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Relationship between Admission GRE Scores and Graduation GPA Scores of Construction Management Graduate Students

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ABSTRACT

Graduate admission committees in some construction management graduate educational programs in the United States may sometimes require students to take and submit their GRE scores as part of the admission requirements. This is because they tend to believe that the GRE scores could predict the academic performance and success of students in graduate school. This study assessed the predictive ability of admission GRE scores on cumulative GPA scores at graduation of construction management graduate students. The hypothesis was that students who scored high in GRE at the time of admission would attain higher cumulative GPAs at graduation. The independent variables were GRE verbal score, GRE quantitative score, and total GRE score while the dependent variable was the GPA score. SPSS v21 and SAS v9.3 statistical analysis tools facilitated the analysis of the data sourced from three construction management graduate programs in the United States. The results showed weak predictive indices where GRE quantitative score was the better predictor of graduation GPA. Thus, the hypothesis of higher GPAs being associated with higher GRE scores was weakly supported. It was recommended that construction management graduate programs should re-evaluate requiring GRE scores as part of their admission criteria.

KEYWORDS

GRE; GPA; construction management; graduate students performance and success

Introduction

Graduate school admission committees in the universities in the United States face difficulties each year in discovering, selecting, admitting and/or funding the education of exceptionally good graduate students. The committees usually screen for applicants who they believe will excel in their graduate educational pursuit if given the chance. In order to make the best admission and placement decisions, committees consider multiple sources of information about the students. When executed correctly, the committees select students who best fit their programs (Holt, Bleckmann, & Zitzmann, 2006; Reisig & Dejong, 2005). The multiple sources of information involve subjective student information that include personal statements of purpose, letters of recommendations, and personal interviews with the graduate school committee or specific departmental personnel. In addition, it involves objective student information such as prior Grade Point Average (GPA) and Graduate Record Examination (GRE) scores (Reisig & Dejong, 2005). These
pieces of information are important in selecting good and capable students for admission into construction management (CM) academic graduate program.

A considerable number of graduate programs have been using GRE scores as part of their requirements for admitting students into graduate school. A study conducted by Holt and colleagues (2006) found out that about 81% of masters programs require GRE scores in which cutoff score is 1000 when both GRE verbal and quantitative scores are aggregated under the old GRE system. With the advent of the new GRE system beginning August 1, 2011, this score translates to about 300 under the new GRE scoring scale and the scores are valid for 5 years from the testing date.

A critical look at the admission criteria of seven major CM graduate school programs in the United States show that they require students to take the GRE and achieve results that meet or exceed the minimum admission score requirement. One of the main reasons for the GRE score requirement is that the admission committees tend to believe that the scores could predict performance and success of students in graduate school (Orlando, 2005). However, no predictive index exists that can aid in forecasting the overall performance and success of students in CM graduate programs.

Different CM graduate educational programs require different levels of GRE scores for admission of students, with doctoral level requiring higher scores than masters’ level education. The purpose of GRE is to measure general readiness of students to pursue graduate education. It tests an array of general knowledge and skills acquired from undergraduate education that are to be demonstrated or applied in graduate school. The performance and success of students in graduate school has been investigated or predicted using the past GRE scores of students, with higher cumulative GPAs expected at the end of graduate education. The outcomes of such investigations have influenced strategic decisions in graduate school programs.

Suhayda and colleagues (2008) conducted a predictive study that concluded that GRE is not a reliable predictor of graduate school educational performance and success. Such research outcomes have led some Ivy League schools to stop requiring GRE as part of their admission criteria. One reason posed for not integrating GRE in the admission process is that it does not mirror, capture or predict the required level of performance of graduate students. Thus, some academic programs have resorted to using their own customized graduate academic admission examinations or criteria that reflect their graduate program requirements while others use the GRE scores to award assistantships or fellowships to financially disadvantaged graduate students in addition to general admissions (Mupinga & Mupinga, 2005). Example of U.S. universities with CM graduate programs that require GRE scores as part of their admission criteria are Purdue University, Colorado State University, Texas A&M University, Virginia Institute of Technology, Auburn University, Clemson University, and the University of Florida. Universities such as Florida International University, University of Texas-Arlington, Louisiana State University, and Polytechnic Institute of NYU-Brooklyn have CM graduate programs that have made GRE scores optional and may waive it based on prior construction industry and/or research experience, strong academic records (grades), stellar letters of recommendation, and construction related undergraduate degree. Arizona State University and Eastern Michigan University have CM programs that do not require GRE scores for their graduate admissions.
With the uncertainty in the predictability of GPA, there is need to investigate the predictive power of GRE scores on the performance of graduate students in order to determine its level of reliability and validity in the CM programs. Therefore, this research investigated the GRE scores as a predictor of cumulative GPA scores of students from three CM graduate school programs in the United States. Specifically, the performance and success of students was measured by the cumulative graduation GPA at the end of graduate education. The GRE score was the predictor variable while the GPA was the predicted variable. The research also focused on determining the magnitude (strength) and nature of the relationship between the GRE and GPA scores obtained.

The research outcome would aid the CM graduate admission committees or education policy/decision makers in using GRE scores to admit students. The outcome may also elicit the decision makers to re-evaluate their use of GRE depending on its ability to predict performance and success since some believe that higher GPAs may be associated with higher GRE scores.

**Literature review**

A review was conducted on the past studies that had investigated the ability of GRE scores to predict performance and success of graduate students. Specifically, the review assessed the studies conducted in different academic disciplines about the association between the GRE scores and the GPA scores of students. The review would provide information that could be compared with the outcome of the current research focusing on the CM program.

**Reliability of GRE in predicting graduate education performance**

The GRE can be general test or subject test. Originally, the test was in the form of paper and pencil format and assessed the fundamental abilities germane to performance in graduate school (Briel, O’Neill, & Scheuneman, 1993). The objective has changed over the times to an extent that the GRE score can now be used to predict graduate school educational performance and success and is administered through computer adaptive test as opposed to paper-pencil in the past.

Mupinga and Mupinga (2005) defined the GRE general test as an aptitude test that reflects the intelligence or ability of students to learn in graduate schools in the USA. It has three sections that measure the quantitative (GREQ), qualitative or verbal (GREV) and analytical skills (GREA). These GRE sections require test takers to solve simple and complex problems, synthesize information, including determining relationships between and among pieces of information that may be elementary or need higher levels of thinking skills (Briel et al., 1993). For the purpose of graduate admissions, different disciplines may require different levels of these skills, while others may be interested only in a particular total GRE score.

Research shows that the predictive validity of GRE scores towards graduate school performance tends to get better when a particular test is associated with a specific discipline (Orlando, 2005). Studies have revealed that the GRE verbal score is a modest predictor of performance and success in academic disciplines that are descriptive while the GRE quantitative score is a better predictor in symbol-oriented disciplines (Orlando, 2005).
The use of GRE score to predict student graduate performance and success has been debatable for a long time (Kuncel, Campbell, & Ones, 1998). Research has investigated the reliability of GRE scores as a predictor of graduate educational performance and success (Holt et al., 2006). These studies have concluded that the test scores predict certain attributes of success in graduate school. In addition, the outcome show results spanning from little predictive validity to strong correlations between the GRE scores and graduate success (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) concluded that the latter to be problematic since it did not control for those who left the programs due to unavoidable reasons such as job commitment, family matters or other personal issues. Nonetheless, Mupinga and Mupinga (2005) upheld that the performance or measure of success of students differ across universities, colleges, disciplines or the type of academic programs the students are pursuing.

In the contrary, there is a body of research opposing the use of GRE scores in the selection and admission of graduate students (Holt et al., 2006). While there is support for using GRE in fields such as veterinary medicine (Power, 2004), there is a significant level of caution in using GRE in disciplines such as physics (Glanz, 1996). Sternberg and Williams (1997) investigated the extent to which the GRE scores predicted the performance and success of graduate students where they concluded that the GRE scores were only modest predictors of first year academic performance but not second year performance. They also found out that the GRE analytical test scores successfully predicted a more significant evaluation of student performance. However, this inference was only true for males. According to Educational Testing Service (ETS), GRE analytical section is a weak predictor of first year graduate school academic performance (Fairtest.org, 2007). Morrison and Morrison (1995) study recorded an even weaker relationship between the GRE scores and graduate school grades.

Despite the drawbacks and limitations, some CM graduate programs still emphasize requiring some minimum GRE score and may not admit graduate school applicants if the minimum GRE score is not met even when the students have good undergraduate GPAs, excellent letters of recommendation, and impressive resumes or vitas. Some admission committees might have other criteria and only use GRE for screening (Hale, 2010). Overall, the final selection decisions depend on the procedures or requirements laid out by the respective colleges or departments.

**Association between admission GRE and cumulative graduation GPA**

There are varied disagreements and inconsistencies in the nature of the relationship or the measure of association between GRE scores and graduation GPAs. Research in engineering academic programs have reported average correlations of .27 in scores between GREV and first year GPAs for engineering graduates and .22 for GREQ scores. Ayers and Quattlebaum (1992) found an opposite correlation coefficients of lower GREV \((r = .07)\) and higher GREQ \((r = .321)\) with GPA scores. Suhayda and colleagues (2008) conducted a study where they reviewed academic records of 738 masters nursing
students in order to develop a compound decision rule for selecting candidates who would be successful in the nursing practice program. The results showed that GRE does not add any predictive value on GPA of students. Such inconsistent outcomes elicited conducting meta-analysis studies to solve the problem. Kuncel and colleagues (2001) meta-analysis study found the correlation between GPA and GREV to be .23 and GREQ to be .21. They concluded that GRE is a valid predictor of graduate success. They also found that GRE subject scores tended to be better predictors than verbal, quantitative, and analytical tests.

Willcockson and colleagues (2009) conducted a study to predict student performance and program success in a graduate level biomedical program. The results showed that GRE strongly predicted program performance \((r = .63)\) defined by final cumulative GPA of students. Stack and Kelley (2002) assessment of forty-eight \((N = 48)\) graduate students in the criminal justice discipline showed that GREV was better than GREQ in predicting GGPA (Standardized regression coefficients being .336 and .245, respectively). Mckee, Mallory, and Campbell (2001) study of criminal justice students found a regression model consisting of both undergraduate GPA and combined GRE measure which explained more variance in GGPA than other combinations of predicting factors (the variance ranged from .305 to .370). This study reaffirmed the outcomes of past studies that concluded on using both the UGPA and the GRE scores in the predictive model to achieve the best prediction of GGPA. Shaurette and Rapp (2014) investigated the writing challenges experienced by CM students especially when they are writing their theses or during their graduate writing work. For the 18 Master of Science students for whom they had data at Purdue University, the GREV and a principle of effective writing test correlated at .440 while the GREV and short writing paper correlated at .588. These relatively strong correlation indices implied that GREV was a reliable and valid predictor of writing performance of CM graduate students.

The aforementioned research outcomes show some levels of inconsistencies in the predictive ability of the GRE scores on the GPAs of graduate students. Most of the results show low predictive indices or abilities. Kuncel and colleagues (2001) concluded that such low correlations observed in the GRE validity research emanate from sampling error and range restriction. The effect of range restriction especially in the analysis of admission scores with other variables is that it reduces their correlation indices and other predictive validity values (Power, 2004). In spite of the limitations and overall low predictive indices, the performance and success of students is still the main concern. As such, performance and success of graduate students in the CM programs is the focus in this research. This is to bridge the gap of limited research conducted in this area.

**Performance and success of students in graduate school**

Performance refers to action-oriented behaviors towards some set goals. In graduate academic setting, the assumption is that those who excel in their day-to-day class activities are those who tend to complete their academic programs in high standing compared to the rest of the students. They accomplish their full academic tasks, earn excellent grades, and are able to graduate at a high level of performance and success. Their performance constitutes the three facets of knowledge: declarative knowledge, procedural knowledge, and motivation (Kuncel et al., 2001).
According to Kuncel and colleagues (2001), declarative knowledge refers to 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 task. That is, the intensity of the action or persistence to act in a certain way. The three components of GRE (verbal, quantitative, and analytical sections) measure the abilities and skills of students that affect their academic performances through declarative and procedural knowledge. For example, the ability to understand simple trigonometric mathematical problem in the quantitative GRE section shows the existence of procedural knowledge that is relevant to graduate school performance (Reisig & Dejong, 2005). However, the GRE does not capture variation in motivation levels (Reisig & Dejong, 2005; Kuncel et al., 2001). Noteworthy, the assumption is that the GRE items mirror long-term learning of materials that can eventually result in graduate educational success.

Overall, the literature review show no research focusing on students outside the United States because the GRE score is rarely required for admitting graduate (or post-graduate) students in universities abroad. Although there is continued use of GRE scores to admit students into some graduate schools in the USA, limited amount of research has focused on the CM discipline regarding the use of the GRE scores to predict overall performance and success of CM graduate students. A rather relatively close study investigated the use of the GRE verbal scores to predict the writing abilities of students in a distant learning CM program at Purdue University (Shaurette & Rapp, 2014). This gap motivated conducting a predictive research in the CM discipline. The research involved a sample of students who were both international (non-U.S.) and domestic (USA) and took GRE to get admission into the CM master’s program. Their performance and success was measured by the cumulative graduation GPA. A trend in the relationship between GPA and GRE was assessed over the academic semesters to evaluate the level of predictability over time.

The results of the study contributed to an up-to-date analysis of the predictability or relationship between the GRE scores and GPAs of graduate students. The outcome would be useful in policy and/or decision-making in the CM graduate programs with regard to using GRE in admitting graduate students. Such decisions could entail whether or not CM graduate admission committees need to rely on the GRE scores to predict the performance and success of students.

**Research methods**

The data (GRE and GPA scores) to aid this investigation were sourced from CM graduate programs in the USA. Different approaches were used to analyze and present the data. Descriptive statistics comprising of mean, mode, median, standard deviation, maximum and minimum, kurtosis, skewness, and analysis of score distribution showed the nature of the distributions and variations of the GRE and GPA scores of the students. Correlation and regression analysis determined the nature and strength of the relationship and/or prediction level between the GRE scores and GPA scores. Trend analysis assessed the existence of upward mobility or downward trend in the correlation indices over the academic semesters. Specifically, the trend analysis aimed at determining whether the trend was increasing, decreasing or stable over time. An increase in the trend would imply an increase in the predictability over time while a decrease would imply inability of the
GRE scores to predict performance and success. A stable trend would imply comfortability with using the GRE scores to admit CM graduate students.

**Aim, objectives, and hypothesis of the study**

The aim of the study was to investigate the predictive ability of the GRE scores on the performance and success of students in the CM graduate programs. The two objectives were to determine the correlation between the GRE and cumulative GPA scores at graduation, and to determine the best predictor of GPA among GREV, GREQ, and GRETOTAL (GREQ + GREV). The hypothesis was that students who scored higher in GRE would also score higher GPAs.

**Sample size, data-screening, and demographics**

Originally, the sample size consisted of a convenient sample of 330 students. The advantage of this sampling is speed, cost effectiveness, and avoidance of systematic errors or bias. However, some bias can arise in focusing more on one data source. Thus, more sources are encouraged. Data screening detected an anomaly where one student had Graduate Management Admission Test (GMAT) score instead of the GRE score. The GMAT score was treated as an error in data entry and was subsequently deleted. Thus, a sample of 329 students (N = 329) was used in the analysis. Masters level students in the CM programs in the United States comprised the population of interest.

The GRE and GPA scores of students were sourced from three CM graduate programs in three different universities in the United States, namely, University of Florida-Gainesville in Florida, Texas A&M-College Station in Texas, and Colorado State University-Fort Collins in Colorado. These universities were chosen for this research because it was believed that their data would provide a good representation of the CM graduate programs in the USA. In addition, they had a long tradition of excellence in CM education. The National Center for Education Statistics (NCES) College Navigator year 2014 explains this academic excellence through a report comprising of students’ information shared annually in a free online format. The students’ information for the three schools included retention and graduation rates. Thus, a school with high retention rate would tend to appeal more to students, have high graduation rate, and perform well overall. Table 1 shows the summary. In Table 1, the University of Florida reported the highest values for all the categories assessed. Except for the average total number of graduate enrollment students who applied to the whole school, the other average values applied to the CM program. Overall, the three universities had average graduate enrollments with a relatively manageable number of students to faculty ratio (20 to 1). Their CM programs tended to have an appreciable number of awards (N = 21), which was supported by relatively high retention and graduation rates.

After data screening, the study data comprised 329 students (males = 231 and females = 98). 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. Only those students with both scores were included in the analysis. Students who might have dropped out of the program were not included because they did not have their final GGPAs. The assumption was that they discontinued due to inability to keep up with the
demands of CM graduate school. Possible reasons could be family commitment or lack of funds. A year of student data implied data availability for students in the spring, summer, and fall semesters of that particular year. Table 2 summarizes the data where the University of Florida registered more students' data than the other two schools. This is because of its higher enrollment, retention, and graduation rates.

These students had graduated successfully from the three CM programs from spring 2009 semester to spring 2014 semester, a 5-year interval. They were domestic and international students from diverse backgrounds considering their socio-cultural, economic, and political status. Further, some had English as the first language while others had English as second or third language. As part of the admission requirements into CM programs, the admission committees needed some minimum GRE scores, undergraduate GPAs of 3.0 and above, previous construction work experience among other evaluation criteria. During the masters CM programs, the students took courses and had the thesis and non-thesis routes towards graduation. The non-thesis option required them to take additional coursework to replace the thesis research credits. Colorado State University required students to submit a professional paper as part of the non-thesis option. The thesis option was a comprehensive research-writing requirement where each student was assigned to one or two faculty subject experts. The faculty members were to guide or mentor the students through the research process to completion. Usually, the writing and overall graduate school process is rigorous and requires students to have good quantitative, writing, comprehension, and analytical skills that are characteristic of graduate education. The students would graduate only after completing the full CM graduate program requirements. English was the mode of instruction for everyone. All students had GRE prior to their admission to evaluate their performance and success in graduate school. Both Texas A&M and University of Florida used GRE as part of the admission requirements for both domestic and international students for the entire data period while Colorado State University used GRE only for international students until the year 2011, after which it was required for

Table 1. Total graduate students and construction management masters students.

<table>
<thead>
<tr>
<th>Schools evaluated</th>
<th>Total no. of graduate enrollment (Fall 2014)</th>
<th>Student to faculty ratio</th>
<th>Construction majors (Average number of awards in 2013-14)</th>
<th>Retention rate</th>
<th>Graduation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado State University-Fort Collins</td>
<td>7,638</td>
<td>16:1</td>
<td>8</td>
<td>86%</td>
<td>64%</td>
</tr>
<tr>
<td>Texas A&amp;M College Station</td>
<td>11,625</td>
<td>23:1</td>
<td>24</td>
<td>91%</td>
<td>79%</td>
</tr>
<tr>
<td>University of Florida</td>
<td>16,710</td>
<td>21:1</td>
<td>31</td>
<td>96%</td>
<td>87%</td>
</tr>
<tr>
<td>Averages</td>
<td>11,996</td>
<td>20:1</td>
<td>21</td>
<td>91%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Note: Data screened from the National Center for Education Statistics website (http://nces.ed.gov/collegenavigator/).

Table 2. Total number of students who graduated from the three construction schools.

<table>
<thead>
<tr>
<th>Year of graduation</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Subtotal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado State University</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Texas A&amp;M College Station</td>
<td>−−</td>
<td>1</td>
<td>14</td>
<td>18</td>
<td>9</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>University of Florida</td>
<td>67</td>
<td>63</td>
<td>58</td>
<td>30</td>
<td>35</td>
<td>17</td>
<td>270</td>
<td>270</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>69</td>
<td>62</td>
<td>46</td>
<td>54</td>
<td>28</td>
<td>329</td>
<td>329</td>
</tr>
</tbody>
</table>

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admitting all the students. As a result, the data for domestic students from Colorado State University who were not required to take GRE for admission into their CM graduate school were not included in this research.

**Data description**

The data comprised of GRE and GPA scores of graduate students. Since the new GRE came into use after August 1, 2011, it was worthwhile to translate the GRE data into the new GRE format using the conversion table provide by ETS. This new GRE score scale is from 130 to 170 for GREV and GREQ parts, 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 three universities required students 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 academic standing. However, there were some exceptions where students scored below 300 in GRE and had graduation GPA below 3.00.

**Research variables**

The independent variables were GRE verbal (GREV) score, GRE quantitative (GREQ) score, and total GRE score (GRETOTAL). The dependent variable was graduation GPA (GGPA). Graduation semester was the class variable. These three GRE variables were in focus in this research for a number of reasons. The main reason was that higher GRE scores was encouraged by general admissions as important in securing admission and can predict performance and success in the CM programs. However, GRE analytical (GREA) was not the focus in this research because the admission committees tended not to emphasize it in their admission criteria as compared to the other GRE parts where they emphasized some minimum score requirements.

**Results**

The analysis of the data utilized SAS v9.3 and SPSS Statistics v21. These statistical data analysis tools were used at different stages of the data analysis process. Trend analysis used SPSS while the rest of the analyses used SAS. Descriptive and inferential statistical results were presented.

**Descriptive statistics**

Mean, median, standard deviation, kurtosis, skewness, and minimum and maximum values for the respective variables were calculated. Table 3 shows the descriptive statistical analysis results.

In Table 3, average scores of 150, 153, 303, and 3.58 and maximum score of 168, 166, 332, and 4 were recorded for GREV, GREQ, total GRE, and GPA, respectively. The GREV, GREQ, and total GRE scores showed a relatively normal distribution of scores while GPA scores was negatively skewed implying that students tended to perform well in graduate school with most scores clumping up on the upper side of the test score measuring scale. Analysis of score distributions showed outliers or extreme values for the total GRE, GREQ, and GGPA scores.
Correlation between the score variables

Examining the scatter plots of the score variables showed some strong and weak correlation coefficients. The independent or predictor variables being the respective GRE scores while GPA as the dependent or predicted variable. Correlation analysis investigated the strength of the relationship between the GRE sections (GREV and GREQ), the total GRE score (GRETOTAL) combining the GREV and GREQ scores, and the graduation GPAs (GGPA). The correlation results were from spring 2009 to spring 2014 semesters. Figures 1 and 2 show the results.

Figure 1 shows the correlation indices of the score variables over the semesters in a table format and the trends in a graphical plot. This figure is robust as it shows useful information in a single display. The correlations between GREV and GREQ ranged from -0.274 to 0.839 over the semesters. GREV and GPA correlations ranged from -0.342 to 0.391 while GREQ and GPA ranged from -0.517 to 0.49. Total GRE and GPA indices ranged from -0.31 to 0.39. Using Pearson Correlation Coefficients guide (+/- .7 and higher = very strong positive/negative relationship, +/- .4 to .69 = strong positive/negative relationship, +/- .3 to .39 = moderate positive/negative relationship, +/- .2 to .29 = weak positive/negative relationship, +/- .1 to .19 = very weak relationship and +/- .01 to .09 = negligible relationship), the correlation coefficients ranged from strong negative relationships to very strong positive relationships.

Table 3. Descriptive statistics of GRE and GPA scores of students.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Std</th>
<th>Skew</th>
<th>Kurt</th>
<th>Min</th>
<th>Max</th>
<th>Analysis of score distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREV</td>
<td>329</td>
<td>150</td>
<td>151</td>
<td>149</td>
<td>6.27</td>
<td>-0.06</td>
<td>0.07</td>
<td>132</td>
<td>168</td>
<td>Relatively normal distribution of scores</td>
</tr>
<tr>
<td>GREQ</td>
<td>329</td>
<td>153</td>
<td>152</td>
<td>151</td>
<td>5.92</td>
<td>0.50</td>
<td>-0.14</td>
<td>138</td>
<td>166</td>
<td>Relatively normal distribution with one extreme high score</td>
</tr>
<tr>
<td>GRE TOTAL</td>
<td>329</td>
<td>303</td>
<td>301</td>
<td>297</td>
<td>9.44</td>
<td>0.66</td>
<td>0.43</td>
<td>280</td>
<td>332</td>
<td>Relatively normal score distribution with seven high and one extreme low scores</td>
</tr>
<tr>
<td>GGPA</td>
<td>329</td>
<td>3.58</td>
<td>3.61</td>
<td>4.00</td>
<td>0.28</td>
<td>-0.57</td>
<td>-0.35</td>
<td>2.74</td>
<td>4.00</td>
<td>Negatively skewed distribution with one extreme low score</td>
</tr>
</tbody>
</table>

Correlation between the score variables

Examining the scatter plots of the score variables showed some strong and weak correlation coefficients. The independent or predictor variables being the respective GRE scores while GPA as the dependent or predicted variable. Correlation analysis investigated the strength of the relationship between the GRE sections (GREV and GREQ), the total GRE score (GRETOTAL) combining the GREV and GREQ scores, and the graduation GPAs (GGPA). The correlation results were from spring 2009 to spring 2014 semesters. Figures 1 and 2 show the results.

Figure 1 shows the correlation indices of the score variables over the semesters in a table format and the trends in a graphical plot. This figure is robust as it shows useful information in a single display. The correlations between GREV and GREQ ranged from -0.274 to 0.839 over the semesters. GREV and GPA correlations ranged from -0.342 to 0.391 while GREQ and GPA ranged from -0.517 to 0.49. Total GRE and GPA indices ranged from -0.31 to 0.39. Using Pearson Correlation Coefficients guide (+/- .7 and higher = very strong positive/negative relationship, +/- .4 to .69 = strong positive/negative relationship, +/- .3 to .39 = moderate positive/negative relationship, +/- .2 to .29 = weak positive/negative relationship, +/- .1 to .19 = very weak relationship and +/- .01 to .09 = negligible relationship), the correlation coefficients ranged from strong negative relationships to very strong positive relationships.

Figure 1. Trend lines of correlation coefficients of GRE verbal (GREV), GRE quantitative (GREQ), total GRE (GRETOTAL), and graduation GPA (GGPA) scores of students by semester over the study period.
The graphical plot of correlation indices in Figure 1 show no clear stability or improvement in the relationships after analyzing the trend lines over the semesters. They show staggered trends over the given timeline. Only nine correlation coefficients \( r \) were relatively strong at \( r > +/- .4 \). These are GREV-GREQ correlation indices for spring 2011, spring 2012, fall 2012, spring 2013, summer 2013, and spring 2014, and GREQ-GGPA correlations for fall 2012, spring 2013, and summer 2013. However, the statistically significant very strong correlation index \( p < .0001 \) of the fall 2012 semester need to be interpreted with caution as the index was calculated from a relatively smaller number of students who graduated that semester \( (N < 10) \). The results from this small sample size could be misleading when generalized to the population of CM students. The other indices ranging from moderate to strong correlations would provide more reliable source of information about the population of CM graduate students in the USA.

When the correlations of the different variables were analyzed for the entire data period without regard to each semester as shown in Figure 2, a total shift in the measures of the relationships were recorded where none of the correlation indices investigated were statistically significant. The results implied that weak positive and negative correlations existed between the respective GRE sections and the GPA scores. It is important to interpret these results with caution since some of them showed negligible or no index of relationship. Inasmuch as the relationships were extremely weak, GREQ recorded a relatively better correlation coefficient on average with GPA compared to GREV and total GRE. The higher peak value of correlation in Figure 2 support this deduction.

**Linear regression of score variables**

Regression analysis evaluated the predictive abilities of the GRE scores on the GGPA scores. The analysis involved the different GRE score sub-parts (GREV, GREQ, and GRETOTAL) and the GGPA scores of students in the three CM programs. Table 4 shows the results.

In predicting the GGPA using the independent variables, \( R^2 \) estimated the amount of variance in the GGPA accounted for by the independent variables. The Root Mean Square Error (RMSE) indicated the magnitude by which the prediction of GGPA tended to be off. Usually, higher \( R^2 \) and low RMSE outcome values would be preferred.
In predicting the GGPA, GREV, and GREQ were used individually and when added together (GRETOTAL) in the regression model. The GREQ recorded a higher $R^2$ value (.0131) than GREV and GRETOTAL suggesting that about 1.31% of the variance in the GGPA was accounted for by the GREQ. The RMSE of .2757 implied that the prediction of GGPA tended to be off by .2757, the lowest compared to the other predictors. The prediction equations were:

$$GGPA = 3.169 + .0027 \text{GREV}$$

$$GGPA = 2.76 + .00535 \text{GREQ}$$

$$GGPA = 2.576 + .0033 \text{GRETOTAL}$$

The equation between GGPA and GREQ shows a steeper slope (.00535) compared to GREV and GRETOTAL. This implies a better positive linear relationship between graduation GPA and GREQ. Therefore, a student who scored relatively higher in the GREQ at the time of admission was more likely to perform better by attaining higher GGPA in the CM graduate school program.

Multiple linear regression analysis predicted the GGPAs from the GREV and GREQ scores. The result showed an improvement in the $R^2$ values implying more variance in the GGPA when both GREV and GREQ were included in the regression model. Thus, the predictive ability could improve when both GREQ and GREV were included in the decision process. The RMSE was .276 with the $R^2$ value of .0146 implying that about 1.46% of the variance in the graduation GPA was accounted for by both GREV and GREQ. The prediction equation was:

$$GGPA = 2.549 + .00178 \text{GREV} + .00498 \text{GREQ}$$

Considering students with the same GREQ scores in the regression model, those with 1 point higher in GREV would attain .00178 points higher in GGPA. Consider GREQ, those students who attain 1 point higher in GREQ would score a GGPA that is 0.00498 points higher. The regression coefficient for GREQ was statistically significant at $p = .05$, [$t (326) = 1.90, p = .0488$] but GREV was not significant [$t (326) = 0.72, p = .4737$]. The interpretation is to reject the null hypothesis if $p < .05$ showing significant difference in the tested statistical statement or fail to reject the null hypothesis if $p > .05$ implying no sufficient evidence to reject the null hypothesis. Therefore, there is need for caution when using the verbal section of GRE to predict the graduation GPAs because of its non-significant outcome from the analysis.

In order to get the contribution of each predictor variable to the prediction of GPA, standardized regression coefficients were calculated. Values of .0402 and .1064 were
obtained for GREV and GREQ, respectively. This meant that a 1 standard deviation change in GREQ resulted in .1064 standard deviation change in the predicted GPA, holding the GREV variable constant.

Critical examination of the raw regression coefficients and standardized coefficients suggested that GREV added very little to the prediction of GPA. That is, the prediction of performance and success would be almost accurate without GREV being included in the decision model.

The data were screened for outliers and possible violations of the assumptions underlying regression. Cook’s D (or Cook’s Distance) and Studentized residuals statistical methods were used in the screening process. The maximum values were .053 and -3.011, respectively.

Overall, the results show that GREQ may be a better predictor of GPA than GREV and total GRE in the CM graduate educational programs. This is because GREV and total GRE scores do not show significant contribution to the prediction of performance and success of CM students.

Discussion

Different graduate level educational programs have put in place different admission requirements for entry of students into their graduate programs. As has been seen in the admission criteria of some universities in the United States, such requirements include GRE scores among other requirements. This is because the admission committees tend to believe that the GRE scores can predict the academic performance of students in graduate school. Research has shown that there are some controversies in the continued use of the GRE scores to admit students into graduate school programs. Some schools have even stopped using the GRE scores citing its inability to predict performance and success of students in graduate school and have opted to use other avenues such as entrance subject specific tests as a way to determine or predict the performance and success level of potential graduate students.

Review of literature has shown inconsistencies in the predictive ability of the GRE score on the graduate school performance and success measured by cumulative GPA at graduation. Some studies have reported a relatively higher predictive power of GREQ in some disciplines and GREV in others. Noteworthy, the predictive indices are low on average. Using restricted scores has been leading to this low predictive ability of the GRE scores. The restricted score principle emanates from different admission committees requiring some specific GRE passing score (say 300 in total GRE score) that students need to meet to secure admission. In addition, committees recommend that students maintain a 3.00 GPA to graduate in good standing. These restricted scores of GPA and GRE negatively affect the overall predictive ability. Despite the controversies and inconsistencies attached to the predictive ability of GRE, some graduate programs still use some minimum GRE score as part of their admission requirements for students. They believe that GRE has the ability to predict useful traits required for performance and success in graduate school. As a result, many studies have predicted the performance and success of students in different academic disciplines, with limited research in the CM programs. Thus, this research bridged this gap by investigating the predictive ability of the GRE scores on the GPAs of students.
in the CM graduate programs. Different descriptive and inferential statistical results formed the basis for summative conclusion.

The results showed a good level of performance in GRE as characterized by the normal distribution of scores. Performance in graduate school was excellent as shown by the negative skewed distribution of the GPA scores. The negatively skewed distribution of the scores implied that the students achieved relatively higher GPAs in their graduate studies in the CM programs. Such achievement of high GPA results may continue in the future.

Analyzing the trend lines of the correlation coefficients calculated over the semesters showed staggering trends of correlation indices ranging from strong negative relationships to strong positive relationships. About 14% of the semesters realized strong correlations and above while about 27% of the semesters had moderate and above in the strength of the relationships. This result is low considering the expectation of more strong relationships for adequate statistical power and inferences. In addition, the correlation coefficients between the GREV, GREQ, GRETOTAL, and GGPA were very weak and lower than past studies in different disciplines. When compared with the outcome of the meta-analysis study by Kuncel and colleagues (2001) that recorded the correlation coefficients of .23 for GREV and .21 for GREQ and GPA, respectively, the correlation indices of .061 for GREV, .114 for GREQ, and .112 for total GRE scores and GGPA recorded from the current study were weaker, lower, and inconsistent (or reversed). Inasmuch as the current study indices are lower or weaker, they show positive relationships in which case, the CM graduate school admission committees may consider admitting students with relatively higher GRE scores than lower ones in the quest for realizing higher performance and success in CM graduate education. Therefore, the outcomes of the correlation and regression analyses weakly supported the hypothesis of higher GPA scores being associated with higher GRE scores. It is important to note that these weak positive indices may not necessarily give the best predictors of performance and success in graduate school because of their low and weak predictive powers. Given the low predictive indices, the CM admissions may be tempted to emphasize the GREQ score more during admission in this quest for higher GPA because its predictive ability tends to be better than the rest of the predictors of graduate performance and success (GPA). That is, GREQ had higher explained variance ($R^2$) in predictor variable GPA (1.31%) compared to GREV (0.37%) and total GRE (1.26%) and had the least distance (RMSE) from the regression line in predicting GPA (.2757) when compared to GREV (.2770) and total GRE (.2758).

In the multiple regression model and analysis where both GREV and GREQ were included in the same prediction model, the predictability of GPA improved with an increase in the variance explained in GPA by both GREV and GREQ (1.46%). The regression model showed GREQ to have a steeper slope than GREV implying a better predictive ability. In addition, the standardized regression coefficients showed that GREQ was a better predictor of GPA than GREV (.0402 and .1064 for GREV and GREQ, respectively). This result was similar to the outcome of the study by Orlando (2005), which concluded on the supremacy of GREQ in predicting graduate success (GGPA) in symbol-oriented graduate programs. However, a contrasting result was recorded when it was compared with a study in the criminal justice discipline. Opposite predictive indices were recorded where GREV was the better predictor of GPA than GREQ (standard regression coefficients of .336 and .245 for GREV and GREQ, respectively). Nonetheless, the steeper slope in the regression model of the current study would make it logical for the
CM programs and/or admission committees to emphasize the GREQ score or encourage students to score high in GREQ to secure graduate admission.

**Conclusion**

The focus of this paper has been to analyze the suitability of the GRE scores as a predictor for graduate school academic performance and success. CM students performed relatively well in the admission GRE and relatively high in their graduate education as shown by the normal and negative skewed distribution of their scores. This good performance could be attributable to their abilities to combine well their verbal and quantitative skills to achieve higher GPAs. The trends in the correlation coefficients between the GRE scores and the GPA scores have been staggering showing no stability over time. This instability may continue for some time in the future.

The correlation coefficients between the GRE scores and GPAs are relatively weak implying low ability of the GRE scores to predict the educational performance and success of CM graduate students. The GPA scores may be more of a function of students’ level of motivation than their abilities to succeed in the CM graduate education. Thus, the level of motivation could be a possible factor influencing the scores or resulting in low correlations between the GRE scores and the GPA scores of students. In spite of the low correlations or predictive abilities, GRE quantitative section was the better predictor of performance and success of students in the CM graduate programs. This may result from GREQ having better correlation with performance in some portions of CM curricular that are quantitative in nature. Thus, in a scenario where admission committees are required to use GRE scores as one of their admission requirements and as a possible predictor of graduate school performance and success of students, they may need to consider giving more emphasis to the GREQ score than the GREV or total GRE score.

Overall, the GRE score is a weak predictor of performance and success in CM graduate school based on the restricted scores, and so graduate school admission committees may consider re-evaluating their requirements or use of the GRE scores to predict graduate educational performance and success. That is, CM graduate programs may need to question the value of requiring GRE scores as part of their admission criteria. This research contributes to the body of predictive research conducted about the performance of students in the CM related programs in the USA. Its outcome can provide useful information to aid admission committees in admitting capable students into CM programs. In addition, the result can provide information to compare with other disciplines. Thus, the rating of CM program among others can be determined.

**Areas for future research**

Further research may investigate the effect of other variables such as GREA, student finances, graduate research, assistantships, or ethnicity in predicting graduate performance and success for both masters and doctoral level students. In addition, it would be important to investigate the gender differences in relation to students’ graduate academic performances and their respective absorption rates into the construction industry workforce. A study that investigates the predictive ability of GRE between domestic and international students would also be worthwhile. Finally, it would be informative to
investigate whether prior universities where the graduate students attained their undergraduate degrees have influence on their GRE and GPA scores.

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