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A Quantitative Study of Factors Predicting High-Achieving Engineering Students' Progress towards Desired Educational Outcomes

Dr. Ibukun Samuel Osunbunmi, Utah State University

Ibukun Samuel Osunbunmi is an Assistant Research Professor, and Assessment and Instructional Specialist at Pennsylvania State University. He holds a Ph.D. degree in Engineering Education from Utah State University. Also, he has BSc and MSc degrees in mechanical engineering. His research interests include student engagement, design thinking, learning environment, evidence-based pedagogy, e-learning, broadening participation in STEM education, sustainable energy, and material characterization. This work was conducted while he was a Ph.D. student at Utah State University.

Prof. Ning Fang, Utah State University

Ning Fang is a Professor in the Department of Engineering Education at Utah State University, U.S.A. He has taught a variety of courses at both graduate and undergraduate levels, such as engineering dynamics, metal machining, and design for manufacturing

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Introduction

Trends in college studies show that the quality of students' involvement in engaging academic resources and maximizing opportunities in their college environment have a relationship with students' academic achievement and the progress they make with their learning [1]–[3]. Satisfaction with college outcomes has also been found to have a relationship with student engagement in academic activities [4]. Active classroom learning strategies have facilitated students' involvement in course learning. Such pedagogical strategies that have improved students' engagement with course learning and academic achievement in engineering classrooms include project-based learning, problem-based learning, flipped classroom, cooperative learning, questions, and discussions [5], [6].
Furthermore, it has been found that motivation has the strongest relationship with persistence to graduation and is a significant predictor of academic performance [7]–[9]. Other studies have noted that highly motivated students have better academic achievement than those who are not [10]. However, others have found no significant relationship between motivation and college outcomes [11]. Prior research shows that living on campus, directly and indirectly, correlates with student engagement and achievement [12], [13]. Engineering living and learning communities have increased peer interaction among engineering undergraduate students and inclusivity in the university [14]. This aligns with the evidence suggesting that living on campus positively influences students' learning outcomes [15], [16].

Moreover, others have suggested that students' background and demographics may influence their learning experience. For example, studies show married students are more likely to persist to graduation and have better wellness than unmarried [17]–[19]. Others have found that the educational outcomes of married students are usually better than unmarried ones. It has also been found that unmarried students are more likely to experience loneliness than married students. However, no correlation was found between loneliness and academic achievement in terms of grade point average [20]. Another socioeconomic factor that has been found to correlate with students' determination to persist to graduate and excel in their studies is their parents' education [21].

However, little is known about factors influencing the progress toward desired educational outcomes of high-achieving engineering students. Therefore, this study uses predictive modeling of students' achievement regarding their progress toward desired educational outcomes. The overall desired educational outcomes addressed in this study include gains in intellectual and scholarly development, gains in scientific and technological knowledge, gains in personal development, and gains in vocational development [1]. Improving students' progress toward desired educational outcomes will result in graduating competent engineers who can effectively advance the nation's scientific and technological landscape.

In this study, the cumulative grade point average (CGPA) indicates students' academic achievement. Researchers have described students with B+ to A+ on the U.S. grade scale or a CGPA of 3.0 out of 4 as high-achieving [22]–[27]. In the university where this study was

conducted, B+ is 3.33. Students with a minimum of 3.5 have been considered high-achieving for a scholarship or as honors students for exceptional academic performance. Also, a 3.5 and above is regarded as a distinction grade called cum laude and its variation. Based on this and existing studies, we described students with a CGPA of 3.5 are high-achieving.

Theoretical framework

The theoretical framework that guided this study is Astin's theory of involvement, also known as the Input-Environment-Output (I-E-O) theory [12], [28], [29]. The theory postulates that the educational outcomes students experience in college result from the quality of their psychological engagement and the quantity of their active participation [12]. Astin's theory of involvement succinctly summarizes "most of the empirical knowledge about environmental influences on student development that researchers have gained over the years" [12, p. 1]. The theory of involvement integrates student involvement with the environment [12].

It is worth noting that the resources available in the college environment are fundamentally essential to student involvement in learning. A well-structured environment engendered to enhance student engagement will facilitate better student learning than an ill-equipped environment [30]. It was commented that there is a possibility of a misconception of treating students independently of the environment and that the environment is independent of +the students [30]. In the present study, we postulate that the availability and use of academic resources in the environment are germane to students' resultant educational progress.

In the Input-Environment-Output (I-E-O) model [12], output signifies students' development and achievement during college [12]. In the present study, the output is desired educational outcomes. Desired educational outcomes are a summation of 4 sub-desired educational outcomes as encapsulated in the College Students Experience Questionnaire (CSEQ) [1]. The sub-desired educational outcomes include scholarly development, vocational preparation, personal development, scientific and technological development, and general education knowledge, as captured by the college students' experience questionnaire [1]. We postulate that students' investment in the quality of effort in their academic task, utilization of resources in the environment, motivation to learn, college environment policy in terms of scholarships that are provided, and parents' educational background are all significant predictors of progress students make in terms of their overall desired progress they make in college.

Method

Research question

The research questions that guided this research are as follows:

RQ 1: What factors have a significant relationship with high-achieving engineering students' progress toward desired educational outcomes?

RQ 2: What factors significantly predict high-achieving engineering students' progress toward desired educational outcomes?

For this study, the independent variables are course learning, parents' educational background, scholarships, using academic resources, and motivation. The dependent variable for this study is the overall gains students make with respect to desired educational outcomes.

Participants

The sample participants were college students in their professional programs at the College of Engineering at Mountain West University in the United States. The sample participants were from the Department of Mechanical and Aerospace Engineering (MAE) and Civil and Environmental Engineering (CEE). The participants' age ranged between 20 and 39 years old. In terms of race, about 98% of the sample participants were Caucasian White. To be selected for this study, the sample participants must be high-achieving students. In defining high-achieving students, the researcher defined them in terms of their cumulative grade point average.
In total, fifty-one students participated in the study. A power analysis we conducted at acceptable power of 0.8 and an alpha (α) of 0.05 for a two-tailed test [31], [32] showed that our sample size is enough to detect a correlation $r = 0.5$ for this quantitative study.

Data collection

Two instruments were used to collect data for this study. They are the fourth edition of the College Students' Experience Questionnaire (CSEQ) and the third edition of the Learning and Study Strategies Inventory (LASSI) [1] [38]. CSEQ provides data on student demographics, scholarships, course learning, and progress made on educational outcomes. LASSI instrument measures course learning, motivation, and use of academic resources. The educational outcomes measured by CSEQ align with ABET criteria for educational outcomes and have been seen as a tool that can be used for accreditation purposes [34]. Both instruments have been validated and confirmed reliable to measure the construct they intend to measure. A reliability score of 0.7 and above confirms that group items measure the same thing [35]. Cronbach alpha reliability of each of the constructs is as follows: Motivation: 0.77; using academic resources: 0.76; Course learning: 0.83; use of campus facilities: 0.74; average progress towards educational outcomes: 0.82[1] [38]. Both instruments have been confirmed as valid. Construct validity, for example, confirms that survey scores can be meaningfully inferred from psychological constructs [1]. Psychological constructs considered in this study are course learning, motivation, use of campus facilities, and progress toward desired educational outcomes.

Data analysis

Descriptive analysis, normality test, Pearson correlation, and ordinary least square regression were conducted to answer the research questions.

Results

Table 1 shows that 78% of the high-achieving engineering students who participated in this study were males, while 22% were females. For the Department of Mechanical Engineering, 83% and 17% of student participants were males and females, respectively. For the Department of Civil

and Environmental Engineering, 73% and 27% of student participants were males and females, respectively. Data from participating institution's Office of Analysis, Assessment, and Accreditation (AAA) shows a similar trend. AAA data shows that, for the Department of Mechanical Engineering, 88% and 12% of the student population were male and female, respectively. In comparison, 77% and 23 % of the Department of Civil and Environmental Engineering student population are male and female, respectively. Overall, females make up about one-fifth of the student population. This indicates that female representation in engineering remains low [36].

Table 1 shows that about 63% of student participants were married, and 37% were unmarried. Also, Table 1 shows that about 69% of student participants had both parents with a college degree, 12% had only their father with a college degree, 10% had only their mother with a college degree, and 10% did not have parents who graduated from college. Figure 4 shows that about 51% of student participants lived within walking distance of the campus, 18% lived in the dormitory or other campus housing, and 31% lived within driving distance. None of the student participants lived in a fraternity or sorority housing. Female representation remains very low.

Table 1: Demography of participants

Demography	%
Sex Distribution	
Male	78
Female	22
Marital Distribution	
Married	63
Not Married	37
Majors Distribution	
Mechanical and Aerospace Engineering	57
Civil and Environmental Engineering	43
Proximity of Residence to Campus	
Dormitory or other campus housing	18
Residence within walking distance of the institution	51
Residence within driving distance	31
Parents of participants who graduated from college	
Father Only	12
Mother Only	10
None of the Parents	10
Both Parents	69

Table 2 shows the result of the normality test that was conducted. A p-value greater than 0.05 for the Kolmogorov-Smirnov test and Shapiro-Wilk test indicates that the data fulfills normality. The result of the normality test, as shown in Table 2, indicates that almost all the constructs considered except for motivation have a P-value greater than 0.05 for both the Kolmogorov-Smirnov and Shapiro-Wilk tests. The normality plots (see appendix): Q-Q plots

and the box plots for all the variables show that the test fulfilled the normality assumption overall. Therefore, we assumed that the data fulfilled normality assumptions.

Table 2: Normality test results

Variables	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Course Learning Experience	0.102	51	0.200	0.986	51	0.802
Campus Facilities	0.116	51	0.083	0.966	51	0.150
Motivation	0.144	51	0.010	0.95	51	0.031
Utilization of Academic Resources	0.119	51	0.071	0.969	51	0.210
Desired educational outcomes	0.104	51	0.200	0.982	51	0.628

The correlation analysis in Table 3 shows that course learning has a significantly moderate positive relationship with students' overall progress toward desired educational outcomes at $r(50) = 0.40$, $p < 0.001$. Also, Table 3 shows that motivation has a significantly moderate positive relationship with students' overall progress toward desired educational outcomes at $r(50) = 0.37$, $p < 0.001$. Table 3 shows that using academic resources, parents' education, and scholarship have a weak and non-significant correlation with desired educational outcomes.

Table 3: Correlation analysis results

	1	2	3	4	5	6
Course Learning	1	0.227	0.386**	0.144	-0.265	0.402**
Using Academic Resources		1	0.119	0.216	-0.158	0.089
Motivation			1	0.225	-0.221	0.369**
Scholarship				1	-0.009	0.011
Parents' Education					1	0.011
Desired Educational Outcomes						1

** Statistically significant at $p < 0.001$.

Table 4 shows the results of the ordinary least square (OLS) linear regression model. As can be seen from Table 4, the model statistically predicted academic success: $F(5, 50) = 2.988$, $p = 0.021$, $R = 0.50$, adjusted $R^2 = .25$. These results indicate a linear relationship in the sample, and the multiple regression model is a good fit for the data. Also, the results show that course learning significantly predicts students' overall progress toward desired educational outcomes, $t(50) = 2.356$, $p = 0.023$. In addition to this, Table 3 shows that motivation is a significant predictor of the overall progress students make toward desired educational outcomes: $t(50) = 2.050$, $p = 0.046$. OLS regression analysis shows that parents' education, scholarship, and use of academic resources are not significant predictors of overall desired educational outcomes.

Table 4: Regression analysis results

	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	7.918	19.449		0.407	0.686
Course Learning	0.818	0.347	0.342	2.356	0.023
Motivation	1.389	0.677	0.295	2.05	0.046
Parent Education	2.909	2.332	0.17	1.248	0.219
Using Academic Resources	0.074	0.387	0.026	0.192	0.849
Scholarship	-3.096	3.87	-0.109	-0.8	0.428

Discussions

This study shows that about two-thirds of high-achieving engineering students have educated parents. However, the correlational analysis and OLS linear regression model suggest a weak non-significant relationship between parents' education and educational outcomes. This contradicts the outcomes of the study of [21].

This study also shows that more than 69% of high-achieving engineering students live on or are close to campus. This suggests that most high-achieving students prefer to live on campus. Evidence suggests that living on campus positively influences students' learning outcomes [15], [16]. Future studies should explore the lived experience of high achieving as to why they prefer to live on campus.

Motivation having a significant and positive moderate relationship with educational outcomes aligns with the result of previous studies [7] [8] [9]. Also, the outcome of this research, which shows that effort invested in course learning is a significant predictor of progress toward educational outcomes, aligns with previous research by others [4].

Conclusions

The present study investigated what factors predicted the progress of high-achieving engineering students toward desired educational outcomes. Descriptive analysis, Pearson correlation coefficient, and ordinary least square regression analysis were utilized in investigating the phenomenon of interest. The following summarizes the major research findings of this study:

1. Motivation is a significant predictor of attained educational outcomes of high-achieving engineering students.
2. Quality of effort invested in course learning is a significant predictor of academic achievement of high-achieving engineering students in terms of the progress they make towards desired educational outcomes.
3. Scholarships and utilization of resources are insignificant predictors of educational attainment.
4. The study shows that two-thirds of high-achieving engineering students have both parents with at least a college degree. However, parental education does not significantly predict students' educational attainment.
5. Most high-achieving engineering students live on or within walking distance of campus.

Implication of research to practice

Students should be encouraged to live on or close to the campus. The administration is encouraged to keep improving the existing environment that fosters programs and activities to enhance students' motivation to learn.

Other forms of intrinsic and extrinsic motivation can be implemented by faculty in teaching and assessment. For example, they allow students to redo and resubmit an assignment after providing feedback without penalizing them. Such practice increases their engagement, learning, and achievement while removing the demotivation and mental stress of having lower grades [37]. Faculty can also make students see the importance of the class at the beginning of the semester. Asking students what they want to take from the class and apply it in their career as the assignment after the first lecture can promote intrinsic motivation. In addition, faculty should utilize active learning pedagogy that has shown evidence to increase student engagement during course learning.

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Appendix

Appendix 1: Q-Q plots and Box plots

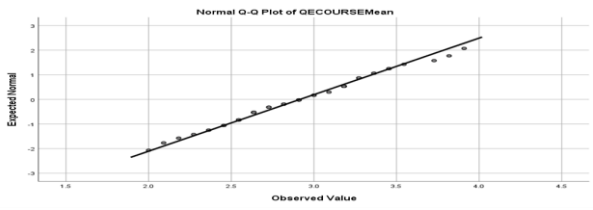

Figure 1: Q-Q Plots for Course learning

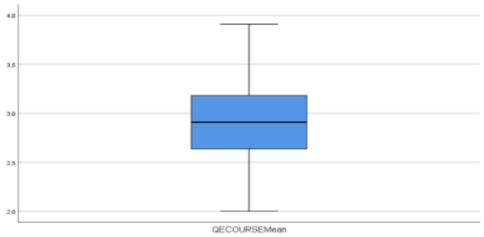

Figure 2: Box plots for course learning

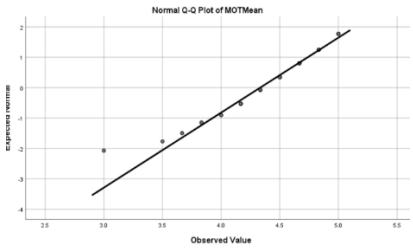

Figure 3: Q-Q Plots for motivation

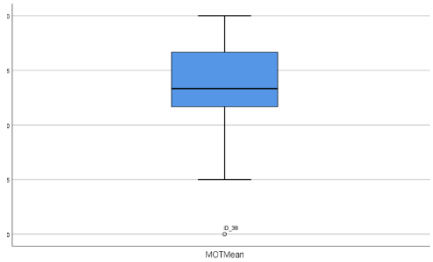

Figure 4: Box plot for motivation

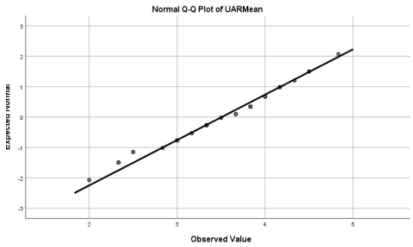

Figure 5: Q-Q Plots for the use of academic resources

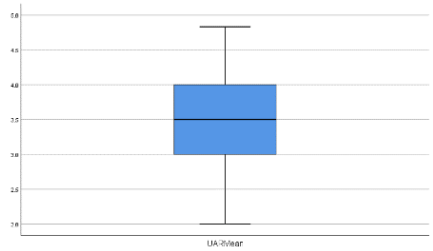

Figure 6: Box plots for using academic resources

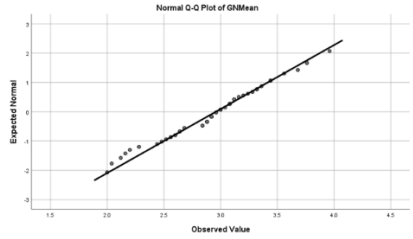

Figure 7: Q-Q Plots for an estimate of gains factor

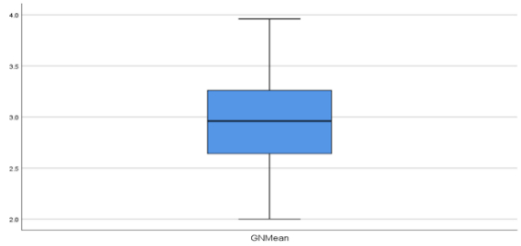

Figure 8: Box plots for an estimate of gains factor