A Comparison between Calculus I and Physics I Grades at the Higher Colleges of Technology (HCT)

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***Abstract* — It has long been believed a correlation between freshman Physics and Calculus exists. Students who score high grades in Physics are expected to do so in Calculus, and vice versa. We will show such correlation exists and will examine its nature and dependency. Our analysis uses the results of first-year engineering students at the Higher Colleges of Technology for the academic year 2017-2018. The data represents male and female students. We will examine available data in different ways and will look into how gender affects our analysis as well as campuses.**

Keywords: Scattering plot, Calculus grades, Physics grades, Correlation, Hypothesis testing, confidence interval.

I. INTRODUCTION

Most of the literature that relate to this subject has focused on the impact of the Math previous knowledge on the performance of the college freshman physics courses. Many studies appear to show that Mathematical knowledge accumulated throw the early years of education is positively correlated to success in traditional introductory physics courses in first year of college. Most of these studies have examined college physics students and their Math preparations such as Math college entrance exams . Many investigators have found positive correlations between grades in college physics and a Mathematics skills pretest administered at or near the very beginning of the course. Typically, these pretests involve algebra and trigonometry, although most investigators do not provide samples of their tests. However, a solid correlation between Mathematics skill and physics performance or grades has varied significantly between different studies. Correlation coefficients vary widely and are not statistically significant for all groups tested .

Another area of the literature focused on the impact of freshman grades in Physics and Math courses on the later courses especially in engineering major. For example, a study that has been conducted by Jane Simpson and Eugenia Fernandez at Indiana University-Purdue University [1] suggested that a significant relationships were found between some Math and science courses and ECE courses. These findings are in line with those of Easter [2] and Potolsky, Cohen, and Saylor [3] who found that grades in prerequisite courses were indicators of grades in subsequent courses. Not surprising, students who earned high grades in the prerequisite classes received higher grades in the subsequent courses as well [1].

On the other hand, there are few studies that link the grades of engineering students in freshman Physics and Math courses such as Physics I and Calculus I. Our investigation will focus on this relation. Students who study engineering are expected to have strong background in Physics and Mathematics foundations. However, is it safe to say, if a student is good in Math, he/she is also good in Physics. A grade in one of the two subjects will most likely replicate in the other subject. To be more specific, a student who scores an A in one of the two subjects will earn a similar grade in the other subject. Our ensemble represents first year engineering students across all HCT's 16 campuses. It's a total of 752 data entry.

In our investigation we rely on a number of statistics tests. We test the linear correlation between scores in Physics and Calculus I for each student. This one to one mapping tells us the expected grade a student will earn in one subject based on the earned grade in the other subject. We examine the general belief that is female students do better than male students in Calculus I and Physics. We also look at the averages of the Calculus I and Physics grades across the campuses and compare those using simple statistics.

In addition, a Z-test will be utilized due to the large sample at hand. Such Z-test will help analyze the averages relating to gender bias (female vs. male students). The assumption that students who are good in Calculus I will be also good in Physics and vice versa will be examined in this investigation also.

For sample sizes exceeding 30 the Central Limit Theorem is applied. The Central Limit Theorem states for any given random and independent samples of N observations, the distribution of sample means approaches normality as the size of N increases, regardless of the shape of the population distribution [3], [4]. For further reading how to construct probability distributions and their applications, see [6]-[10].

II. Procedure and Methodology:

1- Let *x* denotes the grades of MTH 1203 (Calculus I) and let *y* denotes the grades of PHY 1103 (Physics I).

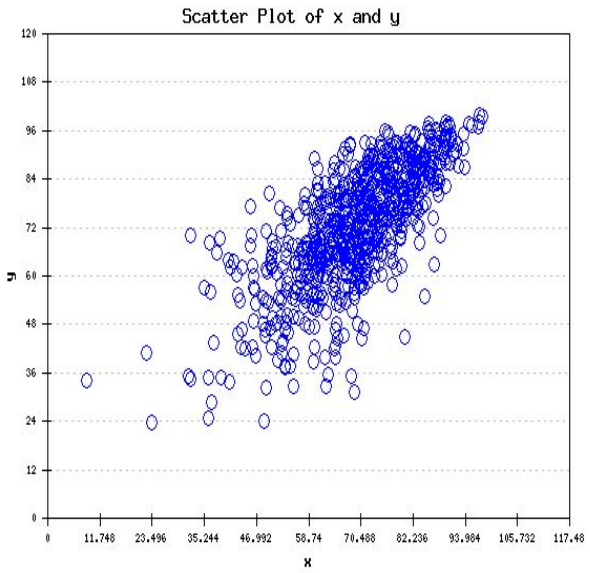

Fig.1 Scattering plot of the grades of Calculus I on the *x-axis* and the grades of Physics I on the *y-axis*

The Data shows that the Calculus I grades' average is 72.28 and the Physics grades' average is 69.28. The correlation coefficient between these averages is (r = 0.7274) which indicates a strong positive linear relation between the grades of Calculus I (x-axis) and the grades of Physics I (y-axis).

This gives a strong evidence that Calculus I grades and Physics I grades at HCT are strongly correlated. The regression line which helps predict a student's grade in either topic is given as

$$y = 0.61839529501415x + 24.583410797869.$$

In terms of confidence, it is almost at any level of significance (even for a tiny one), there is enough evidence to suggest that the population mean for Calculus I grades (μ_1) is higher than Physics I grades (μ_2) at HCT. For example, at the 0.001 significance level, the z-statistic for the test $H_0: \mu_2 = \mu_1$ against $H_1: \mu_1 > \mu_2$ is z = 7.939 which corresponds to a right-tailed test where the critical value is $z_c = 3.09$. It is then concluded that *the null hypothesis is rejected.* Moreover, the 99.9% confidence interval for $\mu_1 - \mu_2$ is $1.756 < \mu_1 - \mu_2 < 4.242$ which does not contain zero. As predicted, the two means μ_1 and μ_2 are not equal and the Calculus I mean (μ_1) is higher than the Physics I mean (μ_2).

2- Now, and for the sole purpose of this study, we will consider a student to be "good student" in Calculus I or Physics I if he/she scores 80% or above as a final grade in either one of the two courses.

The data shows, for those students who are good in Calculus I, the distribution of their Physics I grades looks as follows:

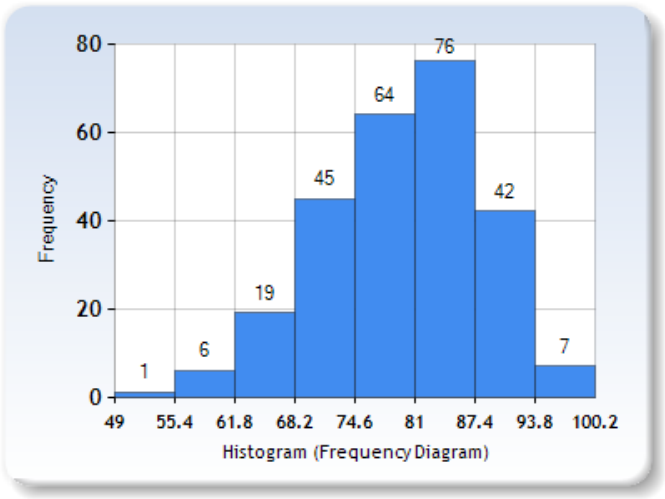

Fig 2: the distribution of Physics I grades for those who are "good" in Calculus I.

This means, approximately 48 % for those who are good in Calculus I are also good in Physics I.

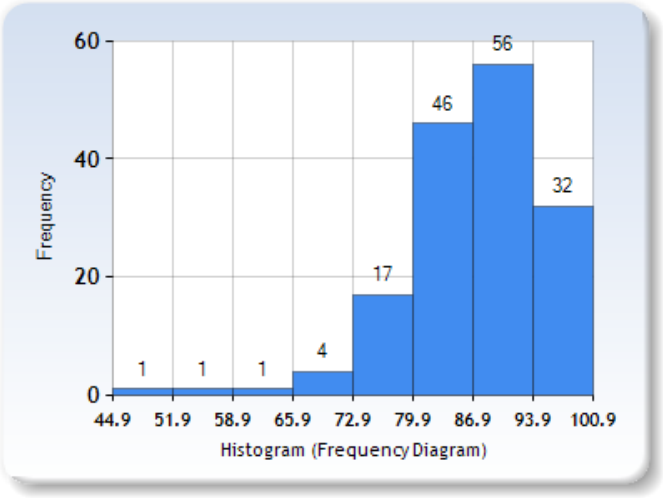

Fig 3: the distribution of Calculus 1 grades for those who are "good" in Physics I.

Fig. 3 tells us that the conditional probability that a student who is good in Physics I is also good in Calculus I is 85 %.

3- The data will show that the females are significantly doing better in Physics I than the males. Let μ_f be the average of females in Physics I and μ_m be the average of males in Physics I. The sample means for females and males are 70.64405 and 67.04341 respectively and the sample standard deviations are 13.3785725 and 13.5700121 respectively. If we test $H_0: \mu_f = \mu_m$ against $H_0: \mu_f > \mu_m$, the test statistics is 4.6197 which means H_0 will be rejected at almost any level of significance. For example, the critical value at the significance level 0.001 is 3.09 which is still less than 4.6197. Thus, we are 99.9% confident that the female grades in Physics I are higher than the males grades.

For Calculus I grades, the sample means for females and males are 72.09107 and 70.7957331 respectively and the sample standard deviations are 15.8501241 and 15.7920614 respectively. If we test $H_0: \mu_f = \mu_m$ against $H_0: \mu_f > \mu_m$, the test statistics is 1.47025 which means H_0 will be rejected at any level of significance greater than 7.08% and will be accepted for any level of significance less than 7.08%. This tells us our conclusion

is dependent on the level of significance. As the level of significance varies, the confidence in our results varies as well. For example, the critical value at the significance level 0.05 is 1.645 which is greater than the z-statistic 1.55, this means we will accept the null hypothesis. In this case, we are 95% confident there is no difference between the grades of males and females in Calculus I. On the other hand, the critical value at the significance level 0.10 is 1.28 which is less than the z-statistic 1.55, this means we will reject the null hypothesis. In this case, we are 90% confident that there is a significant difference between the Calculus I grades of males and females.

III. Results/Conclusions:

To sum up, our results show:

1) Average grades for Calculus I and Physics I indicate that first year students are most likely better in Calculus I than Physics I.

2) The conditional probability that a student who is good in Calculus I is also good in Physics I is 48 %. However, the conditional probability that a student who is good in Physics I is also good in Calculus I is 85 %. So, it is more likely to get a student who is good in Physics I and is also good in Calculus I than to get a student who is good in Calculus I and is also good in Physics I.

3) The females are doing "significantly" better in Physics I as the confidence level was so high.

4) For Calculus I grades, there is no significant evidence that the female students score better grades than male students and vice versa.

a. Recommendations for Further Studies

Further study is needed to see how our findings change with campuses and if the same results still hold. In addition, one may want to conduct a study to find why students do better in Calculus I than Physics I at least in their first year of college.

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