RELATIONSHIP OF MATHEMATICS AND PHYSICS GRADE POINT AVERAGE WITH CONSTRUCTION SCIENCE GRADE POINT AVERAGE

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Abstract: The purpose of this study is to determine the role of knowledge in mathematics and physics courses of Construction Management (CM) students on the performance of their undergraduate study. This study deals with the grades in construction science and construction courses of students to measure the performance of the students. Similarly, the performance of students in mathematics and physics are measured on their respective subject grade. This study employed correlation methods to investigate the relationships of the mathematics and physics Grade Point Average (GPA) with their construction science and construction GPAs. The study includes the data of CM students graduated between 1982 and 2010 in University of Nevada Las Vegas. The correlation analyses indicated a significant correlation between construction science and construction GPAs with mathematics and physics GPAs of CM undergraduate students. The multiple regression analyses revealed the GPAs in mathematics and physics as significant variables to predict GPAs in the construction science as well as construction courses.

Keywords: Construction management, Grade point average, Physics, Mathematics.

Introduction: The construction management undergraduate students in accredited programs take a minimum of 15 semester credit hours of mathematics and science courses as per American Council for Construction Education (ACCE) requirement. Additionally, they should have to take a minimum of 20 semester credit hours in construction science and a minimum of 20 semester credit hours in construction [1]. In Construction Management (CM) program, construction science courses are those courses that cover design and engineering concepts, such as, steel design, concrete design, soils and foundations. However construction courses includes those courses that do not required design and engineering concepts, such as estimating, scheduling, project management, cost control. ACCE also requires a minimum aggregate of both construction science and construction combined of 50 semester credit hours. It is well believed that the construction science courses require a significantly higher level of knowledge, skill, and ability in mathematics and physics than do the construction courses. Previous study showed that students having good grades in mathematics and physics courses can have good overall GPA [2]. Therefore, students must perform well in mathematics and physics courses to perform satisfactorily in construction science courses. But, in reality, students must perform equally well in construction science and construction courses to develop the level of knowledge, skills and abilities that are critical to becoming a successful professional in the construction industry. It is obvious that the overall GPA of the students directly depends upon all of these courses i.e. higher the grade in all courses, higher will be overall GPA. The University of Nevada Las Vegas, Department of Civil and Environmental Engineering and Construction places an emphasis on ensuring that students take the necessary mathematics and physics courses so that they are able to apply these courses' fundamental concepts in order to be successful in construction science and construction courses.

Students pursuing the Bachelor of Science in Construction Management at University of Nevada Las Vegas can select either management option or the engineering science option. But, both options require the same courses in construction and business. The main difference is in the requirement of mathematics, science, and construction courses credits. The management option's courses in construction science are based on an applied analysis approach and are less focused on theoretical aspect, whereas, construction science courses in the engineering science option are traditional engineering courses [1]. The offered mathematics courses for CM undergraduate students are: Calculus I, II, and III (MATH 181,182 and 183 respectively), and Mathematics for Engineers and Scientists I (MATH 431) etc. The offered physics courses for CM undergraduate students are: General Physics I, and II (PHYS 151, and 152 respectively), Physics for Scientists and Engineers I and III (PHYS 180 and 182 respectively). The Construction science courses considered for this study are: Structures of Architects (ABS 341, 440, 441), Elementary Surveying (CEE 121), Fundamentals of Construction science (CEM 101/150), Construction Materials and Methods (CEM 252), Soils and Foundations for Construction(CEM 330), Facility Systems Design and Construction(CEM 350, 351), Temporary Construction Structures (CEM 432), and Construction Equipment (CEM 454). The Construction courses considered for this study are:

Fundamental of Construction Management (CEM 100), Quantity Survey and Document Analysis (CEM 253), Construction Safety (CEM 301), Construction Field Inspection (CEM 450), Construction Estimating (CEM 451), Construction Cost Control (CEM 452), Construction Scheduling (CEM 453), Construction Management Practice (CEM 455), Construction Management Capstone (CEM 456), Construction Law and Contracts (CEM 485), Building Substructures (CEM 434), and Construction Site Water Management (CEM 460).

The CM students in University of Nevada Las Vegas take minimum of 15 credit hours of mathematics and physics courses before they start taking construction science courses. Although, the number of credit hours taken in mathematics and physics are very low in compared to credit hours taken in construction science and construction courses, the impact of these courses on their overall GPA is very high [2]. Since, overall GPA includes all mathematics, physics, construction science and construction courses, it is believed that good knowledge in mathematics and physics should improve the understanding in construction science and construction courses. Therefore, this study focused to determine the correlation of physics and mathematics GPAs with construction science and construction GPAs of CM students.

Research Hypothesis: The main variables considered for this study are mathematics GPA, physics GPA, construction science GPA, and construction GPA. The major objective of this study is to determine the impact of mathematics and physics GPAs in the construction science and construction GPAs. Two research hypotheses for this study were formulated. Table 1 shows the research hypotheses of this study.

Table 1. Research Hypothesis

Hypothesis No.	Research Hypotheses (H_a)
I	H_a1: A higher GPA in mathematics will result in higher construction science and construction GPAs of CM students.
II	H_a2: A higher GPA in physics will result in higher construction science and construction GPAs of CM students.

Null Hypothesis: To conduct the statistical test, these research hypotheses will be converted to null hypotheses as described in Table 2 for this study. The statistical test hypothesizes that the correlation coefficient between these variables is not significantly different from zero. Mathematically it can be expressed as shown in Equation 1.

$$\beta_1 = \beta_2 = 0 \quad (1)$$

Table 2. Null Hypotheses

Hypothesis No.	Null Hypotheses (H_o)
I	H_o1: There is no relationship between Mathematics GPA and the construction science and construction GPAs of the CM students
II	H_o2: There is no relationship between Physics GPA and the construction science and construction GPAs of the CM students

For the null hypothesis to be false, the p-value must be less than or equal to 0.05. Given that the null hypothesis is true, the p-value represents the probability of observing a test statistic that is at least as large as the one that is actually observed.

Literature review: the student characteristics, teaching effectiveness, gender, academic classification, performance in prerequisite courses, and overall academic ability play significant role in the performance of students as per several studies conducted by choudhury [3], coleman and gotch [4], seymour et al. [5], and rose et al. [6].

A research was conducted to determine the factors that affect the student's performance in Environmental Control Systems Courses at an undergraduate level in the Department of Construction science at a large South Central University [7]. Ten factors were considered for the analysis. The population collected for the study

consisted of the 223 students attended such courses in Summer Semester of 1997 and 1998, Fall Semester of 1997, and Spring Semester of 1998. The multiple regression analysis showed that such courses are not correlated with class size. Personal characteristic variables such as gender and academic classification are inversely related to student performance. The study found that the overall academic ability of a student is positively correlated with student performance. The F-test was conducted which was found statistically significant at the 0.0001 level. The R-square value of the model was found to be 0.37. From the multiple regression analysis, the model was developed which is shown in Equation 2.

GRADE=62.48+0.05*CLSIZE+
0.95*SEMESTER-2.04*SEX+
2.3*LEVEL+0.64*INSPIRE+
0.24*FEELING-0.93*CONTRIB+
0.21*UNDSTAND+0.5*SATISFY+
5.36*GPA (2) Where,

GRADE = Grade of Environmental Control Systems Course
CLSIZE = Number of students in the class
SEMESTER = Fall, Summer, or Spring semester
SEX = Male or Female
LEVEL = Academic classification of a student, Senior or Junior
INSPIRE = Interest and enthusiasm for class work (Leikert scale 1-5)
FEELING = Feeling toward the course (Leikert scale 1-5)
CONTRIB = Students contribution to the class (Leikert scale 1-5)
UNDSTAND = Perceived level of understanding of the materials taught (Leikert scale 1-5)
SATISFY = Overall course satisfaction (Leikert scale 1-5)
GPA = Overall Grade Point Average of the students

A research was conducted to examine the effects of overall academic capability of students on their performance in this course [7]. The overall academic capability of a student was measured by GPA. Sample size for this study was 329 taken from the population of students who attended the Environmental Control System courses in Fall, Spring, and Summer semesters from 1997 through 2001. A simple linear regression technique was used to predict the model shown in Equation 3.

GRADE=10.76+37.15*GPA-4.17*GPASQ+2.08*MAJOR (3)

Where, GRADE = student performance in terms of numerical grade, GPA = grade point average of a student, GPASQ = quadratic term of GPA, MAJOR = academic major of a student.

The overall academic capability and the major of a student for this research have statistically significant effects on the student performance in the Environmental Control Systems courses. The R-square value for the model was found to be 0.59. The model could be helpful to the instructors to formulate teaching strategies.

A research was performed by Orth to identify variables that could serve as predictors of student retention and success in an undergraduate Construction Management program [8]. The independent variables in this study were: high school rank, high school GPA, high school class size, number of high school science courses, numbers of high school mathematics courses, SAT composite score, matriculation age, gender, race, and residence. The samples were taken from students enrolled from fall 1992 to fall 1997 in the Building Science Department at Purdue University. The total sample size was 343. A logistic regression model was developed and the relationship was tested at the 0.05 significance level. The Wild Chi-Square test showed that the high school GPA and the number of high school mathematics subjects with graduation in the Construction Management program were found to be statistically significant at $\alpha = 0.05$. This study results showed that the students who had taken significant mathematics courses in high school have a high graduation rate. It indicated that the mathematics education is vital for Construction Management students to graduate from this program.

Shrestha and Shields found that the GPA of undergraduate students in construction science course is directly correlated with the GPA of mathematics taken in university level [1]. They found a significant correlation between mathematics GPA and final test score of the students in this course. However, no significant correlation was found between physics GPA and final test score of this course. A multiple regression model created to predict the final test score of CM student in this course using mathematics and physics as input variables was not found to be significant.

Study methodology: This study analyzes the correlation between mathematics and physics GPAs and construction science and construction GPAs. Methodically, this study consists of five steps. The first step was to perform a literature review to determine whether any study had been conducted related to this research. The second step of the study was to collect the mathematics, physics, construction science, and construction GPAs data of undergraduate cm students. It was followed by the descriptive analysis. Then, correlation tests were conducted between the mathematics and physics GPA with construction science and construction GPAs. If a significant correlation is found between the mathematics and physics GPA with construction

science and construction gpas, then the final step of the study will develop a multiple regression model to predict the construction science and construction gpas using the mathematics and physics gpas as input variables. Additionally, conclusions and recommendations for future research areas will be discussed.

Sample Description: The data of CM students graduated from 1982 to 2010 of University of Nevada Las Vegas were randomly collected. The data of undergraduate construction management students were obtained from Office of Undergraduate Advising and Graduate College, University of Nevada Las Vegas. In the data analysis, only the students who had taken mathematics and physics courses at the university level were considered. According to ACCE accreditation, the CM students had to take at least two mathematics and physic courses.So the average GPA of mathematics and physics were calculated for each student to use in the analysis. The grades of various subjects under construction science and construction courses were calculated for each student. Furthermore, average grades of the construction science and construction courses were calculated for each student to use in the analysis. The total sample size for the analysis was 86. A linear correlation and multiple regression analysis were conducted to determine the significant relationship between construction science and construction GPAs with mathematics and physics GPA of the students.

Results: the descriptive data analysis shows that the mean GPAs for construction science, construction, mathematics, and physics were 3.22, 3.31, 2.86 and 2.67 respectively. The mean and median are very close to each other. There is a small variation in the data set shown by the low standard deviation value. table 3 describes the results of descriptive statistics for these data.

Table 3. Descriptive Statistics of Construction Science, Mathematics, and Physics GPA

Variables	No. of Samples	Mean	Standard Deviation
Construction Science Grade	86	3.22	0.37
Construction Grade	86	3.31	0.34
Mathematics Grade	86	2.86	0.50
Physics Grade	86	2.67	0.59

The Pearson Correlation test was conducted to determine the correlation coefficient between the construction science and construction courses GPAs with mathematics and physics GPAs. The data were tested for normality using Anderson-Darling normality test before conducting correlation analysis. Table 4 describes the results from normality test. To be normal, the p-value should be more than 0.05. The test results showed that the construction science, construction and mathematics grade data were normally distributed. However the physics grade was not normally distributed. This will not affect the correlation test, because it is robust as long as the variables are independent [9].

The power of the test is the probability of finding the statistically significant difference when such a difference actually exists. The power was set as 0.80 for this correlation test. The power analysis was conducted using Power Analysis & Sample Size Software (PASS 12) to determine the number of sample size to get correlation of 0.40 at alpha level 0.05. The results showed that 46 samples are required to get power of test as 0.80. Therefore, the sample of 86 taken in this study is large enough for valid conclusions.

Table 4. Anderson Darling Test Results

Variables	No. of Sample	p-value	Remarks
Construction Science Grade	86	0.22	Normally Distributed
Construction Grade	86	0.94	Normally Distributed
Mathematics Grade	86	0.20	Normally Distributed
Physics Grade	86	0.01	Non-Normal

Pearson Correlation Analysis: The results of the Pearson Correlation analysis are presented in Table 5, and indicate that there is indeed a statistically significant relationship between the construction science GPA with mathematics and physics GPAs. The correlation between the construction science

GPA and mathematics GPA was found to be 0.37. Also, the correlation between the construction science GPA and physics GPA was found to be 0.45. Even though these correlations were moderate, they were significant at alpha level 0.01. It also indicates that the relationships are positive. This positive correlation indicates that the increase in mathematics and physics GPA results in an increased construction science GPA of CM students.

Table 5. Pearson Correlation Test Results with Construction Science GPA

Variables	No. of Sample	Pearson Correlation Coefficient	p value
With Construction Science GPA			
Mathematics GPA	86	0.37**	<0.01
Physics GPA	86	0.45**	<0.01

** Significant at alpha level 0.01 (2-tailed)

The results of the Pearson Correlation analysis are presented in Table 6, and indicate that there is indeed a statistically significant relationship between the construction GPA with mathematics and physics GPAs. The correlation between the construction GPA and mathematics GPA was found to be 0.40. Also, the correlation between the construction GPA and physics GPA was found to be 0.30. Even though the correlations between these variable were moderate, they were significant at alpha level 0.01. It also indicates that the relationships are positive. This positive correlation indicates that the increase in mathematics and physics GPA results in an increased construction GPA of CM students.

Table 6. Pearson Correlation Test Results with Construction GPA

Variables	No. of Sample	Pearson Correlation Coefficient	p value
With Construction GPA			
Mathematics GPA	86	0.40**	<0.01
Physics GPA	86	0.30**	<0.01

** Significant at alpha level 0.01 (2-tailed)

The correlation coefficient between construction science GPA and Physics is higher than that of construction GPA and mathematics indicates that students should have good knowledge in physics to get good grade in construction science. Moreover, students should have good knowledge in mathematics than in physics to get good grade in construction.

Multiple Regression Analysis: The results of the Multiple Regression analysis between construction science GPA with mathematics and physics GPAs are presented in Table 7.

A regression model was developed between construction science GPA with mathematics and physics GPAs, which is shown in Equation 3. This model can be used to predict construction science GPA using mathematics and physics GPAs as input variables. The F value for this was found to be 17.33. The R-square value for this model was 30 percent. The model is also statistically significant at alpha level 0.001. The model showed that the increase in one GPA in mathematics will yield 0.23 GPA in construction science course and the increase in one GPA in Physics will yield 0.25 GPA in construction science course of CM students.

Table 7. Multiple Regression Results of Construction Science GPA with Mathematics and Physics GPA

Variables	R Value	Constant	R^2	Significance
Mathematics GPA	0.23	1.89	0.30	<0.01*
Physics GPA	0.25			

* Significant at alpha level 0.01

Construction Science GPA = 1.89 + 0.23 Mathematics GPA + 0.25 x Physics GPA (4)

The results of the Multiple Regression analysis between construction GPA with mathematics and physics GPAs are presented in Table 8. A regression model was developed between construction GPA with mathematics and physics GPAs, which is shown in Equation 4. This model can be used to predict construction GPA using mathematics and physics GPAs as input variables. The F value for this was found to be 11.41. The R-square value for this model was 22 percent. The model is also statistically significant at alpha level 0.001. The model showed that the increase in one GPA in mathematics will yield 0.25 GPA in construction course and the increase in one GPA in Physics will yield 0.14 GPA in construction course of CM students.

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Table 8. Multiple Regression of Construction GPA with Mathematics and Physics GPA

Variables	R Value	R^2	Sig.
Mathematics GPA	0.25	0.22	<0.01*
Physics GPA	0.14		

Significant at alpha level 0.01

Construction GPA = 2.22 + 0.25 x Mathematics GPA + 0.14 x Physics GPA (5)

The findings of Shrestha and Shields (2009) showed that R-square value of model to predict the final test scores of Fundamental of Construction Science course based on mathematics and physics GPA was 0.25. The R-square value of the model developed during this study was 0.30, which is higher than that study's model.

Conclusions: The results proved our hypotheses to be correct. Our first hypothesis related to relationship between the construction science GPA with mathematics and physics GPAs was proved to be true for this sample. The result showed that the better mathematics GPA and physics GPA are, the better the construction science GPA of the CM students will be. The correlation coefficient between construction science GPA and Physics is higher than that of construction science GPA and mathematics, indicates that students should have good knowledge in physics to get good grade in construction science.

Similarly, our second hypothesis states that there is a correlation between the construction GPA with mathematics and physics GPAs which found to be also true for this sample. It also indicates that the higher the grade in mathematics and physics, the higher the construction GPA of CM students will be. The higher correlation between mathematics and construction indicates that students should have a good knowledge in mathematics than in physics to get good grade in construction.

It should be noted that the correlation between these variables does not necessary imply that one causes the other. However, in this context it can be concluded that the overall GPA and construction science courses GPA of CM students are impacted by their performance in math and physics GPA. There are various factors that impacted the GPA of the students in any courses, but this analysis showed that performance of their pre-requisite courses directly affected their subsequent courses' GPA.

The findings of this research shed some lights on how important it is for the undergraduate students to perform better in mathematics and physics to achieve higher construction science and construction GPA in the CM undergraduate program. The data were not available to determine impact of other factors on GPA of CM students. The authors would also like to recommend further study to determine the impact of class size, instructor ability and types of instruction, gender, teaching effectiveness, and other undergraduate construction management subjects' knowledge on their overall GPA.

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