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Modeling Students' Performance: UAE University Case Study

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Abstract:
This study analyzed the relationship between student graduation scores (grade point average-GPA) and explanatory variables such as high school scores, English scores (International English Language Testing System), gender, high school stream (art or science), and students' residence locations (rural or urban). A Durbin–Watson linear regression model and a nonparametric kernel model were used to test the relationship. Students' graduation transcript data (2015–2020) was used. Results showed a significant correlation between GPA and English score (N = 784, R = 0.8455) and GPA and stream. This is likely because of the change in medium of instruction from Arabic in schools to English in the university. The results could be used for admission policy and curriculum design at schools.

Keywords: Grade point average, explanatory variables, nonparametric kernel model, United Arab Emirates, Geography.

1. INTRODUCTION

Student achievement is important for supporting university rankings and for graduates who enroll in graduate studies and then obtain professional positions (Li & Zhang, 2010). Therefore, understanding factors affecting students' performance is essential for effective strategic planning (Le et al., 2020) so that universities can raise their students' academic quality through various means, e.g., selection of good students, instructors, and faculty; improvement of facilities and campus life; extra short courses; facilitation of students' involvement in research; conference attendance; research programs; and discussion of local, national, and global problems. Exploring graduates' historical transcripts can reveal patterns and factors to facilitate such an improvement process.

Knowledge regarding the relation between university grade point average (GPA) and other explanatory variables, such as high school and English scores, help identify factors influencing student achievement. Consequently, universities can create special programs to improve student performance at early stages of tertiary education (intervention strategies), for instance, programs that enhance students' time management, motivation, communication with teachers, and preparation for examinations (Capella, Wagner, & Kusmierz, 1982; Kern, Fagley, & Miller, 1998). For example, Dorodchi et al. (2018) analyzed 91 students to predict those at risk, using variables such as age, gender, major, and performance scores (quiz grades, reflections, and self-assessment). To predict student dropout, Guarrin (2013) sampled 1200 engineering students, using variables such as demographics, socioeconomic status, admission scores, type of school attended, options for enrollment, and grades.

The literature reveals that many factors affect student achievement, including demographic factors (e.g., gender, ethnicity, family background), prior academic performance (e.g., school grades), and individual attributes (e.g., motivation); course-related factors include active learning and academic environment (Bijsmans & Schakel, 2018; Brahm, Jenert, & Wagner, 2017; Ifenthaler & Yau, 2020). At many universities, prior academic performance (e.g., school grades) and entrance examinations are widely used as primary admission factors. In China, for example, students must sit for the Chinese National College Entrance Examination, and in the United States, students take the Scholastic Aptitude Test (SAT) or the American College Testing by ACT, Inc. Their performance on these tests affects their chances of being accepted into a college (Chong-en, Chi, & Qian, 2013).

Empirical studies on the relation between school grades and higher education achievement have been conducted in various countries (Gill, 2019; Martinez, 2001; Zimmerman & Johnson, 2017). For example, studies by Bettinger, Evans, and Pope (2013), Chong-en et al. (2013), and Cohn, Cohn, Balch, and Bradley (2004) found that high school achievement is a significant predictor of college grades. Some studies have also shown that secondary school grades accounted for 20% of the variance in college achievement, whereas standardized test scores accounted for approximately 18% (Soares, Guisande, Almeida, & Páramo, 2009). However, Hoffman and Lowitzki (2005) found limitations in predicting college success via high school grades and test scores, especially for minority students. Conversely, this is evident for all students, as documented by Mouw and Khanna (1993), who found that 30% of students expected to succeed in higher education ended up failing, whereas 50% of those expected to fail did in fact succeed. Therefore, no consensus exists on high school grades as the main explanatory factor; instead, other factors must also be considered. This study explores some other such explanatory variables.

Of course, different disciplines attract different types of students based on their interests, values, and abilities (Braxton & Hargens, 1996). To control differences due to disciplines, all students for this study were chosen from the Department of Geography at United Arab Emirates University (UAEU). Since its establishment in 1977, no study has been conducted at the Department of Geography to assess the relation between school grades and college performance (GPA). Therefore, analyzing historical transcript data along with other explanatory variables can fill a gap in the literature and lead to better understanding of how to foster student achievement.

In other words, this study's main objective was to check correlations between student graduation score (GPA) and explanatory variables, such as high school score, English score, age, high school stream (art/science), gender (dummy variable), and student's residence location (rural/urban; dummy variable).

The paper is organized as follows: Section 2 provides a background about UAEU and its admission requirements; Section 3 describes the methodology; Section 4 reports the results; and Section 5 concludes the study.

Department of geography and urban sustainability at uaeu (case study)

Founded in 1976, the UAEU was the first and is the largest university in the UAE, with approximately 15,000 students registered during academic year 2018–2019. Enrolled male students represented 19%, and female students represented 81% of the student population. Each year, the university admits approximately 4000 undergraduate students into nine colleges (UAEU, 2020a).

Admission to UAEU has passed through a series of quality enhancement phases. Admission standards include the following. Most colleges have raised the Grade 12 Certificate requirement from 70% to 80%. However, the College of Medicine and Health Sciences requires a minimum of 90%. Further requirements include a score of 5.5 on the International English Language Testing System (IELTS) or 525 on the Test of English as a Foreign Language Institutional Testing Program. On the Internet Based Test, a score of 70 is required (UAEU, 2020b). Notably, a student can be admitted conditionally if their IELTS score lies between 4.5 and 5.0, provided that they obtain a score of 5.5 within the first university semester.

The UAEU Department of Geography and Urban Sustainability was established in 1977. Initially, the department focused on training geography and social sciences teachers (Hobbs & Yagoub, 2003). However, with the growing demand for Geographic Information Systems/Science (GIS) professionals within UAE and globally, the department established a GIS track in 1999, the Master Program of Remote Sensing and GIS in 2005 (Yagoub, 2005; Yagoub & Engel, 2009), and a doctoral program in 2014. The department now has 300 registered students, 15 faculty members, 2 instructors, 2 teaching assistants, and 4 GIS laboratories. Students must complete 120 credit hours to earn a Bachelor in Geography (BA) degree.

2. METHODOLGY

This study's data were drawn from UAEU geography graduates admitted between 2007 and 2015, who graduated between 2015 and 2020. Their transcripts were obtained from the Office of Institutional Effectiveness at the university. Besides overall GPA at graduation, data included information on gender, birthdate, high school score, English score (IELTS), and high school stream (art/science). Initially, the data included 842 records, but many did not include all items and some included outliers. After data cleaning, we used 784 records for our analysis.

The GPA score (0–4) was converted to a scale score (0–100) to be consistent with the high school score (0–100) by multiplying each GPA by 25. IELTS bands (0–9) were also converted to a 0–100 scale. Gender (female = 0, male = 1), high school stream (art = 0, science = 1), and geographic residence (rural = 0, urban = 1) were coded as dummy variables.

2.1 Null Hypothesis

We hypothesized no correlation between GPA and other variables such as high school score, English (IELTS) score, gender, high school track, and residence. The hypothesis was tested through an analysis of 5-year records of geography graduates (2015–2020) using a deductive approach. The relation between GPA and other explanatory variables was modeled using the following formula:

$Y_i = a + b*X_i$, Equation [1]

where Y denotes GPA, a and b are coefficients to be estimated, and X_i is an explanatory variable such as high school score, English score, or age.

Studies have shown that predicting GPA from a single equation for both men and women usually leads to gender bias (Linn, 1978; McCornack & McLeod, 1988). Therefore, in this study, a separate dataset was created for each gender, and a common one was also created to reveal differences. Multiple linear regression was used where GPA was the dependent variable and explanatory variables were independent. Analysis of variance (ANOVA) and F-test were used to check the significance of correlation between GPA and other explanatory variables (alpha values, p-value <0.05). The coefficient of correlation (R, between −1 and 1) was used to check degree of relation between variables. Durbin–Watson d-statistic was used to test for no serial correlation.

A nonparametric kernel regression model (Zhao & Ma, 2016) was also used to estimate the GPA and address the limitation of the linear regression model and descriptive statistics. The nonparametric kernel model estimates mean outcomes for a given set of covariates. The model takes the following form:

$Y = f(x_1, x_2, x_3, x_4, x_5) + \epsilon$, Equation [2] where Y represents the dependent variable. In this study, Y represents the GPA, x_1 represents the high school score, x_2 the English score, x_3 the high school stream, x_4 gender, and x_5 the number of years a student takes to graduate.

The output model was assessed using sensitivity analysis. In this approach, various parameters and inputs are systematically varied to observe their impacts on the model's results (Goodchild et al., 1993). A sensitivity test was used to investigate the impact of increasing the English-score predictor's value.

3. RESULTS

Descriptive statistics

Table 1 displays descriptive statistics. Skewness value of 0.2017 for GPA indicates that its distribution is approximately symmetric. The normal distribution has a skewness of zero but that is not the case here.

Relation between GPA, high school score, and English (N = 784)

High school score and English score (IELTS) are used as the main criteria for admission to the UAEU. Most graduates (76.2%) have high school scores (86–100), while 83.3% have low college GPAs (75–85). This indicates inconsistency between high school scores and GPA. Statistical significance is attained when a p-value is equal to or smaller than the significance level ($p \leq 5\%$). Indeed, GPA had significant low negative correlation with high school scores (N= 784, R = −0.0124, p-value = 3.13E-95) (Table 2). Restriction of the admission score to 75% tends toward significantly higher average scores and a narrower range of scores than the larger pool (Kobrin, Patterson, Shaw, Mattern, & Barbuti, 2008). Studies have shown that regression coefficients could still be estimated without bias, but the estimate of R^2 would be inconsistent (Cohn et al., 2004; Jensen & Wu, 2010; Rothstein, 2004).

A strong, significant positive correlation existed between GPA and English (N = 784, R = 0.8455, p-value = 9.5E-192) (Table 2). This is logical because many students with good English skills can cope with the change of instructional medium from Arabic (in schools) to English (at the university). The coefficient of determination (R^2) was 0.709 for the relation between GPA (Y) and English (X). This indicates that 70.9% of GPA variation was due to English fluency. When learners are more proficient in language use, they can understand course material better and consequently earn higher scores. The null hypothesis was rejected at the 0.005 level, showing a relation between GPA and English. Similarly, Ghana, Stoffelsma and Spooren (2019) found significant effects of English reading proficiency on students' GPA. Other previous studies by Bayliss and Raymond (2004), Garcia-Vasquez, Vázquez, López, and Ward (1997), Maleki and Zangani (2007), Sahragard, Baharloo, and Soozandehfar (2011), and Yushau and Omar (2007) found a significant positive relation between language proficiency and academic achievement. In fact, the majority of geography courses require greater verbal comprehension compared with some other courses, e.g., art, music, and mathematics. Lack of language proficiency hinders new students' adaptability to the university environment, and students frequently have trouble understanding lectures (Evans & Morrison, 2011; Lacina, 2002; Rochel & Harrington, 2013; Tompson & Tompson, 1996). Indeed, students in many universities worldwide where English is a second language face difficulties. For example, 42% of Norwegian students and 72% of German students reported substantial comprehension difficulties (Hellekjaer, 2010). IELTS cannot accurately measure oral comprehension and communication skills; therefore, more English courses are needed.

Classifying the data by gender also showed that English and high school stream are the primary factors affecting GPA (Tables 3 and 4). However, McCornack and McLeod (1988) found that models with gender effects tended to be less accurate than those using a common equation. Still, in this study, results showed consistent output for both men and women.

Relation between GPA and number of years at the university

The majority of graduates (87%) took 4.5 years to complete a BA degree in geography; 9% graduated within four years and 4% within six years. GPA and the number of years a student takes to graduate showed insignificant low correlation (R = 0.0976, p-value = 0.1600) (Table 2). Most graduates (97%) earned a BA degree at the age of 22–25 years and 3% earned it between 26 and 30 years. However, studies regarding age's effect on student performance reveal conflicting results. Yusuf, Okanlawon, and Oladayo (2020) found that age influenced students' academic performance at tertiary institutions, and the younger the student, the better the performance. However, Maksy and Yoon (2020) found weak to moderate evidence that older students performed better than younger ones. Similarly, Schrouder and Rhodd (2013) reported that in a public administration course, older, more experienced students performed better than younger, less experienced students. Lastly, students who take longer to graduate might have social or work constraints or problems with the English language.

Relation between GPA, gender, and high school stream

GPA and gender showed insignificant low correlation (R = −0.0047, p-value = 0.0841) (Table 2). In an introductory finance course, Chan, Shum, and Wright (1997) and Didia and Hasnat (1998) found no significant association between students' gender or age and grades. In this study, however, the number of females (84%) and the overall GPA average showed that female students in the Geography Department had a higher average GPA (3.04) than males (2.97). Moreover, a sample of those with a GPA above 3.0 (195) indicated that females represent 81%. Additionally, the main reason more females have enrolled in UAEU as a whole and in the Geography Department is their performance in high school and English, their overall performance being higher than males'. According to the UAE Federal Competitiveness and Statistics Authority (FCSA, 2020), 43.3% of students at secondary schools are female, and 56.7% are male. Therefore, the school ratio approximates equality. However, females' high GPA aligns with Chong-en et al.'s (2013) study, which found that gender correlated significantly with college grades, thereby suggesting that females have higher undergraduate GPAs than males throughout the 4 years of study. Astin (1971) and Mutchler, Turner, and Williams (1987) also found that women consistently earned better grades than men, perhaps because women might better select courses that conform to their abilities (Decore, 1984). However, GPAs for different students represent a different mixture of courses; indeed, men and women might experience systematic differences between their assortment of courses (McCornack & McLeod, 1988). Further, studies indicate controversial results regarding cognitive and general intelligence between genders (Lubinski, Benbow, Shea, Eftekhari-Sanjani, & Halvorson, 2001; Price, 2017). At any rate, some reasons females in UAE perform better than males in the Geography Department might be attributed to the norm that females experience more stay-at-home time than males and thus have greater concentration toward education. Moreover, females work hard to prove their independent capacity.

GPA and the Science, Technology, Engineering, and Mathematics (STEM) stream (Arts = 0, Science = 1) show display a positive correlation (R= 0.8277) (Table 2). Some geography courses (e.g., population, cartography, remote sensing, digital image processing, and spatial analysis) require mathematical skills. In these courses, students with a STEM background have a greater probability to score high marks. Thayamathy, Elango, and Karunarathna (2018) found that students from a biological stream performed better than those from a physical stream. Another study by Yousef (2013) found a significant difference in performance between students majoring in art in high school and those majoring in science, with those from science backgrounds performing better.

Relation between GPA and graduates' residence location (urban/rural)

Data regarding the residence of graduates were available only for 462 female students (Table 5), so this section's analysis is based on that dataset. In general, urban areas offer better educational opportunities and greater access to higher education than rural areas (Liu & Wu, 2006), and a majority of female geography graduates (74%) resided in urban areas (Table 5). This aligns with the geographic distribution of the UAE's population, with urban population representing 90% (World Bank, 2020). However, the difference in GPA performance is slim (Table 5), probably because the majority of rural areas have good infrastructure, for instance, electricity, Internet, road networks, and accommodations. Globally, the gap between rural and urban areas has decreased (Li, Whalley, Zhang, & Zhao, 2008).

Linear and nonparametric kernel regression models

The linear regression model was estimated using Equation [1] (Table 6). The F-ratio in ANOVA tests was used to check whether the overall regression model fits the data (Table 6). The result showed that independent variables statistically predicted the dependent variable, $F = 1616.93$, $p = 0.000 < 0.0005$ (Table 6). As the F value was not close to 1.0, the null hypothesis was rejected, i.e., a relation does exist between GPA and other variables such as high school score, English (IELTS) score, gender, and stream. However, a further test is needed for serial correlation between the dependent variable and its predictors.

To validate the model and to ensure that the distribution of the dependent variable, GPA, is normal, we investigated the absence of serial correlation in the data. The Durban–Watson d-statistics test was used to test the null hypothesis of no serial correlation. The value obtained from the test was 0.1163375, a value close to zero, which implies rejecting the null hypothesis of no serial correlation. A small Durbin–Watson statistical value d of less than 1.57 for sample size 100 and p-value = 0.05 implies rejection of the null hypothesis (Montgomery, Jennings, & Kulahci, 2015). Moreover, from descriptive statistics in Table 1, the skewness value of 0.2017 for the dependent variable (GPA) indicates that the data are right skewed, implying a problem in the data's normality. Finally, serial correlation's existence indicates that the model is not well fitted (Figure 1).

Nonparametric kernel regression

To address the serial correlation problem, we estimated nonparametric kernel regression using Equation [2], and based on 784 observations, the model was constructed (Table 7 and Figure 2). The coefficient of multiple determination was 0.9285; this means the model can explain 92.85% of GPA scores' variation.

Sensitivity analysis was conducted to reveal the impact of increasing the English score's value from 50 to 61. Table 8 shows this change's impact, which doubled the English predictor's coefficient. A comparison of the two models—linear regression and nonparametric kernel regression—based on the two model fits (Figures 1 and 2) found the nonparametric kernel regression model better than the linear regression model.

4. CONCLUSIONS

Factors affecting student success at a university range from personal characteristics such as motivation and prior academic performance to the educational environment. This study's results evinced that students with good English skills from a high school science stream have a better chance of earning a high college GPA. The nonparametric kernel regression model showed better fit than the linear regression model, which suffers from serial correlation. Increasing the number of school-level English courses and encouraging students to take science courses is likely to improve their university performance. Although students achieved admission entrance requirements, our results suggest that offering English classes and STEM short courses for students would aid their performance. One implication of this study indicates that raising the geography program's admission requirements from 5.0 to 5.5 would likely improve students' GPA significantly. To conclude, future studies should investigate motivational factors that impact students' GPA.

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Table 1: Descriptive Statistics of Graduates' Scores, Dept. of Geography, UAEU, 2015–2020

	High school score	English score	Track	Gender	Number of years	GPA
Mean	87.0995	55.3406	0.3788	0.1594	5.9298	72.1135
Standard Error	0.2196	0.1125	0.0173	0.0131	0.0299	0.3231
Median	88.0000	56.0000	0.0000	0.0000	6.0000	71.0000
Mode	90.0000	56.0000	0.0000	0.0000	6.0000	70.0000
Standard Deviation	6.1487	3.1493	0.4854	0.3663	0.8359	9.0477
Sample Variance	37.8062	9.9184	0.2356	0.1342	0.6988	81.8607
Kurtosis	−0.5193	−0.0649	−1.7539	1.4787	0.1135	−0.7272
Skewness	−0.2977	−0.3291	0.5005	1.8641	0.3034	0.2017
Range	30.0000	11.0000	1.0000	1.0000	4.0000	38.0000
Minimum	70.0000	50.0000	0.0000	0.0000	4.0000	55.0000
Maximum	100.0000	61.0000	1.0000	1.0000	8.0000	93.0000
Sum	68286.0000	43387.0000	297.0000	125.0000	4649.0000	56537.0000
Count	784	784	784	784	784	784

Table 2: Common correlation (R) between GPA and explanatory variables (N = 784)

	High school score	English score	Track	Gender	Number of years	GPA
High school score	1.0000					
English score	−0.0951	1.0000				
Track	−0.0293	0.5437	1.0000			

Gender	−0.2622	−0.0172	−0.0169	1.0000		
Number of years	−0.2730	0.0595	0.1317	0.0199	1.0000	
GPA	−0.0124	0.8455	0.8277	−0.0047	0.0976	1.0000

Table 3: Female correlation (R) between GPA and explanatory variables (N = 659)

	High School score	English score	Track	Number of Years	GPA
High School score	1.0000				
English score	−0.0655	1.0000			
Track	−0.0225	0.5265	1.0000		
Number of Years	−0.2933	0.0507	0.1355	1.0000	
GPA	0.0179	0.8418	0.8197	0.0979	1.0000

Table 4: Male correlation (R) between GPA and explanatory variables (N = 125)

	High School score	English score	Track	Number of Years	GPA
High School score	1.0000				
English score	−0.2783	1.0000			
Track	−0.1033	0.6280	1.0000		
Number of Years	−0.2041	0.0965	0.1166	1.0000	
GPA	−0.1759	0.8644	0.8699	0.0973	1.0000

Table 5: Statistics on graduates' residence locations (urban or rural)

Location	Number of female graduates	%	Median GPA	Average GPA	Standard deviation
Urban	341	73.81	3.01	3.0	0.41
Rural	121	26.19	2.92	2.98	0.36
	462	100			

Table 6: Linear Regression Model

Number of observations = 784; F (5, 779) = 1616.93; Probability > F = 0.0000; R-squared = 0.9114; Root MSE = 2.7017

<table>
<tr><td></td><td colspan="2">Robustness</td><td></td><td></td><td></td></tr>
<tr><td>GPA</td><td>Coefficient</td><td>Std. Err.</td><td>t</td><td>t
P > |t|</td><td>[95% Conf. Interval]</td></tr>
</table>

High school score	0.1023	0.01598	6.40	0.000	0.07096	0.1337
English score	1.6365	0.03594	45.53	0.000	1.5659	1.7070
Track	9.6732	0.2487	38.90	0.000	9.1850	10.1614
Gender	0.7831	0.2746	2.85	0.004	0.2439	1.3222
Number of years	0.1607	0.1233	1.30	0.193	−0.0813	0.4028
Constant	−32.1072	2.7721	−11.58	0.000	−37.54901	−26.6655

Table 7: Nonparametric Kernel Regression
Number of observations = 784; Continuous kernel: Epanechnikov; E (Kernel observation) = 784; Discrete kernel: liracine; R-squared = 0.9285; Bandwidth: cross validation

	Observed Bootstrap				Percentile	
	Estimate	Std. Err.	z	P > |z|	[95% Conf. Interval]	
Mean GPA	72.12314	.3365421	214.31	0.000	71.50548	72.71845
Effect						
High school score	0.0945554	0.0168694	5.61	0.000	0.0622622	0.1277715
English score	9.570762	.2266091	42.23	0.000	9.066458	9.947175
Gender	0.7028181	0.2769382	2.54	0.011	0.1756682	1.177529
Stream	9.850043	.2822433	34.90	0.000	9.39611	10.39581
Number of years	0.1157033	0.105833	1.09	0.274	−080123	.3427544

Table 8: Sensitivity Analysis

English score	Estimate	Std. Err.	z	P > |z|	[95% Conf. Interval]	
(56 vs 50)	9.570762	.2266091	42.23	0.000	9.066458	9.947175
(61 vs 50)	17.58175	0.4242191	41.44	0.000	16.62057	18.2935

Figures

Figure 1: Linear Regression Model Fitting, Geography Department, UAEU, 2015–2020

Figure 2: Nonparametric Kernel Regression Model Fitting, Geography Dept., UAEU, 2015–2020