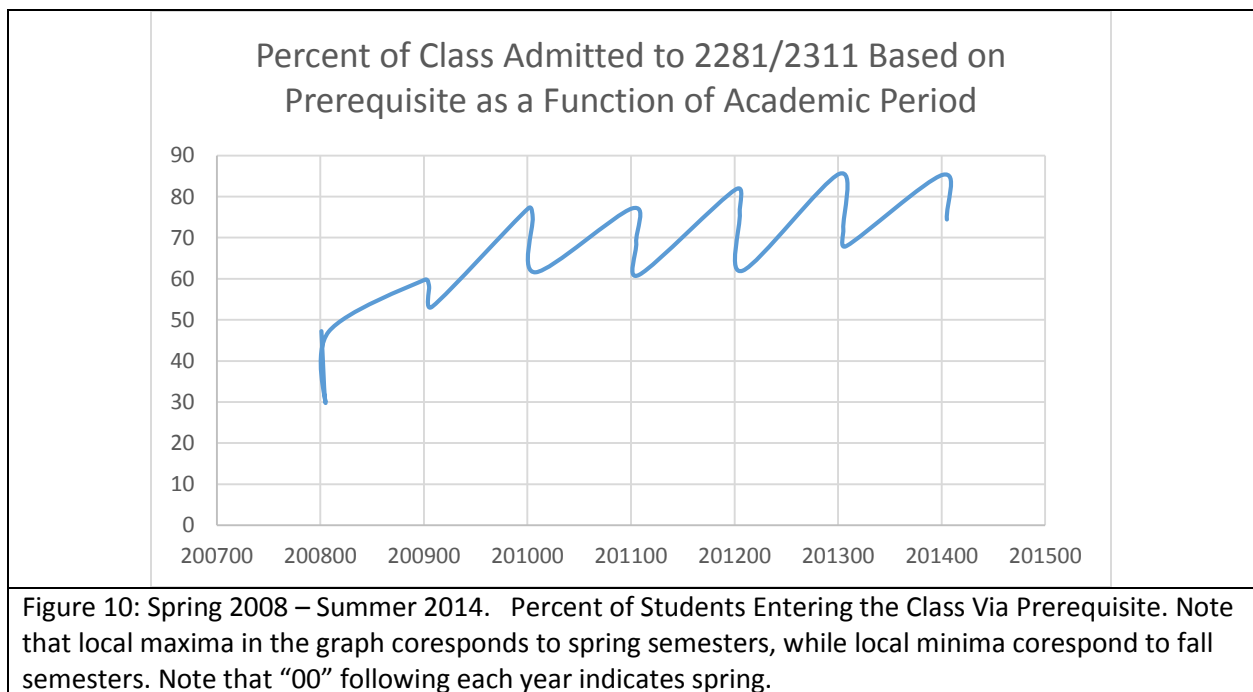

Midterm Grades Compared wtih Final Grades
Spring - Summer 2014
2311 and 2281

Figure 8: For students that have midterm grades, the distribution of midterm grades is compared with final grades for students from Spring to Summer 2014. The data is presented as frequency.

Prerequisite Classes:

The classes allowed as prerequisites for MAC 2281 and 2311 are MAC 1114, MAC 1140, and MAC 1147, which are trigonometry, pre-calculus and combined trigonometry and pre-calculus respectively. Figure 9 bellow shows percentage of students in 2281 or 2311 based on the prerequisite class they took. The remaining 30%, not in Figure 9, are students that did not take a prerequisite class, meaning they either had an override or entered via a valid Aleks Score. To see how the percentage of students entering 2281/2311 varies as a function of academic period, see Figure 10 noting that spring semesters tend to have high enrollments and fall low enrollments entering 2281/2311 based on prerequisite. The pass rates for MAC 2281 or 2311 for spring 2008 to summer 2014 separated by prerequisite classes are given in Table 1. Figure 11 plots passing rate versus how long ago a prerequisite class was taken. The orange line through the center of the graph is the average passing rate for all students who took a prerequisite within thirty months of taking the 2281 or 2311. After this time period the data is more erratic and not predictable, so this data was not included in the plot for Figure 12. What is noticeable is students who have taken the prerequisite course less than a year from taking 2311 or 2281 have a passing rate of about 56% while those students who took a prerequisite course greater than a year and less than 30 months have a passing rate of about 47%, ten points lower. Tables 2 and 3 consider how students have performed based on where they took their most recent prerequisite. Table 2 considers the time period spring 2008 to summer 2014 while Table 5 considers the time period spring to summer 2014. For both time periods, students that took their prerequisite at FAU out preformed students that took their prerequisite at any other universities. However, based on the counts in Tables 2 and 3 it is not worth considering performance at other universities. Figure 12 plots the passing rate for students who took their prerequisite at FAU as a function of Academic Period from spring 2008 to summer 2014.

Figure 9: Percent of Class in 2281 and 2311 vs the most recent prerequisite class that a student took. The time period is from the timer period spring 2008 to summer 2014.

Prerequisite Class	Pass Rate
MAC 1114	56
MAC 1140	52
MAC 1147	58

Table 1: Pass Rates for 2281 and 2311 for Spring 2008 to Summer 2014 based on prerequisite class.
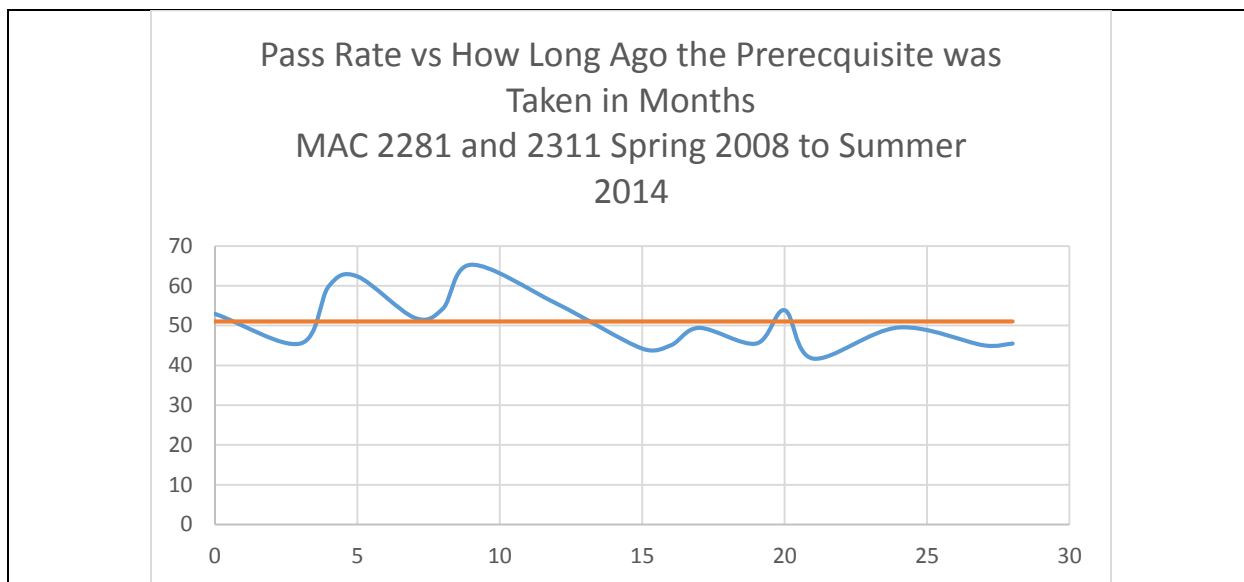
Percent of Class Admitted to 2281/2311 Based on Prerequisite as a Function of Academic Period

Figure 10: Spring 2008 – Summer 2014.   Percent of Students Entering the Class Via Prerequisite. Note that local maxima in the graph coresponds to spring semesters, while local minima corespond to fall semesters. Note that "00" following each year indicates spring.

Pass Rate vs How Long Ago the Prerecquisite was
Taken in Months
MAC 2281 and 2311 Spring 2008 to Summer
2014

Figure 11: Percent Passing vs how long before the class started a student took their most recent prerequisite. Time is measured in months, and data here beyond 30 months is not considered since after this point the data is highly variable. The line through the center for the curve is the average of the passrates used to construct the curve.

	FAU	Broward	Palm Beach	Other	None
Pass Rate	59	41	43	53	67
Number of Students	1899	278	348	331	1265
Table 2: Pass Rate Based on where a prerequisite class was taken spring 2008 to summer 2014					

	FAU	Broward	Palm Beach	Other	None
Pass Rate	53	31	46	40	70
Number of Students	198	29	26	35	61
Table 3: Pass Rate Based on where Prerequisite Class was taken spring 2014 to summer 2014					
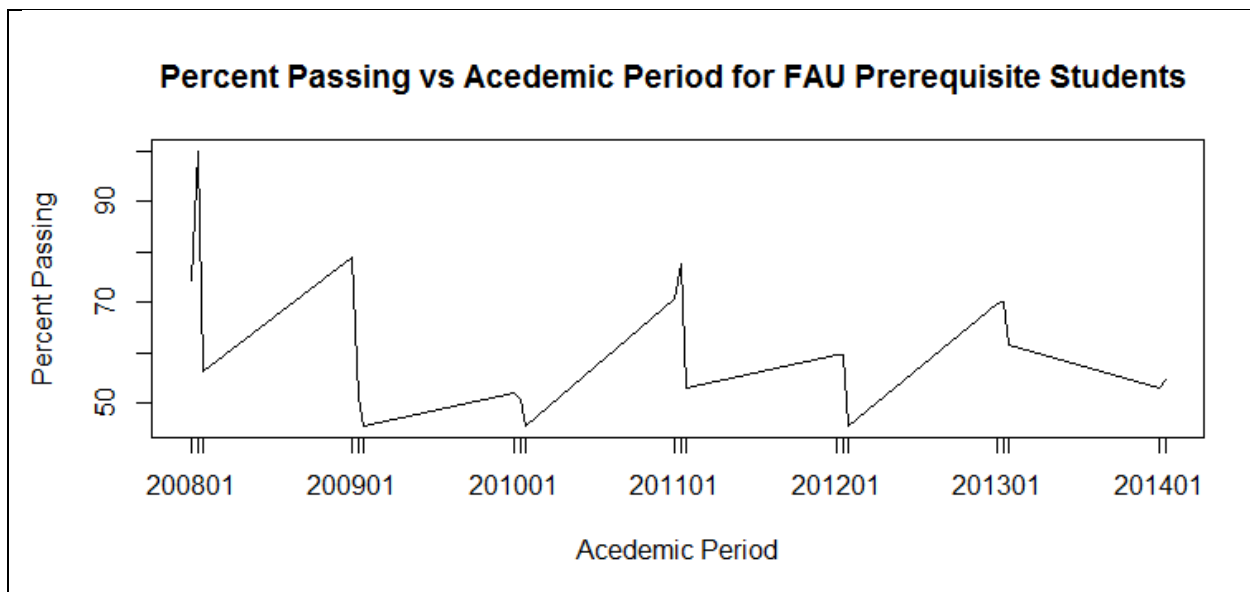
Figure 12: Pass Rate vs Academic Period for students that took their most recent prerequisite course at FAU. Note that "01" following each year indicates spring.

Aleks Scores:

After midterm grades Aleks Scores appear to be the best predictor of student success. Figure 13 below plots passing rate versus Aleks Score from Spring 2008 to Summer 2014. The plots suggests that students with an Aleks Score of 60 would expect to have a passing rate of 63% while students with an Aleks Score of 70 would be expected to have a passing rate of 67%. Recall that based on prerequiste the best passing rate was 53% (see Table 3). Figure 14 plots passing rate versus how long ago a student took their Aleks exam prior to taking 2281 or 2311. As can be noted after about 5 months the passing rate is below 60%, which makes sense, since Aleks Scores are not valid after 5 months meaning these students qualified for the class by a way other than Aleks.
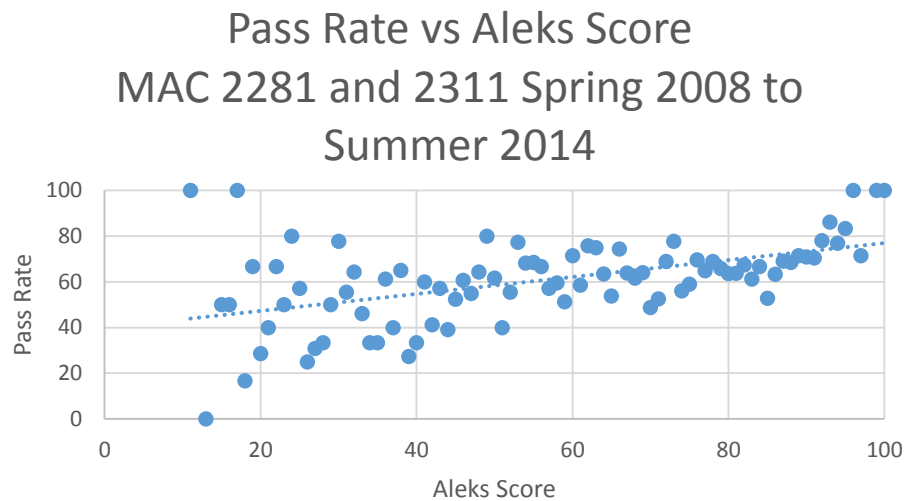
Figure 13: Passing Rate vs Aleks Score for MAC 23111 and 2281 during spring 2008 to summer 2014.
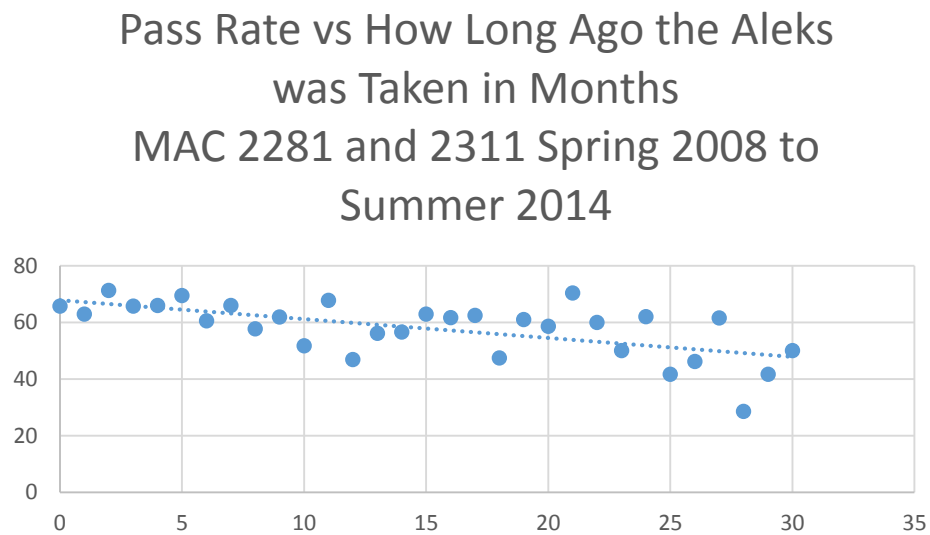
Figure 14: Percent Passing 2281 or 2311 vs How long the Aleks test was taken before the start of the class in months.

Instructor Differences

We note that different instructors have different DFW rates.   The details are in an appendix.   From a data analytic point of view, there could be variation on year and seasonal differences as noted for the data in general.   We should also remove any dependency on student preparation (Aleks Scores and prerequisite scores and where taken).   We have not done this for this study.   There are probably some more significant issues that need to be in this analysis.

The instructors do not give common exams. Further, even if exams were common, there is probably a grading difference on when and how much partial credit is given.   There is no standard grading rubric. For the LA sections in fall 2014 and one non-LA section, the exams were the same and there was a common agreed to rubric. So those results are probably meaningful.   We need to extend this across the courses if we are to get a meaningful evaluation.

Further, we need to determine if say a C from professor 1 translates into improved performance on subsequent math courses than a B from professor 2.   We might be able to analyze this on a continuation data analytic study.

Distribution of Majors:

Figures 15 and 16 show the distribution of the class for semesters spring 2008 to summer 2014 and spring 2014 to summer 2014 respectively. It should be noted from Figure 15 that the majority of students in the class are pre-engineering (PENG) over all semesters, and from Figure 16 we see PENG making up 40% of the class for spring and summer 2014. Figure 17 demonstartes that over the past few years PENG has taken an inceasingly larger portion of the class size,while Figure 18 shows the pass rate for PENG has been around 60% since 2011 with occassional spikes up or down. Since the PENG is the dominating major in the 2281/2311 but does not show up significanlty unitl spring 2011 it maybe more useful to consider the distribution of majors since 2011, as displayed in Figure 19, with the corresponding pass rates in Figure 20. From Figures 19 and 20 we see that PENG has on average maintained 40% of the class on avarege with a passing rate of around 60%, being slightly better than the class historical average of 58%. Figures 21 and 22 show the class distribution and corresponing pass rates for spring and summer 2014. Here we see PENG makes up over 40% of the class but only had a 40% passing rate being well below the average. As can be seen from Figure 18, this does not represent a new trend of a lower pass rate necessiarily, since the time series data predicts this occassional happening but something to keep an eye on. It should also benoted that PENG did not have a coding in the data base until 2010,so it is not clear how to identify pre-engineering students before this time period in the class.
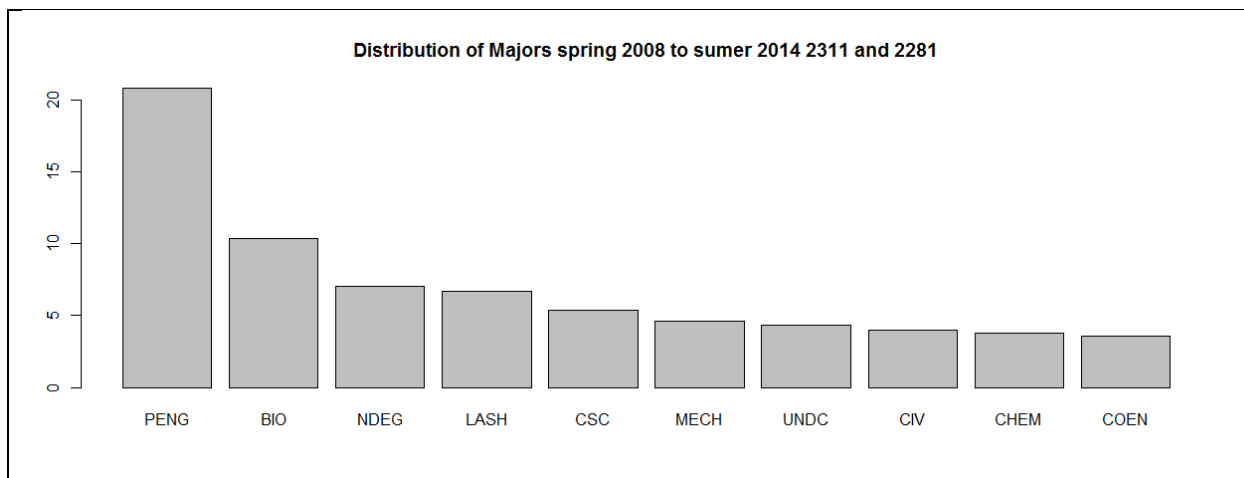
Figure 15: Percent of Class vs Major for spring 2008 to summer 2014 , 2311 and 2281. See Appendix for Major abreviation definitions.
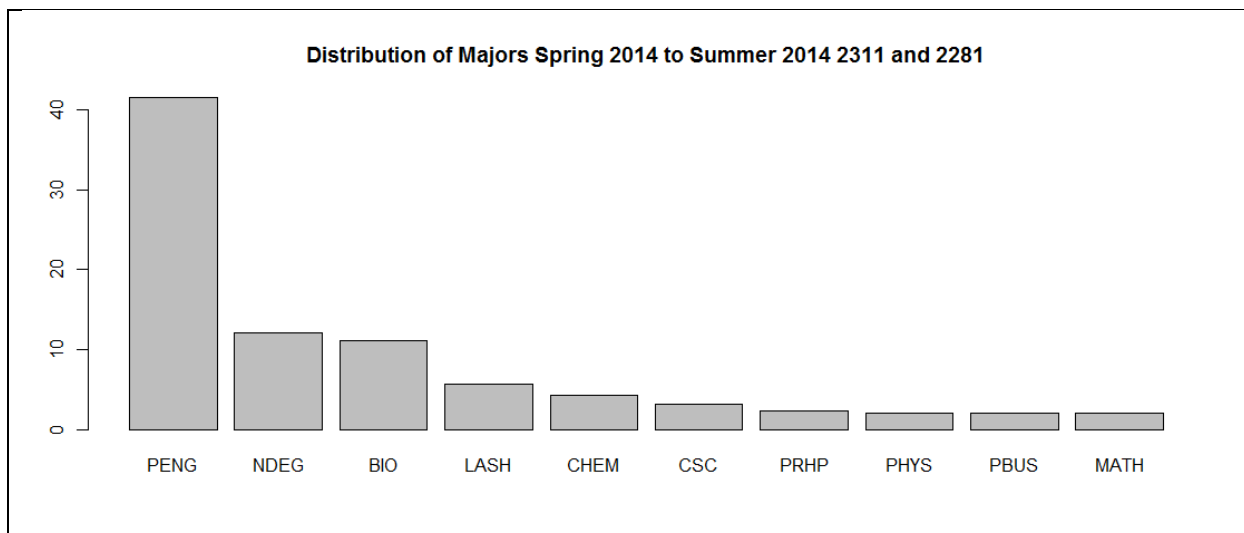

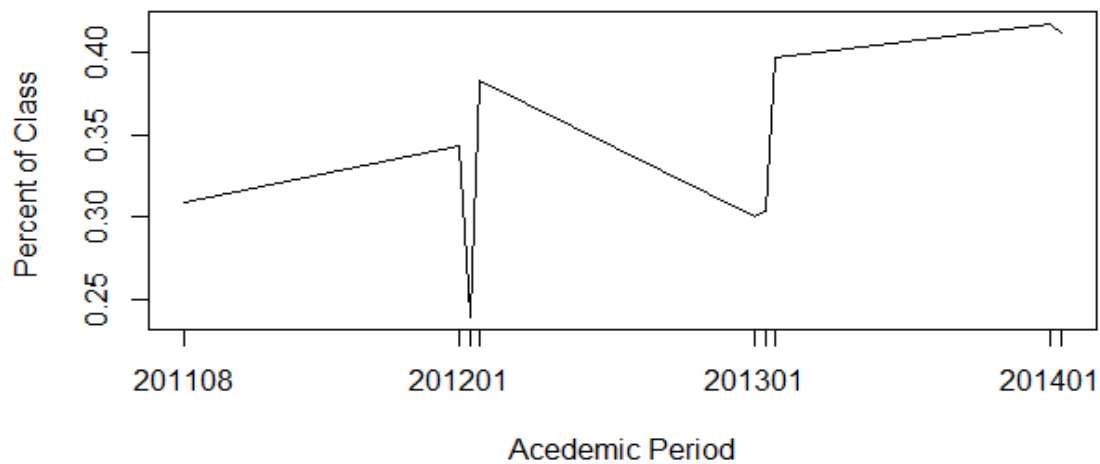Figure 16 : Percent of Class vs Major for Spring2014 to Summer 2014 , 2311 and 2281. See Appendix for Major abreviation definitions.

Figure 17: The Percent of the Class that Pre-Engineering Students Comprise as a Functions of Academic Period Starting in Fall 2008.
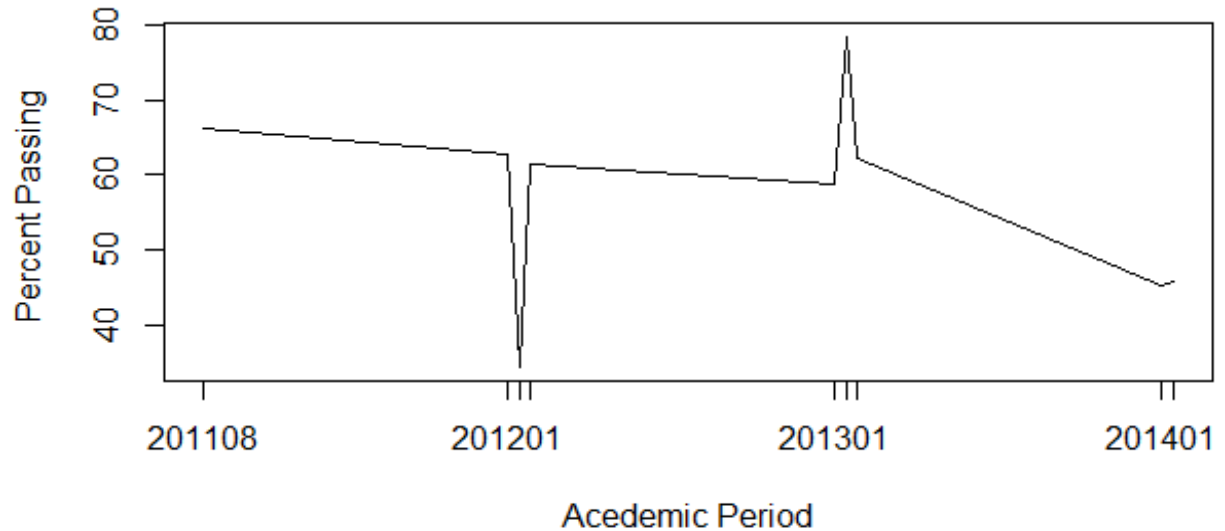
Figure 18: Pass Rate for Pre-Engineering Students from Fall 2011 to Summer 2014. Note that "01" following each year indicates spring. The three bars for each year indicate spring, summer and fall.
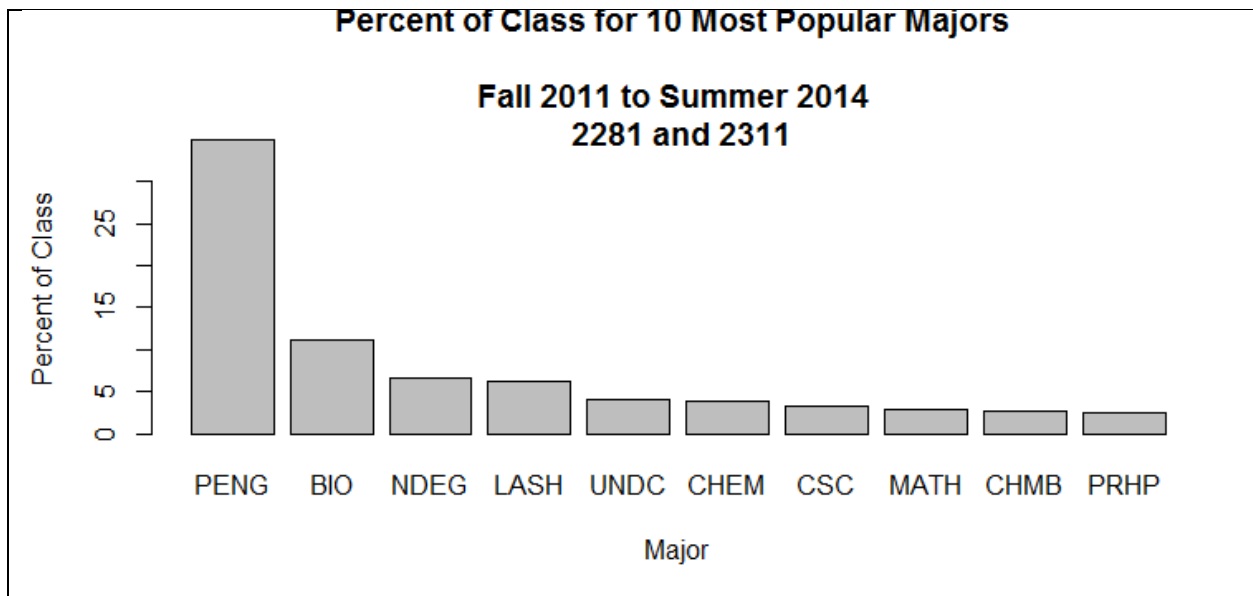
Figure 19: Percent of Class vs Major for the 10 most popular Majors from Fall 2011 to Summer 2014 for Mac 2311 and 2281. See Appendix for Major abbreviation definitions.
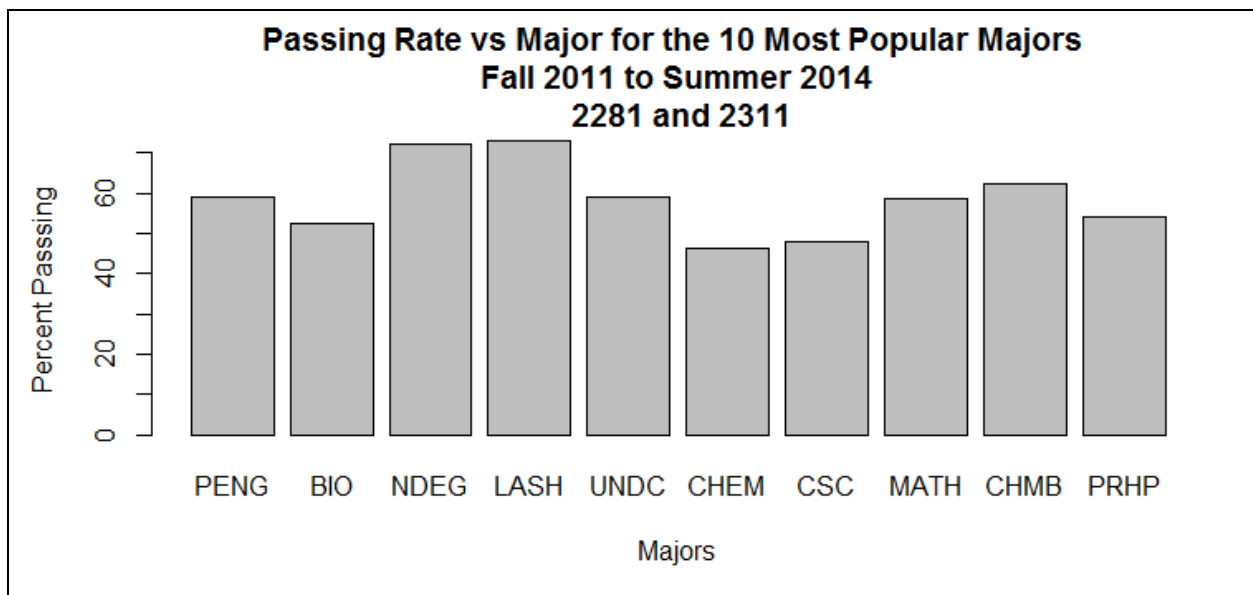
Figure 20: Pass Rates for the 10 Most Popular Majors from Fall 2011 to Summer 2014. See Appendix for Major abbreviation definitions.
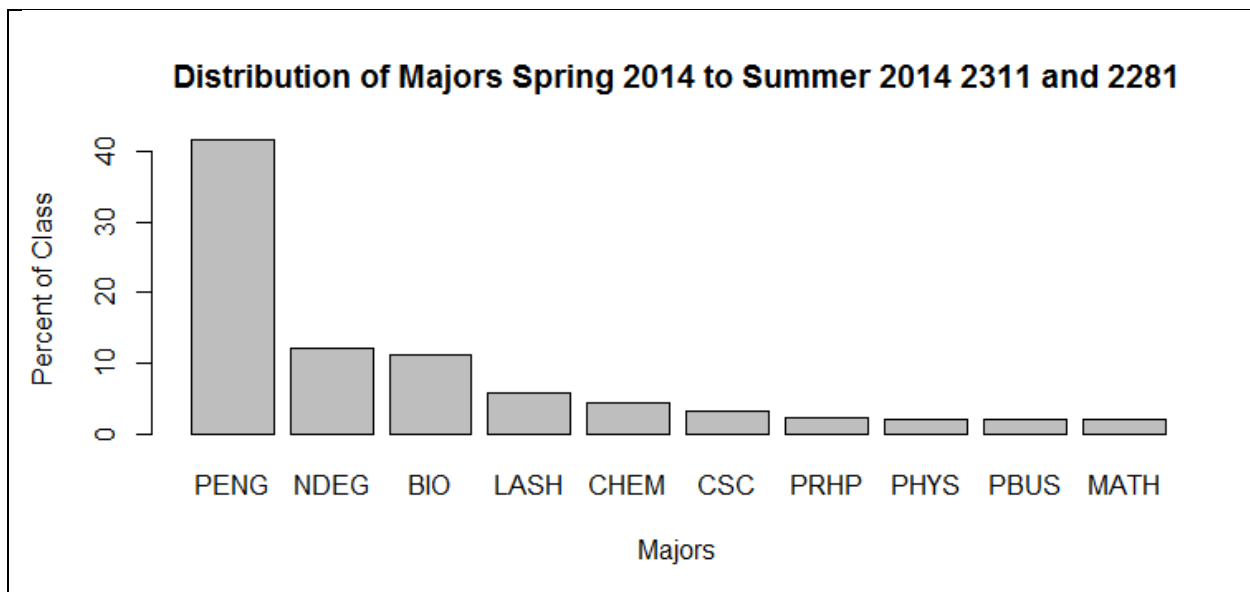
Figure 21:Percent of Class vs Major for 10 Most Popular Majors in 2281 and 2311 for Spring to Summer 2014
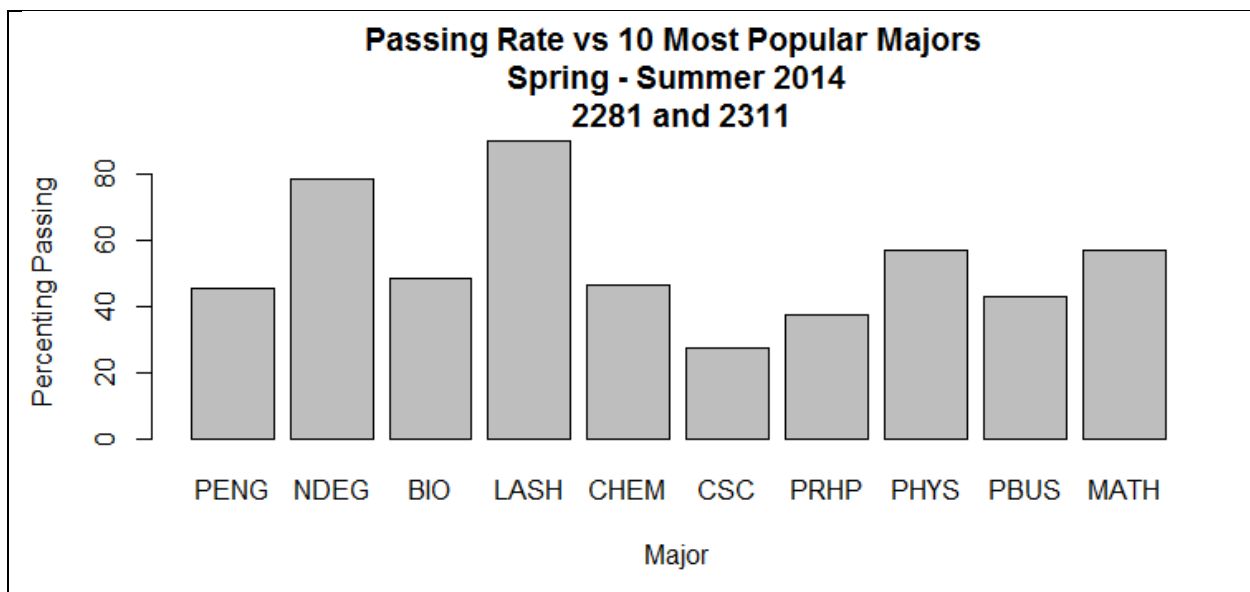
Figure 22: Percent of Students Passing vs Major for 10 Most Popular Majors in 2281 and 2311 for Spring to Summer 2014. Note that PENG does not appear to preform very well compared with NDEG and LASH, however, we expect more variability here since these groups make up less than 10% of the class (See Figure 26)

Fall 2014 Data

Shortly after the above data was compiled the below data was received on students from fall 2014. The passing rate for the entire class for this semester was 46% with a class size of 342. 9 of the 342 students however took a "boot camp" preparatory class prior to taking 2311/2281. 5 of these 9 students passed resulting in a 56% pass rate. The sample size was not large enough to detect any significance however the positive result may warrant further investigation. The grade distributions for the full class and the subset that took the boot camp are given in Figures 23 and 24 respectively.

Other than the boot camp, another experiment was conducted where two classes were of type LA and another was a control class (same quizzes, tests and pacing as the LA but not LA). The two LA classes had pass rates of 68% and 83% while the control had a pass rate of 48%.
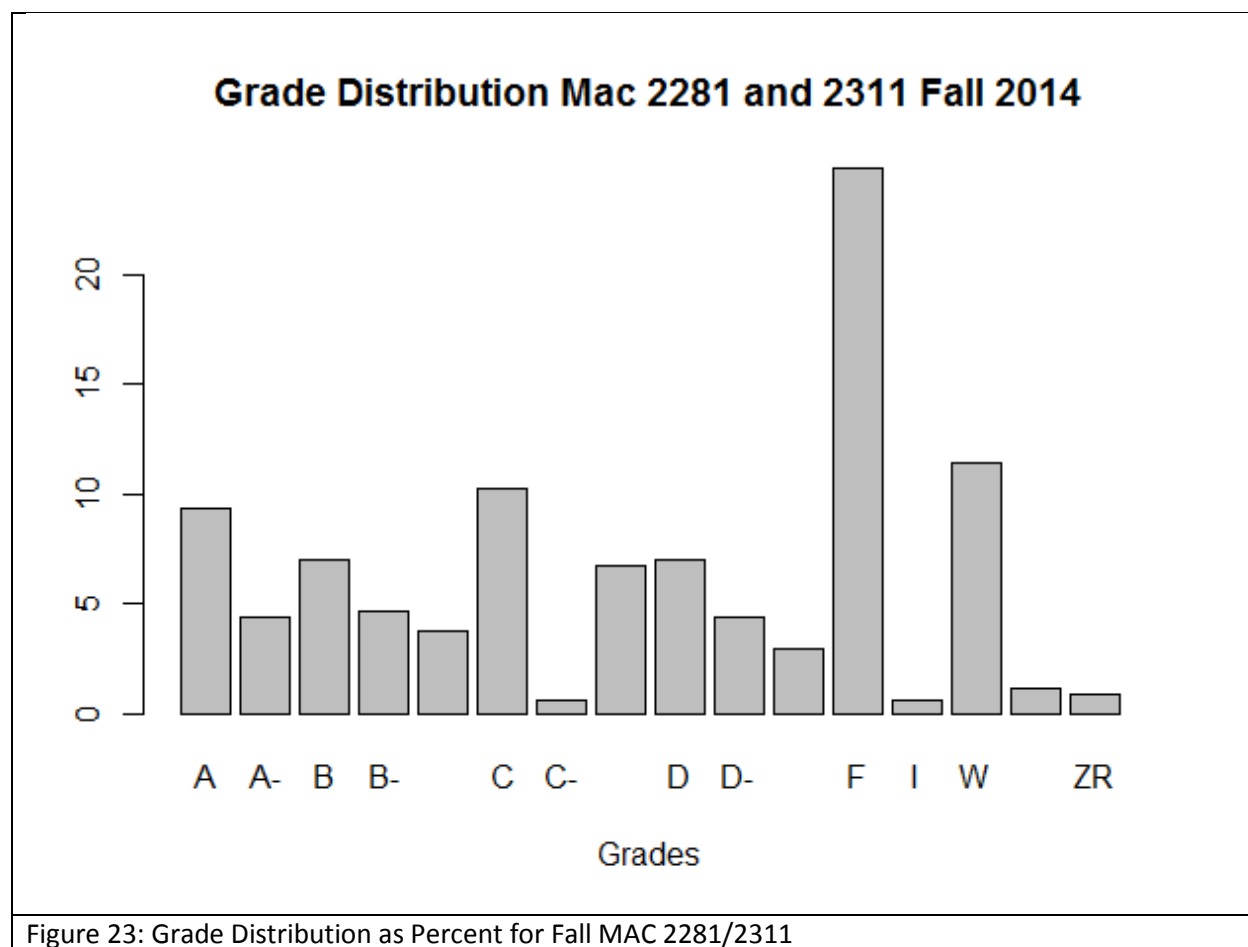
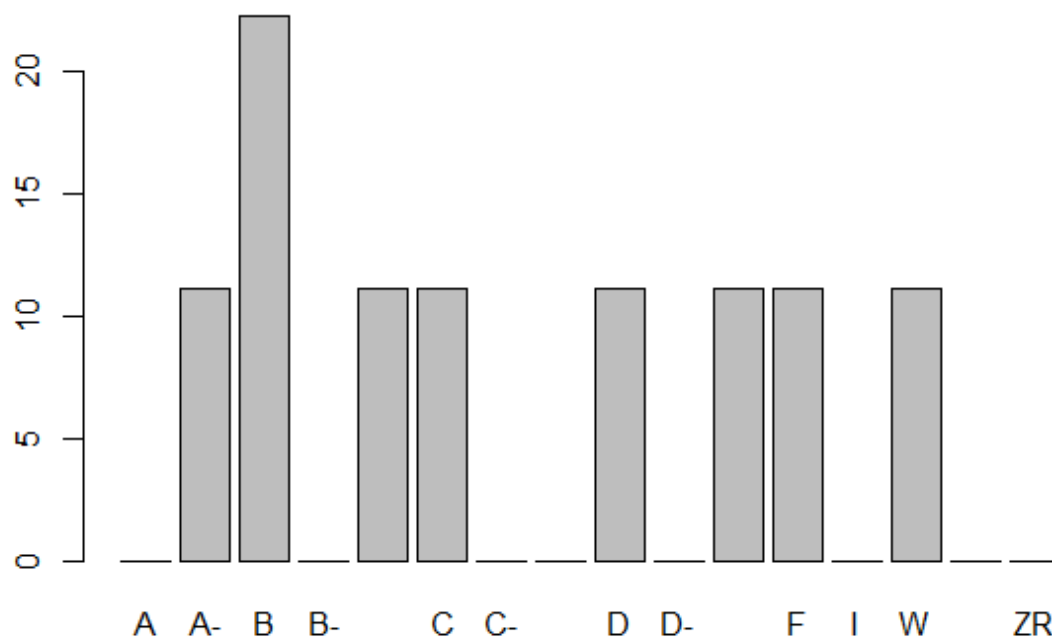Figure 23: Grade Distribution as Percent for Fall MAC 2281/2311

Figure 24: Grade Distribution as Percent for Fall MAC 2281/2311 Boot Camp Students

Conclusion:

For Semesters spring 2008 to summer 2014, MAC 2281 and 2311 on average passed 58% compared with a 50% pass rate for the spring and summer 2014 semesters. It should be noted that there is seasonality to the data, so when evaluating student performance looking at only one semester is misleading (see Figure 3). Due to the seasonality we would expect the fall 2014 pass rate to be lower than the spring 2014 pass rate, which it was being 46% (see Fall 2014 Data section) by about 4%. It should be noted that spring, summer and fall 2014 had lower pass rates than the historical average of 58%. This is not necessarily a new trend it maybe just part of the seasonality, however, it is important to determine what factors affect student success and of those which are seasonal and which are not.

Midterm Grade is the most effect predictor of student success present in the study. Historically, a passing midterm grade will result in a passing final grade 85% of the time. For semesters' spring and summer 2014 students that passed their midterm had an 80% chance of passing the class. Though there is some seasonality in midterm grades as a predictor, it has not fallen below 80% accuracy since 2011 (see Figure 6).

Student's that took a prerequisite for MAC 2281/2311 prior to taking the class make up about 30% of the class and have a passing rate between 52%-58% depending on which prerequisite class they took considering spring 2008 to summer 2014. There is seasonal variation to this information however, as demonstrated in Figure 10, noting that spring semesters tend to have more students enrolled based on prerequisite compared spring with summer and spring semesters. It also should be noted that those who took their prerequisite less than a year before starting the course had a passing rate of 56% as compared with those students that took the class between 1 and 2 years had a passing rate of 46% (see Figure 11). Students that take their prerequisite classes at FAU tend to outperform students that take the prerequisite at other universities with a passing rate of 59% historical and seasonal oscillations that range of 50% to 70% pass rates (see Figure 12). Students taking their prerequisites at other universities tend not to make a significant portion of the class (see Tables 2 and 3).


Following midterm grades, the best predictor of student success is Aleks Scores. For a student that receives a score of 60 on the Aleks, we would expect that student to have a 63% chance of passing. For a student with an Aleks Score of 70 we would expect a 67% chance of passing (see Figure 13). We also note that looking at Aleks Scores greater than 5 months before that start of the class result in an expected pass rate of less than 60% which makes sense, since these students entered 2281/2311 by a means other than Aleks and form the data tend not to perform as well (see Figure 14 and Tables 2 and 3). Putting things in perspective, a passing midterm grade is the best predictor of student success. An Aleks Score of 60 or better within 5 months of the class is better than taking a prerequisite class. Also it is better to take a prerequisite class at FAU versus another university (See Table 2). From Tables 2 and 3 note that the "None" category which is comprised of students that entered the class via Aleks or override has a historical pass rate of 67% and for the spring and summer 2014 a pass rate of 70%. This is higher than we would expect for Aleks suggesting that professors giving overrides are out performing Aleks assessment. This information was difficult to quantify however since overrides information was not available at the time of the study and Aleks Scores have changed throughout the time period from 2008-2014. However this category makes up about 30% historically and about 17% for spring and summer 2014 (see Tables 2 and 3). The percent of the class enrolled based on Aleks or override can be deduced from Figure 10 since this figure gives the percent from prerequisite and the remainder of the class is Aleks or override.

Since 2011 the most popular major has been pre-engineering (PENG) making up about 40% of the class with some oscillations and about a 60% pass rate. For spring and summer 2014 the passing rate is about 40%, which has happened before (see Figures 18).

Following the above study, data for fall 2014 was received indicating a pass rate of 46%. Nine of the students in the class had participated in a boot camp. These nine students had a pass rate of 56%, and although the sample size was not sufficient to detect any significance, the positive result maybe reason to look at this further. Other than the boot camp, another experiment was conducted where two classes were of type LA and another was a control class (same quizzes, tests and pacing as the LA but not LA). The two LA classes had pass rates of 68% and 83% while the control had a pass rate of 48%.

Appendix:

Below are the Grade distributions as percent for both 2281 and 2311 side by side for spring 2008 to summer 2014. Note there are 1823 students in MAC 2281 and 2298 in MAC 2311

Figure 25: Comparing Grade Distribution for 2281 and 2311 Separately from Spring 2008 to Summer 2014
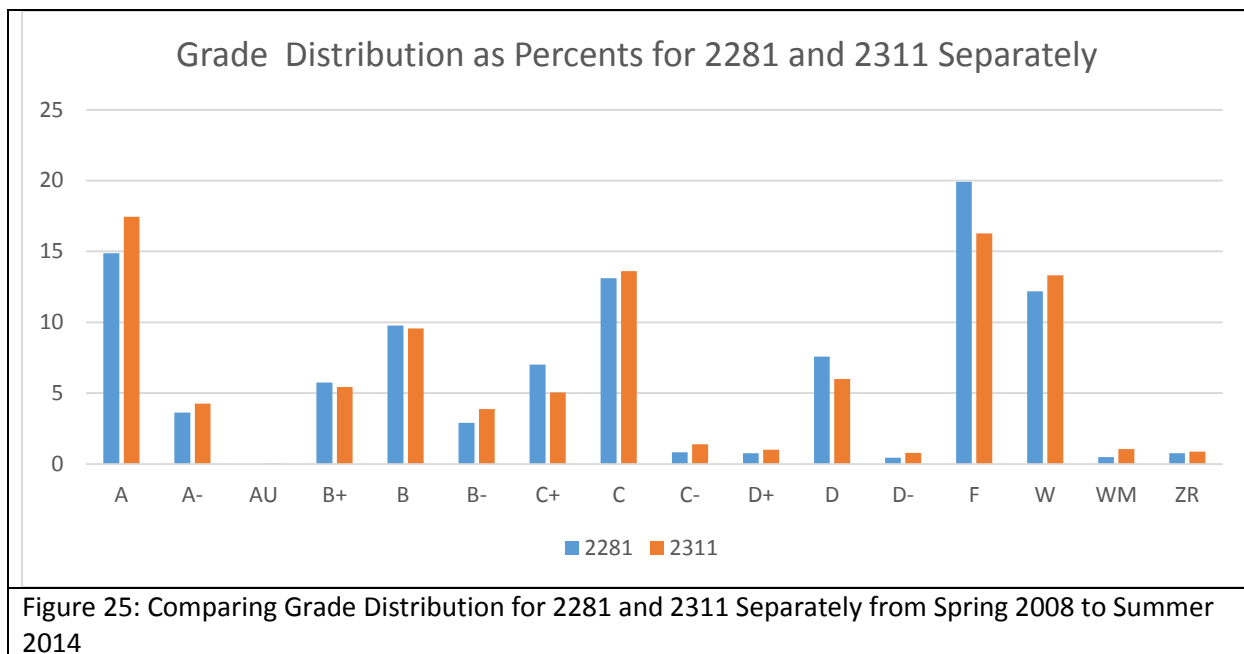
PENG	Pre – Engineering
NDEG	**Non-Degree**
BIO	**Biology**
LASH	**Liberal Arts and Science Honors**
CHEM	**Chemistry**
CSC	**Computer Science**

PRHP	**Pre-Health**
PHYS	**Physics**
PBUS	**Pre-Business**
MATH	**Math**
CIV	**Civil Engineering**
MECH	**Mechanical Engineering**
COEN	**Computer Engineering**
UNDC	**Undecided**
Table 4: Major Definitions and Abbreviations Used in Figures 20-27 and 22-23	

Instructors:

Listed below is the distribution of pass rates for each instructor who has taught the course, over all semesters from spring 2008 to summer 2014 (Figure 26) and the actual pass rates per instructor (Figure 27). The corresponding descriptive statistics are given in Table 5. Table 5 and Figure 26 indicates a bell curve around 60 coinciding with the overall pass rate for the entire class. Figure 27 presents the raw data used to create Table 5 and Figure 26. Table 6 along with Figures 28 and 29 represent the same information, except over the time period spring – summer 2014. Here we see pass rates to be skewed to the left which agrees with the lower pass rates for this time period (see Figure 2). Figure 30 shows the distribution of pass rates over all terms from spring 2008 – summer 2014 broken down by season. Note that the fall seasons are more skewed towards lower pass rates agreeing with the fact that lower pass rates are associated with fall seasons as demonstrated in Figure 30.

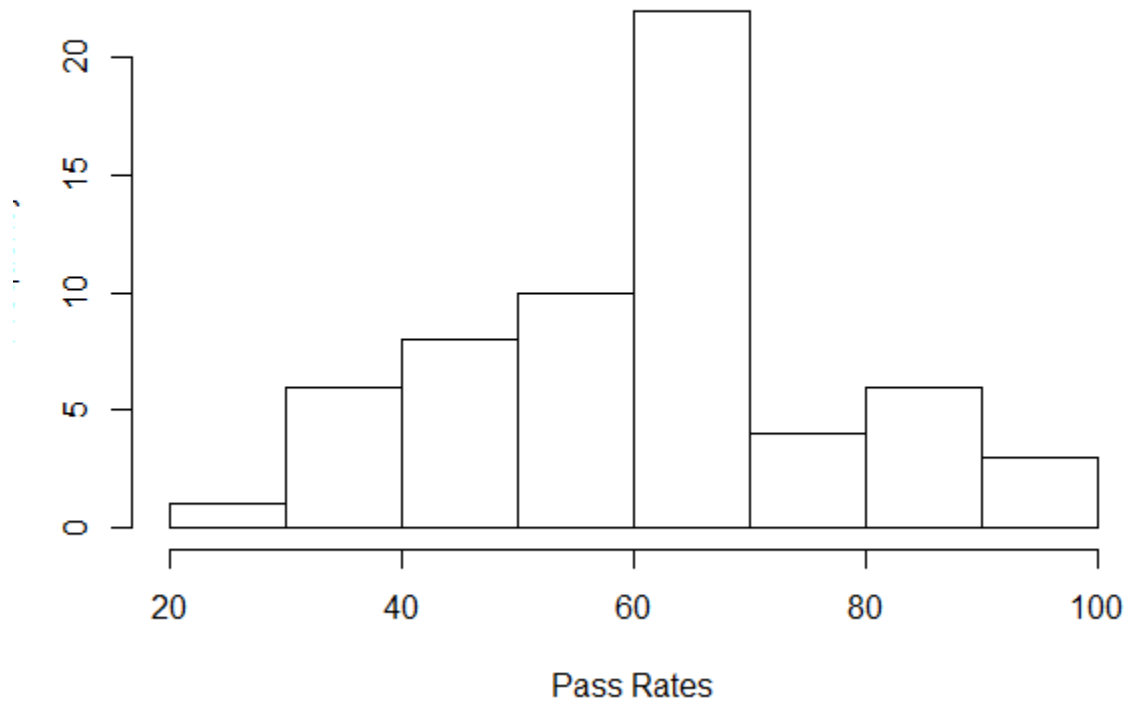|	
Average	62
Standard Deviation	16.13
Max	100
Min	23
Median	62
Q1	52
Q3	69
Table 5: Summary Statistic (unweight) for instructor pass rates per instructor taken from Spring 2008 to Summer 2014	

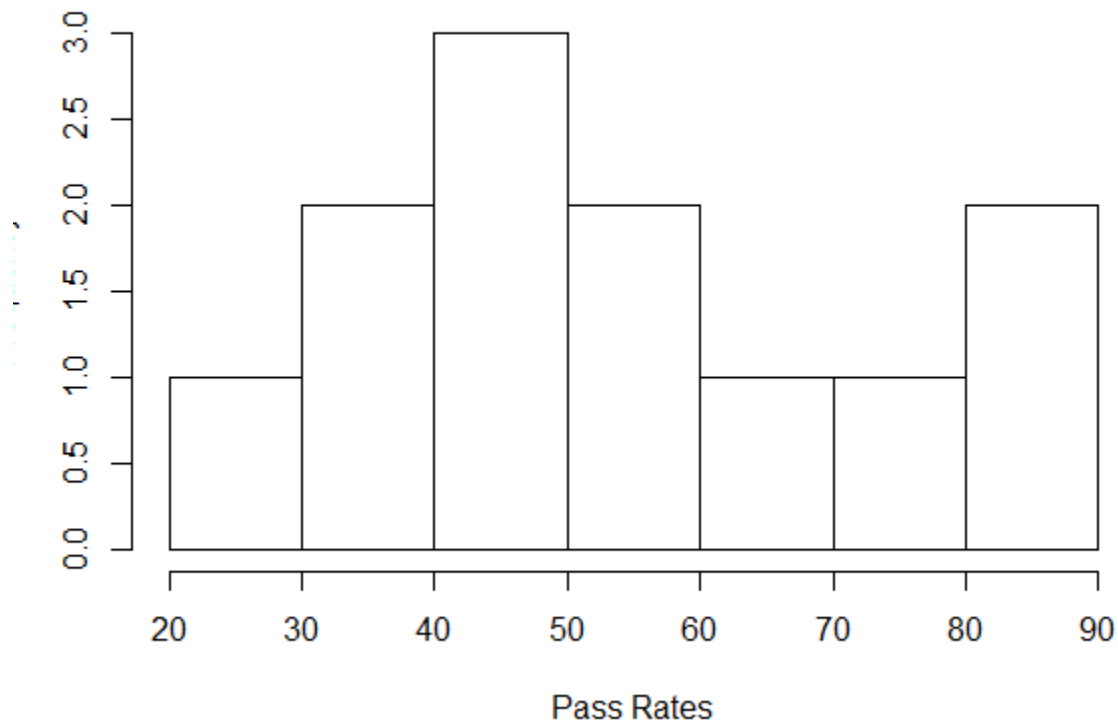Figure 26: Histogram of Pass Rates from Spring 2008 to Summer 2014 for Each Instructor (Raw data is in Figure 10). Note that unweighted refers to the fact class size is not considered in this computation, only the individual pass rates for each instructor.

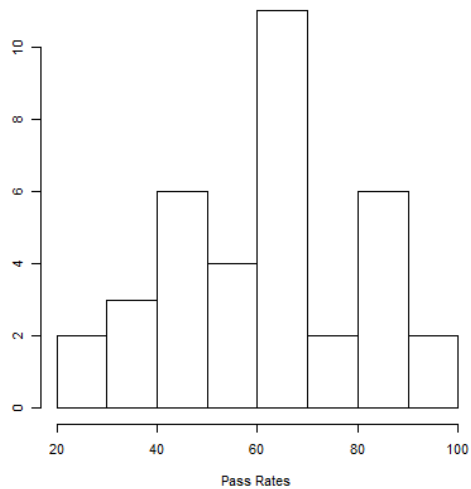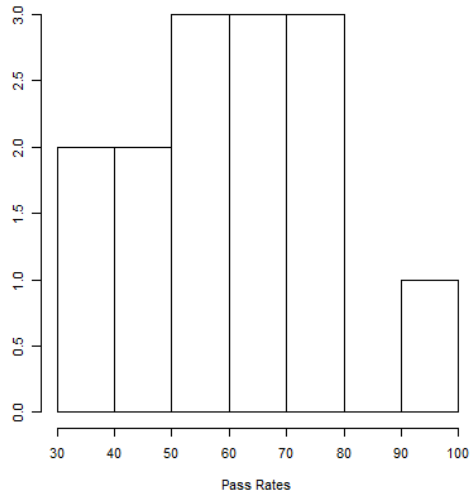|	
Average	52
Standard Deviation	18
Max	23
Min	82
Median	48
Q1	46
Q3	63
Table 6: Summary Statistics for instructor pass rates per instructor. Taken from Spring to Summer 2014	
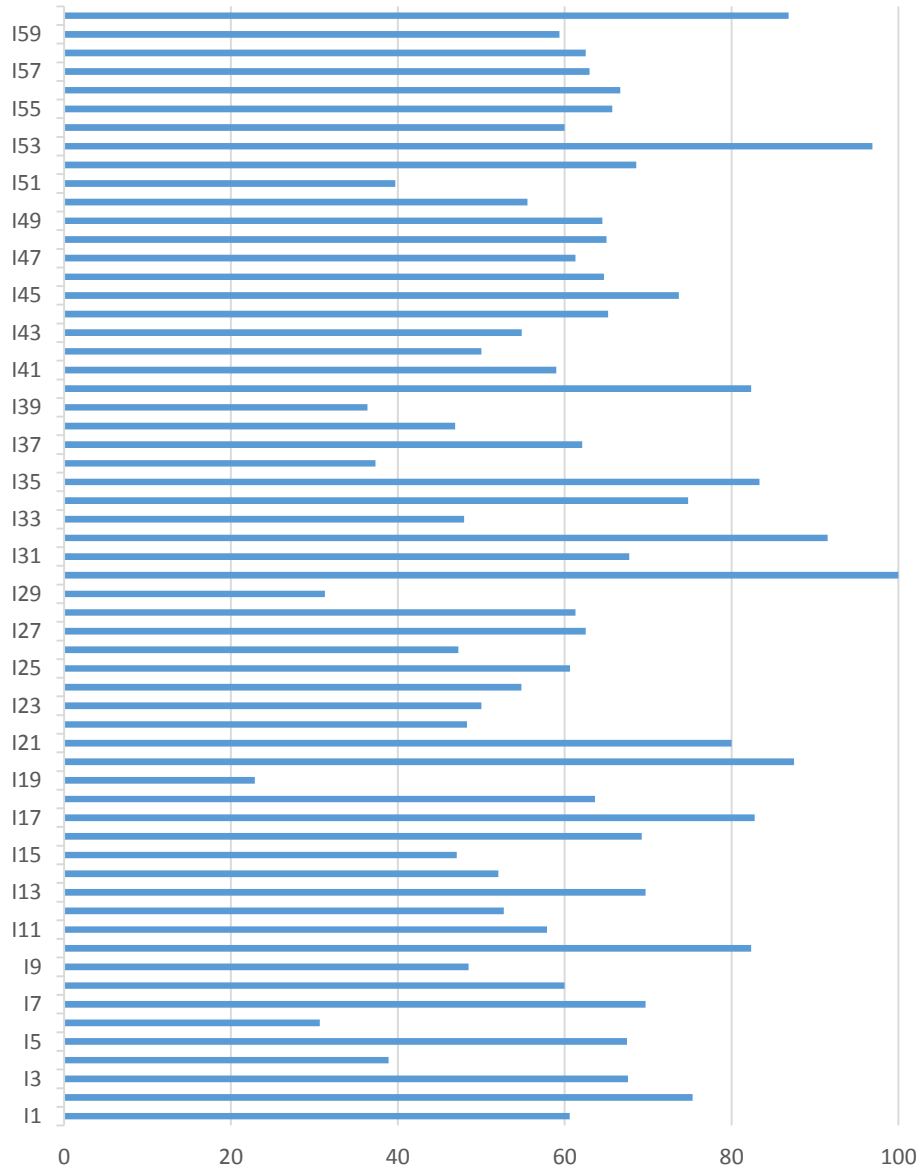
Figure 27: Overall Pass Rates for each individual instructor who has taught MAC 2281 or 2311 during spring 2008 to summer 2014. Instructor names have been replaced by I1-I59.

Unweighted Distribution Of Pass Rates For All Instructors Spring to Summer 2014 2311 and 2281

Pass Rates

Figure 28: Histogram of Pass Rates from Spring to Summer 2014 for each Instructor, (raw data is in Figure 27). Note that unweighted refers to the fact class size is not considered in this computation, only the individual pass rates for each instructor.
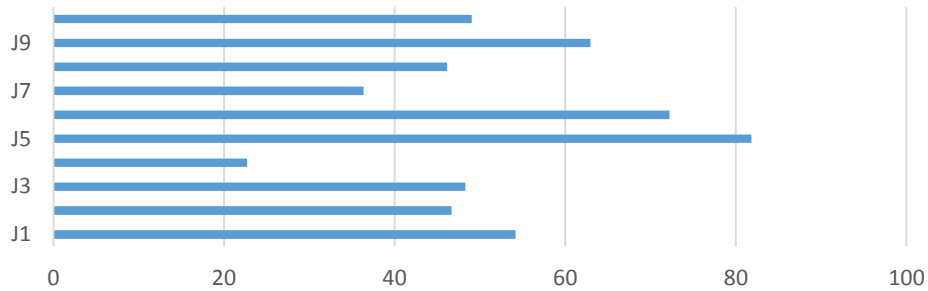
Figure 29: Overall Pass Rates for each individual instructor who has taught MAC 2281 or 2311 during spring to summer 2014. Instructor Names have been replaced by J1-J.
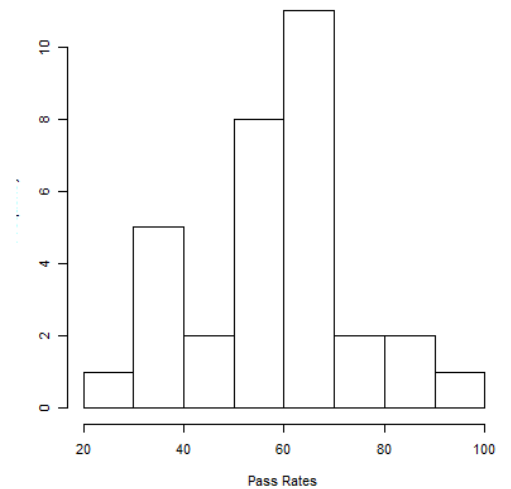

Figure 30: Distribution of Pass Rates for All Instructors for Spring, Summer and Fall terms respectively for 2281 or 2311 during spring 2008 to summer 2014.