

Investigating the Predictive Ability of Admission GRE Scores on Graduation GPA Scores of Domestic and International Students in Construction Management Graduate School Programs

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GRE scores have been part of graduate admission requirements for both domestic and international students in some construction management educational programs in the USA because academic committees tend to believe that it predicts academic performance and success of students. This study assessed the predictive ability of admission GRE scores on cumulative graduation GPA scores of domestic and international graduate students. The hypothesis was that students who scored high in GRE would attain higher graduation GPAs and that there was no difference in performance based on the nationality of students. The independent variables were GRE verbal, GRE quantitative and total GRE scores while the dependent variable was the GPA score. SAS v9.3 statistical analysis software facilitated the analysis of the data obtained from three construction management graduate schools in the USA. The results showed weak predictive indices where GRE quantitative was the better predictor of GPA. Thus, the hypothesis of higher GPAs associated with higher GRE scores was weakly supported. In addition, the hypothesis of no difference in performance based on the nationality of the students was also supported. It was recommended that admission committees should re-evaluate requiring GRE scores.

Key Words: Construction Management, GPA, GRE, International Students, Performance

Introduction

Each year, graduate admissions in universities in the United States of America (USA) face difficulties in admitting good students who they expect to eventually succeed in their graduate educational pursuit. The task becomes even more difficult when they admit non-USA students who are not familiar with the educational system in the USA. Nevertheless, admission committees expect both USA (domestic) and non-USA (international) students to perform relatively at the same level and excellently in their graduate academic work right from the start until graduation.

In order to arrive at the best decision, the admission committees consider subjective and objective sources of information to select students who best fit their academic programs. The subjective information may include personal statements of purpose, letters of recommendations and personal interviews with the designated graduate school personnel while objective student information may include prior Grade Point Average (GPA) and Graduate Record Examination (GRE) scores (Holt, Bleckmann & Zitzmann, 2006; Reisig & Dejong, 2005).

A critical look at graduate admissions in some of the construction management (CM) programs in the USA show that they usually require students to take the GRE and achieve results that meet the admission requirements. Admission committees believe that GRE scores can predict graduate performance, excellence and success, with doctoral level programs requiring higher GRE cut off scores than master's level programs. Achieving higher GPAs at the end of the program is the ultimate expectation of both international and domestic students.

Discussions have alluded that GRE is not a dependable predictor of success in graduate school education. In fact, some Ivy League CM schools have stopped incorporating GRE in their admission requirements. In this light, it can be deduced that GRE score does not successfully predict the performance of graduate students. In order to alleviate

the use of GRE, some academic programs have resorted to using their own customized graduate admission examinations that reflect their graduate program requirements (Mupinga & Mupinga, 2005). On the other hand, some CM schools in the USA such as Purdue University, Colorado State University, Texas A &M University, Virginia Institute of Technology, Auburn University and the University of Florida require GRE for their graduate education admissions.

Therefore, this research investigated the GRE scores as a predictor of GPA scores of students from three major CM graduate programs in the USA. Past GRE scores of students was the variable used as a predictor of performance and success. Cumulative graduation GPA (GGPA) at the end of graduate school education was the measure of performance and success of students. The research utilized quantitative statistical analysis to examine the level of performance and success in GPA using GRE as the predictor since admissions tended to use it with other requirements when admitting graduate students (which may be both domestic and international students).

Literature Review

Assessing Reliability of GRE in Predicting GPA

GRE as an aptitude test that reflects the ability of students to learn is required by universities in the USA to admit students into graduate schools (Mupinga & Mupinga, 2005). It has three sections measuring quantitative (GREQ), qualitative (GREV) and analytical skills (GREA). These sections require test takers to solve simple and complex problems, synthesize information, including resolving relationships between and among pieces of information that may be basic or require higher level thinking (Briel et al., 1993). Different disciplines require different levels of these skills.

Research shows that predictive validity of GRE scores towards graduate school success tends to get better when a particular test matches a specific discipline (Orlando, 2005). Studies have revealed that the GRE verbal score is a modest predictor of success in academic disciplines that are descriptive while the GRE quantitative score is a better predictor in symbol-oriented disciplines (Orlando, 2005).

Using graduate admission GRE score to predict student graduate performance and success has been debatable (Kuncel, Campbell & Ones, 1998). Some studies have investigated the reliability of GRE scores as a predictor of graduate school success while others have shown that the test predicts certain attributes of success in graduate school (Holt et al., 2006). The results span from little predictive validity to strong correlation between GRE scores and graduate school achievement (Orlando, 2005; Kuncel, Hezlett & Denize, 2001; Morrison & Morrison, 1995). However, the criteria used to assess graduate academic success vary considerably across studies. Some studies have used first year graduates' GPAs and final GPAs, while others utilized percentage of students who were able to complete their academic programs (Orlando, 2005). Orlando (2005) identified the latter path to be problematic since it did not account for those students who left programs because of job commitments or critical matters arising from personal or family issues. Nonetheless, Mupinga and Mupinga (2005) upheld that the measure of success of the students vary across institutions, colleges, disciplines and the type of programs the students are pursuing.

Varied inconsistencies exist in the outcomes of the nature of the relationship between GRE and graduate GPA. Research in engineering programs has shown correlation results of 0.27 in scores between GRE verbal (GREV) and first year GPAs for engineering graduates and 0.22 for GRE quantitative (GREQ) scores. Ayers and Quattlebaum (1992) found an opposite correlation coefficients of lower GREV ($r = 0.07$) and higher GREQ ($r = 0.321$) with GPA scores. Such inconsistencies of results have resulted in meta-analysis studies to help resolve any dilemma. Kuncel et al. (2001) meta-analysis found correlation of GPA and GREV to be 0.23 and GREQ to be 0.21. They concluded that GRE is a valid predictor of graduate success and that GRE subject scores tended to be better predictors than verbal, quantitative, and analytical tests.

Stack and Kelley (2002) assessment of forty-eight ($N = 48$) graduate students in criminal justice discipline showed that GREV was better than GREQ in predicting GGPA (Standardized regression coefficients being 0.336 and 0.245 respectively). Shaurette and Rapp (2014) conducted a study in a Master of Science program at Purdue University where they investigated about the writing challenges experienced by CM students especially when they are writing their theses or partaking to their graduate writing work. For the 18 students for whom they had data, the GREV and

a principle of effective writing test correlated at 0.440 while the GREV correlated with short writing paper at 0.588. The strong correlation indices implied that GREV was a valid predictor of writing performance of graduate students.

It is evident from the studies that the predictive abilities of GRE have been varied and inconsistent. Notably, the results show low predictive indices or abilities.

Performance and Success of Students in Graduate School

It is a general assumption that students who excel in their daily class activities or complete their semester academic tasks in high standing compared to the rest tend to have higher performance and success in their education upon graduation. They earn excellent grades in all courses and accomplish all requirements. Their performance can constitute the three facets of knowledge: declarative knowledge, procedural knowledge, and motivation (Kuncel et al., 2001).

Kuncel et al. (2001) defines declarative knowledge as realizing what to do when faced with a problem to find a solution while procedural knowledge refers to being able to accomplish a task. Motivation is the drive to complete a job. The three components of GRE measure the abilities and skills of students that affect their academic performances via declarative and procedural knowledge. For example, the ability to understand linear mathematical problem in quantitative GRE shows existence of procedural knowledge that is relevant to graduate school performance (Reisig & Dejong, 2005). However, the GRE does not capture variations in motivation levels (Reisig & Dejong, 2005; Kuncel et al., 2001). Nonetheless, the assumption is that the GRE test items mirror long-term learning of materials that should culminate in graduate educational success in the end.

GRE and International Students

No matter how well a test is written, it has been shown that no test can assess all characteristics of human intelligence and this makes GRE not valid and reliable (Mupinga & Mupinga, 2005; Larsen & Buss, 2004). Considering international students and their GRE testing, the context and content of the test has shown some elements of biasness. Thus, researchers on this subject matter recommend not using GRE scores as the main predictor of graduate performance and success when admitting international students; instead, use other factors such as special or unique individual talents, work experiences, letters of recommendations, interviews and other important student accomplishments (Mupinga & Mupinga, 2005).

Specifically, the bias in GRE testing is that it tests speed and socio-cultural background of the test maker. Thus, the test maker does not recognize the thinking process of those whose first language and culture is not English (Walpole et al., 2002). For example, consider this GRE verbal analogy question: *Batter is to baseball as…..is to football*. It implies that someone not from the American socio-cultural setting will not capture this analogy question and subsequently fail it. This is just one area that depicts culture oriented testing of GRE where international students may experience inadequacies in testing. In this case, football as a game in the American cultural system has a different meaning to the rest of the world who believe football and soccer games are synonymous.

It is important to recognize that international students score relatively higher in GREQ than GREV (Walpole et al., 2002). However, there are some concerns about this stereotyping because the verbal score of international students might not be a good reflection of the actual ability of a student. For example, English language of a student might be better than the GRE verbal score when assessed in a face-to-face conversation. In addition, there are other concerns about test security and evidence of cheating in tests or some students memorizing GRE vocabulary or facts that in some cases may culminate in high scores but in reality the student can hardly communicate or write well in English (Walpole et al., 2002). These scenarios call for interview of applicants to verify the validity of the scores and thus contributing to the ultimate success in graduate school education especially in CM programs where effective communication is vital to graduate student development.

Overall, the review of literature has shown that the CM discipline is still deficient in research depicting the use of GRE scores as a predictor of overall performance and success of graduate students. This gap motivated conducting a predictive research in the CM discipline.

Research Methodology

The data were from the CM graduate education programs from three different universities. Descriptive statistics comprising of mean, mode, median, standard deviation and box plot distribution showed how the GRE and GPA scores were distributed and varied for the two nationalities and for all the students. Correlation and regression analyses determined the nature and strength of the relationship or prediction between the GRE and GPA scores

Aim, Objectives and Hypothesis of the Study

The aim of the study was to investigate the predictive ability of GRE scores on graduate educational performance and success (GPA scores) for domestic and international students in CM graduate programs. Three objectives were in focus: the first objective was to determine the correlation between entrance GRE and cumulative GPA scores at graduation for domestic and international students. The second one was to determine the best predictor of graduation GPA (GGPA) among GREV, GREQ, and GRETOTAL (GREQ + GREV) for domestic and international students. The third evaluated the difference in performance in GRE and GPA between domestics and international students.

The hypothesis was that CM students who scored higher in admission GRE would also score higher GPAs at the end of graduate school education. In addition, it was hypothesized that good performance in the GRE (quantified by GRE scores) and graduate school (quantified by GPA scores) did not depend on nationality of the students.

Sample Size and Demographics

The sample size consisted of 351 students (N = 351). The GRE and GPA scores of students were sourced from construction management graduate schools in the USA, namely, University of Florida-Gainesville in Florida, Texas A&M-College Station in Texas, and Colorado State University-Fort Collins in Colorado. These universities had a long tradition of excellence in CM education.

After data screening, the data comprised of both domestic (N = 250) and international (N = 101). Texas A&M University did not have student data from spring 2009 to summer 2011. Colorado State University had some students with GPA scores but no GRE scores. Therefore, only those students with both scores were included in this study. The students who might have fallen out of the academic programs were not included in the study because they did not graduate and so did not have their graduation GPA scores, the predicted variable in this study. The assumption is that they fell out because they were unable to cope up with the demands of graduate education. The reasons could be personal such as family matters or lack of finance. Nonetheless, a year of student data implied data availability for students graduating in the spring, summer and fall semesters of that particular academic year.

These students had graduated from the three academic programs from spring 2009 semester to summer 2014 semester, over a five-year interval. The sample comprised of both domestic and international students admitted into the program and had completed successfully. They were from diverse backgrounds considering their socio-cultural, economic, and political status. During their masters program, they had the thesis and non-thesis routes towards graduation. They were to graduate only after completing the full graduate school requirements. English was the mode of instruction for all students. All the students had taken GRE prior to their admission to evaluate their performance in graduate school education. Both Texas A&M and University of Florida used GRE as part of the admission requirements for both domestic and international students while Colorado State University used GRE for admitting only international students. As a result, the data for domestic students at Colorado State University who were not required to take GRE for admission were not included in this research. Masters level students in CM programs in the USA were the population of interest in this study.

Data Description and Research Variables

The data comprised of GRE and GPA scores of graduate students. Since the new GRE came into use after August 1, 2011, it was important to translate the GRE data into the new GRE format using the conversion table provided by ETS. This new GRE score scale ranges from 130-170 for GREV and GREQ sections respectively. For this data, total GRE scores ranged from 280 to 332. The highest GPA was 4 with a few cases below 3.0. The requirements of the universities were that students needed to score about 300 or above in the GRE in order to secure admission. They were also encouraged to maintain a 3.00 GPA in order to graduate in good standing.

The independent variables were GRE verbal (GREV) score, GRE quantitative (GREQ) score, and total GRE score (GRETOTAL). The dependent variable was graduation GPA (GGPA). Nationality (domestic or international) of the students and graduation semester were the class variables.

Results

The analysis of the data utilized SAS v9.3. The next section shows the descriptive and inferential statistical results.

Descriptive Statistics

Mean, median, standard deviation, and minimum and maximum values for the respective variables were calculated for all students and for domestic and international students separately. The results are presented in Tables 1 and 2.

Table 1. Descriptive statistics of GRE and GPA scores

Variable	N	Mean	Median	Mode	Std	Min	Max	Distribution plot
GREV	351	150.46	151	149	6.13	133	168	Normal distributions
GREQ	351	152.88	152	151	6.08	138	166	Normal distribution with one high extreme score.
GRE TOTAL	351	303.34	302	297	9.38	280	332	Normal distribution with five extreme scores.
GGPA	351	3.58	3.61	4.00	0.27	2.74	4.00	Negatively skewed distribution with one extreme low outlier

In Table 1, the GREV, GREQ and total GRE scores for all the student were normally distributed while GPA scores was negatively skewed implying that most scores tended to clump up on the upper side of the score measuring scale.

Table 2. Descriptive statistics by Nationality

Variable	GREV		GREQ		GRE TOTAL		GGPA	
	USA	International	USA	International	USA	International	USA	International
N	250	101	250	101	250	101	250	101
Mean	151.15	148.76	151.15	157.17	302.3	305.93	3.57	3.60
Median	151	148	151	158	301	305	3.61	3.63
Mode	149	143	151	166	297	295	4	3.81
Std	5.10	7.93	5.06	6.29	8.09	11.67	0.29	0.24
Min	139	133	138	144	280	282	2.74	4.00
Max	166	168	166	166	330	332	4.00	2.94
Distribution of scores	Normal	Normal	Normal	Negatively skewed	Positively Skewed	Normal	Negatively Skewed	Negatively skewed

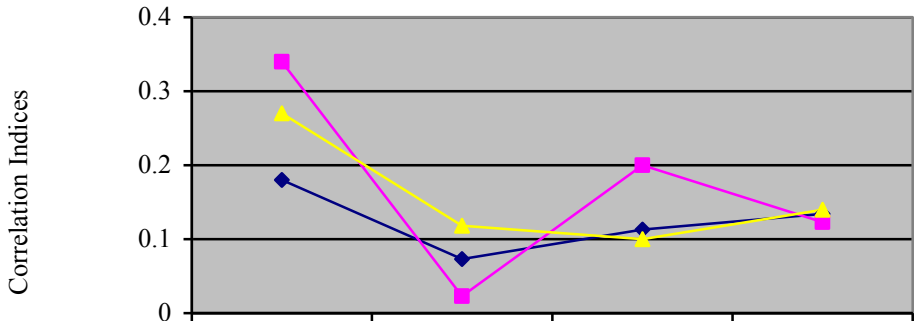
Table 2 shows the descriptive results of the analysis conducted to evaluate the differences in performance in GRE as well as in graduate school as measured by cumulative graduation GPA scores. Pooled *t*-test statistics further investigated and tested the mean differences in scores between domestic and international students. The pooled *t*-test assumed equality of variance and the results were as follows:

- GREV: [t (349) = -3.39, p = .0009].
- GREQ: [t (349) = 9.39, p < .0001].
- GRETOTAL: [t (349) = 3.33, p = .0010].
- GGPA: [t (349) = .86, p = .3929].

It is evident from the statistical significant *t*-test results that the performance in GRE depends on whether a student is a domestic student or an international student. However, GGPA is not statistically significant implying that the performance does not depend on the nationalities of the students.

Correlation between the Score Variables

Correlation analysis investigated the strength of relationship among GREV and GREQ, GRETOTAL and GGPA for all the students as well as domestic and international students separately. Using the modified Pearson Correlations Coefficients guide (+/- 0.7 and higher = very strong positive/negative relationship, +/- 0.4 to 0.69 = strong positive/negative relationship, +/-0.3 to 0.39 = moderate positive/negative relationship, +/-0.2 to 0.29 = weak positive/negative relationship, +/-0.1 to 0.19 = very weak relationship and +/-0.01 to 0.09 = negligible relationship), the correlations ranged from moderate positive relationships to negligible relationships.



	GREV vs GREQ	GREV vs GGPA	GREQ vs GGPA	GRETOTAL vs GGPA
All students (N=351)	0.18	0.073	0.113	0.134
All domestics (N=250)	0.34	0.023	0.2	0.123
All Internationals (N=101)	0.27	0.118	0.1	0.14

Figure 1. Correlation coefficients of GRE verbal (GREV), GRE quantitative (GREQ), GRE Total (GRETOTAL), and graduate GPA (GGPA) for all students and separated by nationality.

Figure 1 shows a graphical plot of correlation coefficients. From the plot, GREQ recorded a relatively higher correlation index on average for all domestic students than all the students and international students separately.

Linear Regression of the Score Variables

Regression analysis evaluated the predictive abilities of GRE on GPA scores. The results are presented in Table 3.

Table 3. Regression analysis of score variables (N=351)

	RMSE	R^2	Standardized Coefficients
GPA vs GREV	0.274	0.0053	0.073
GPA vs GREQ	0.273	0.0176	0.133
GPA vs GRETOTAL	0.272	0.0178	0.133
GPA vs GREV & GREQ	0.272	0.0201	0.050, 0.124

In Table 3, R^2 estimated the amount of variance in GPA accounted for by the independent variables. The root mean square error (RMSE) indicated the magnitude by which the prediction of GPA tended to be off. Typically, higher R^2 and low RMSE values would be preferred. The prediction equations were as follows:

- GGPA = 3.094 + 0.0033 (GREV).
- GGPA = 2.67 + 0.006 (GREQ).
- GGPA = 2.4 + 0.0039 (GRETOTAL).

The regression equation between GGPA and GREQ shows a relatively steeper slope compared to GREV and GRETOTAL implying a relatively better positive linear relationship between GGPA and GREQ. Thus, a student who scored higher in the GREQ at the time of admission was likely to perform better in the CM graduate school.

Multiple linear regression analysis predicted GPA scores from GREV and GREQ scores. There was an improvement in R^2 value. This implied more variance in GPA when both GREV and GREQ were in the model. Therefore, the predictive ability could improve when both variables were in the decision process. The prediction equation was:

- GGPA = 2.39 + 0.0023 (GREV) + 0.0056 (GREQ).

In order to get the contribution of each predictor variable to the prediction of GPA, standardized regression coefficients were calculated. Values of 0.050 and 0.124 were obtained for GREV and GREQ respectively. Examining the raw regression coefficients and standardized coefficients suggested that GREV added very little to the prediction of graduate GPA. That is, prediction would be almost accurate without GREV.

Therefore, the analysis results show that GREQ may be a better predictor of GPA at graduation in construction management graduate educational programs compared to GREV. Verbal portion of GRE and total GRE do not show significant contribution to the prediction of graduate students performance and excellence.

Discussion and Conclusion

The review of literature has shown inconsistencies in the ability of GRE to predict performance of students in graduate school. In spite of the controversies and inconsistencies arising from the use of GRE, some graduate educational programs still use some predetermined minimum GRE score as part of their admission requirements because they believe that GRE scores have the ability to predict graduate educational performance and success of students. This research focused on investigating the predictive ability of GRE on GPA of domestic and international students in CM programs in the USA. The research reported different descriptive and inferential statistical results.

The results showed an appreciably high level of performance in GRE depicted by the normal distributions of scores. Performance in graduate school was excellent as shown by the negative skewed distribution of the GPA scores. The negatively skewed distribution of scores implied a relatively higher value of scores achieved. The statistically significant results in the performance in GRE between the domestic and international students implied that international students tended to perform better on average in GRE than domestic students. Even though international students performed better on average in GPA than domestic students, their performances were not statistically significant. One of the reasons for no significant difference in graduate performance or GPA scores could be because the students received graduate instructions from almost similar curriculum and so the expectations and levels of success were similar across the schools. Based on the statistical results, we can confidently fail to reject the hypothesis that performance and success in graduate school does not depend on the nationality of a student. This outcome could provide useful information to admission committees in CM graduate educational programs where they may consider encouraging and admitting more students who are internationals into their programs.

The correlation coefficients between the GREV, GREQ, GRETOTAL, and GGPA were very weak and lower than past studies. From the analysis, correlation coefficients of 0.073 for GRE verbal, 0.113 for GRE quantitative, and 0.134 for total GRE were recorded for relationship between them and GGPA. These values were very weak predictors of performance and success. Therefore, the correlation and regression analyses outcomes weakly supported the hypothesis of higher GRE score tending to be associated with higher GPAs. Given the low predictive ability and the correlation analysis of the predictor variables, GREQ score becomes a better predictor among the variables investigated in this research. Thus, admissions may emphasize GREQ more in this quest for higher GPAs in CM graduate programs because its predictive ability tend to be better than the other predictors of GPA score.

In the multiple regression model and analysis where both GREV and GREQ were in the same prediction model, the predictability of GPA improved with an increase in the variance explained in GPA by both GREV and GREQ. The regression model showed that GREQ had a steeper slope than GREV implying better ability to predict GPA. The standardized regression coefficients showed that GREQ was a better predictor of GPA than GREV (i.e., 0.050 and

0.124 for GREV and GREQ respectively). However, this was not consistent with past studies such as criminal justice discipline which had an opposite prediction indices where GREV was best predictor of GPA than GREQ (standard regression coefficients of 0.336 and 0.245 for GREV and GREQ respectively). The steeper slope in the model would make it logical for CM programs to emphasize the GREQ score as an admission requirement.

In conclusion, this research show that international students tend to perform better than domestic students in the CM graduate educational programs by combining their verbal and quantitative skills even though domestic students perform better in GREV. The correlations between GRE and GPA are relatively weak and show low predictive ability of graduate educational success across all students and between domestic and international students. In spite of the low correlations and predictive abilities, GRE quantitative section was a better predictor of performance and success. This outcome may result from GREQ having better correlation with performance in some portions of CM curricular that are quantitative in nature. Overall, GRE is a weak predictor of success in CM graduate school and so graduate school admission committees may consider re-evaluating their requirements or use of GRE scores to predict graduate educational performance and success. This research contributes to the predictive research conducted about the performance and success of students in the CM programs in the USA. Its outcomes can provide useful information to aid committees in admitting domestic and international students into CM programs.

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