Math 333: A Study in Studying

Michael McCourt

I am interested in studying important aspects of my MATH 333 class last semester. This was the first time I taught that class, and I would like to learn about how the students progressed through the year, and what groups of students found the class useful. Doing this will help me become a better professor by understanding the success and failures of my classes.

I acquired this information personally, and the data I have is laid out as follows:

- 31 students in the class
- 10 columns of information
    - Homework average (continuous, 0-100)
    - Quiz average (continuous, 0-100)
    - Exam average (continuous, 0-100)
    - Final average (continuous, 0-100)
    - Exam 1 grade (continuous, 0-100)
    - Exam 2 grade (continuous, 0-100)
    - Exam 3 grade (continuous, 0-100)
    - Years at IIT (ordinal, {2,3,4,5})
    - Major (categorical, {CS,CPE,EE,AE,PHYS,BME,CHE,PED})
    - Grade (ordinal, {A,B,C,D})
- Some of the exam 3 data is missing, as that exam was not required

My topics of interest include:

1. I want to know how effective the quizzes and homeworks were at determining a student's exam grade. What correlation exists between these variables?
2. How good was I at adjusting to my students' needs? I want to measure this by comparing the first and second exam grades and determining if there was an increase.
3. Many different students took this class, and I want to if students who waited longer to take this did so because they were not going to do well at it, or because they were going to do well and wanted an easy class later in their career. Was there a difference in grades based on what year you were in at IIT?
4. Only some of the students in the class took it because it was required; other students took it because it was an "easy" elective. Is there a difference in grade based on student major?

As suggested in the first question, I will run a correlation between the three components of the students' final grade; grades in this class were computed as

$$G = .2H + .2Q + .6E$$

where G is the final grade, H is the homework average, Q is the quiz average, and E is the exam average. From this equation it is obvious what the relationship to the final grade is, but in this question, I want to determine if good performance in one of these areas suggests good performance in the others. It seems

likely that is the case, but sometimes students choose not to do homework, and sometimes students do not attend class and miss the quizzes, so there may be other factors at play. The correlation results are displayed below.

Correlations

		Homework Average	Quiz Average	Exam Average
Homework Average	Pearson Correlation	1	.682**	-.065
	Sig. (2-tailed)		.000	.726
	N	31	31	31
Quiz Average	Pearson Correlation	.682**	1	.392*
	Sig. (2-tailed)	.000		.029
	N	31	31	31
Exam Average	Pearson Correlation	-.065	.392*	1
	Sig. (2-tailed)	.726	.029	
	N	31	31	31

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

These results suggest that there is a strong correlation between the homework grades and the quiz grades – this could be explained by the fact that students who care about the homework are also those which most strongly care about their attendance. There is also a slightly significant correlation (at the α=.03 level) between quiz performance and exam performance, suggesting that doing well on the quizzes will yield good exam grades. In an interesting twist, good performance in homework actually seems to indicate poorer performance on exams, although the correlation is minor and is not statistically significant.

The second question I want to answer deals with student performance on the first two exams. The third exam is omitted because it was not required. My first thought is to run a Matched Pairs test, where I study the difference between each student's first and second exams. To do this, I need to assume that the student grades are normally distributed; this seems unlikely, as I imagine the student grades are more closely uniformly distributed. To test this normality assumption, I have run a Kolmogorov-Smirnov test for goodness-of-fit to the normal distribution. The results are below.

One-Sample Kolmogorov-Smirnov Test

		Exam 1	Exam 2
N		31	31
Normal Parameters[a,b]	Mean	78.5161	82.3548
	Std. Deviation	16.50226	18.63607
Most Extreme Differences	Absolute	.169	.226
	Positive	.131	.184
	Negative	-.169	-.226
Kolmogorov-Smirnov Z		.941	1.256
Asymp. Sig. (2-tailed)		.339	.085

a. Test distribution is Normal.

b. Calculated from data.

This test does not strongly reject that the data is normally distributed, but it is close to rejecting the second exam. As a result, I will instead run a Wilcoxon Sign-Rank test on the difference between the first and second exams. The result of this test is below.

Ranks

		N	Mean Rank	Sum of Ranks
Exam 2 - Exam 1	Negative Ranks	12[a]	12.13	145.50
	Positive Ranks	19[b]	18.45	350.50
	Ties	0[c]		
	Total	31		

a. Exam 2 < Exam 1

b. Exam 2 > Exam 1

c. Exam 2 = Exam 1

Test Statistics[a]

	Exam 2 - Exam 1
Z	-2.009[b]
Asymp. Sig. (2-tailed)	.045

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

The results of this test indicate that there is a significant difference between the first and the second test, albeit only barely significant at the α=05 level. If a similar test had been run with two independent samples, it is likely we would have been unable to make a significant conclusion. Because the Positive

Ranks outweigh the Negative Ranks, we can conclude that student grades did improve, even though this is a 2-tailed test.

To determine if there is a significant difference between student grades depending on what year the student was, we can run an ANOVA. Technically, we should run a Kruskal-Wallis test on the student's final grades with the factor being the student major, but I am willing to assume normality here because I have too little data to reject that assumption. The ANOVA results are below.

ANOVA

Final Grade

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	108.411	3	36.137	.321	.810
Within Groups	3043.640	27	112.727		
Total	3152.051	30			

This test shows no significant difference between the 4 populations represented in this class: second, third, fourth and fifth year students. Although we could conclude from this that you will receive the same grade irrespective of your time at IIT, I will instead say that I think there was insufficient data to make a solid conclusion. Consider the following sample sizes:

- Second Year – 2 students
- Third Year – 24 students
- Fourth Year – 4 students
- Fifth Year – 1 student

In my opinion, these sizes are too small (except for third year students) to make a solid conclusion. I may be able to combine data from this year with last year's data to make a more significant statement, but only after this semester is completed.

The next topic I would like to consider is similar to the previous topic – does a student's major impact their final grade. There are different reasons why this might be true: a student may more heavily value complex variables because of his/her major; students from the same major likely have the same advisor, which may affect the importance that students give a class. It is my opinion, however, that this study will suffer the same problem as the previous study because only 8 majors are present in this class. To create a more significant test, I will instead run a Mann-Whitney U-test comparing the engineering majors to the non-engineering majors. The results are below.

Ranks

	Engineer or Not	N	Mean Rank	Sum of Ranks
Final Grade	Not Engineer	11	10.64	117.00
	Engineer	17	17.00	289.00
	Total	28		

Test Statistics[a]

	Final Grade
Mann-Whitney U	51.000
Wilcoxon W	117.000
Z	-1.999
Asymp. Sig. (2-tailed)	.046
Exact Sig. [2*(1-tailed Sig.)]	.047[b]

a. Grouping Variable: Engineer or Not

b. Not corrected for ties.

In this test, we can see that engineering students did seem to perform significantly better than their non-engineering counterparts. Both the asymptotic results of the test and the exact test show significance at the α=.05 level. Furthermore, because this is a nonparametric test, we do not need to worry about the potentially inaccurate assumption of normality of the grade data.

This statistical analysis seems to indicate that I am a solid teacher, and that engineers perform better in my class than non-engineers. Furthermore, it suggests that homework performance is a great indicator of quiz performance, but a terrible indicator of exam performance. I should therefore reconsider how I assign my homeworks, to make them a more effective method of preparation for the exams.