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Investigating Factors that Predict Academic Success in Engineering and Computer Science

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Research Paper: Investigating Factors that Predict Academic Success in Engineering and Computer Science

Abstract

Over the years, researchers have found that student engagement facilitates desired academic success outcomes for college undergraduate students. Much research on student engagement has focused on academic tasks and classroom context. High impact engagement practices (HIEP) are effective for undergraduate student academic success. However, less is known about the effects of HIEP, specifically on engineering and computer science (E/CS) student outcomes. Given the high attrition rates for E/CS students, student involvement in HIEP could improve student outcomes for E/CS students, including those from various underrepresented groups.

More generally, student participation in specific HIEP activities has shaped their everyday experiences in school, both academically and socially. Hence, this study's primary goal is to examine the factors that predict academic success in E/CS using multiple regression analysis. Specifically, this study seeks to understand the effects of high-impact engagement practices (HIEP), coursework enjoyability, confidence at completing a degree on the underrepresented academic success, and nontraditional E/CS students. We used exploratory factor analyses to derive an """academic success""" variable from five items that sought to measure how students persevere to attain academic goals.

The present study's secondary goal is to address the gap in research literature concerning how HIEP participation affects student persistence and success in E/CS degree programs. Our research team developed and administered an online survey to investigate and identify factors that affect HIEP participation among underrepresented and nontraditional E/CS students. Respondents (N = 531) were students enrolled in two land grant universities in the Western U.S. Multiple regression analyses were conducted to examine the proportion of the variation in the dependent variable (academic success) explained by the independent variables (i.e., high impact engagement practice (HIEP), coursework motivation, and confidence at completing a degree). We hypothesized that (1) high impact engagement practices will predict academic success; (2) coursework motivation will predict academic success; and (3) confidence at completing a degree will predict academic success. Results showed that the multiple regression model statistically predicted academic success , $F(3, 270) = 33.064$, $p = .001$, adjusted $R^2 = .27$. These results indicate a linear relationship in the population, and the multiple regression model is a good fit for the data.

Further, findings show that confidence in completing a degree is significantly predictive of academic success. Also, coursework motivation is a strong predictor of academic success. Specifically, the result shows that an increase in high impact engagement practices is associated with an increase in 'students' academic success. In sum, these findings suggest that student participation in High Impact Engagement Practices might improve academic success and retention. Theoretical and practical implications are discussed.

Introduction

Students can view academic success from different perspectives, including getting good grades, excitement about one's program of study, and developing skills useful in the job market after graduation. Recently, researchers have been focused on improving student engagement, which is one of the precursors or determinants of academic success. The high attrition rates of students initially enrolled in an engineering/computer science (E/CS) degree after the first year has led researchers to question the effectiveness of more traditional educational practices. To this end, many studies have been carried out to develop activities that foster engagement and participation among students, especially first-year students and students from underrepresented minority groups. Engineering and computer science majors must attract students from diverse backgrounds, including women, nontraditional students, first-generation students, and students from underrepresented racial and ethnic groups, to meet the workforce's ever-changing demands and realize the documented benefits of diversifying the engineering field. Students in underrepresented groups are often more liable to be at risk of dropping out or switch majors due to lack of inclusiveness, fear of failure (especially among first-generation students), and engineering courses' competitive nature.

Engagement is one of the main factors that can be used to predict academic success. An engaged student is more likely to have short-term goals such as an intention to participate in an internship program or long-term goals such as intentions to pursue graduate studies or move into the technical workforce. Tutoring sessions, field trips, and research projects have been introduced to the undergraduate engineering student's curriculum ostensibly to increase engagement. Peer discussions in undergraduate courses have helped develop the personal and social skills to thrive in an engineering major. Peer discussions seem to enhance student learning compared with courses that do not allow peer discussions [2]. Capstone projects serve as a great tool to provide culminating senior academic/intellectual experience for students, especially those at the end of their educational program; such a project will give E/CS students an insight into the activities they will likely be involved in while on the job.

Engineering student societies and clubs are also promising avenues to promote engagement among students. These student groups/clubs may participate in hackathons, competitions, and service activities, bringing a fun, hands-on factor to their engineering curriculum. Such groups promote interaction within minority groups and improve 'students' sense of belonging, and curbs loneliness. However, team-building skills need to be developed to ensure inclusiveness and proper leadership and development of the engineering group [3]. Course work motivation is another factor that could influence students' outcomes. Students who enjoy their engineering program of study often spend more time learning and understanding their course materials. They are also more likely to persist when faced with a problem while seeking a solution. Conversely, students who do not enjoy their course work are likely not encouraged to explore further and research the materials. Indeed, they are more likely to drop out of an engineering major.

Purpose

The present study examines factors that predict academic success and investigates the effects of several combinations of the factors, including high impact engagement practices (HIEP), course work enjoyability, and confidence in completing a degree on academic success. Multiple regression analyses were conducted to examine the proportion of the variation in the dependent variable (academic success) explained by the independent variables (i.e., HIEP, coursework enjoyability, and confidence at completing a degree).

Literature Review

Researchers have shown that several engagement practices (such as service learning, study abroad programs, learning communities, internships, and culminating senior experiences (capstone projects) promote engagement among college undergraduates in general [4]. However, little is known about engineering 'students' level of involvement in these practices and combinations of practices that would result in the maximum attainment of academic success for students from various backgrounds and among different levels of their study program (i.e., first-year or senior students). Additionally, these engagement practices' voluntary nature means that students from minority demographic groups might not participate, and they are more at risk of dropping out of an engineering program. However, studies have shown that participation in HIEP improves E/CS HIEP participation could be a predictor of academic success [5]. The combination of several engagement academic practices, and experience would increase the general knowledge within a major, improves competence (self-efficacy), social interactions, and job opportunities [1] through internships.

Service-learning is a practice that combines classroom learning with volunteer work to achieve community goals and helps students understand how their coursework relates to social issues in real-life scenarios [6]. Other studies suggest that service-learning could be an avenue to attract and retain female engineering students [7] Learning communities could improve academic success because it involves shared and collaborative learning of students enrolled in similar classes around a theme to create a learning environment [8]. E/CS students, especially first-year students, can benefit from learning communities because having a group of peers with similar goals and career interests in the same classes would foster openness about struggling with coursework, social and personal interaction (building friend groups) and increases interaction within the classroom [9]. Internships provide E/CS students on-the-job training opportunities to implement classroom curriculum into real-world applications. Internships also provide E/CS student insights into their career after graduation and set short and long-term goals. Undergraduate research experiences help E/CS students to have more interaction with faculty members, and students are mentored to make creative and significant contributions to their engineering discipline [5]. Study abroad programs give E/CS students opportunities to learn about other diverse cultures, improve interaction with students from other minority groups, and better understand their engineering major's significance in other countries.

Theoretical-based coursework is one of the contributing factors of large numbers of first-year E/CS leaving the engineering field [10]. Such coursework makes relating concepts taught in class to real-world scenarios quite difficult and creates a negative feeling of engineering concepts among E/CS students. Students tend to enjoy their coursework if they can see the benefits in real-world applications and the flexibility to solve real-world problems. E/CS curriculum should be updated accordingly to reflect technological advancement in the field. Teaching students, especially first-year students, outdated technologies and innovation could discourage students from continuing in their majors. Students might not see the relevance of such coursework in advancing their studies and careers. Students generate coursework motivation when they see the relevance to their careers. Coursework overload could have a negative effect on academic success, especially among first-year students, because they might develop overwhelming feelings. Also, faculty must be aware of the diverse background of E/CS students, which means that some students are less equipped to handle overloaded coursework than others.

Academic achievement is also a marker for persistence, admission, and further studies in a graduate school in an engineering major. Academic achievement is powered by a students' deliberate practice, willpower, interest, love of learning [11]. Over the recent years, researchers have investigated some factors that affect academic achievement. For example, a student's personality and habit can be a factor. Other studies propose that factors such as age, gender, marital status, and financial status can affect students' academic achievement and performance [12]. [13] suggested that psychological factors such as depression, anxiety, stress, self-esteem, addiction, and mental disorders could also affect a student's academic achievement. Academic achievement can be predicted by a student's high motivation, presence of short and long-term goals. Students who have career goals in their engineering majors are more likely to persist than students without career goals [14].

Confidence in completing a degree can be defined as a student's state of mind and belief in graduating in their study program. Persistence is one of the main contributing factors to completing an engineering degree. Persistence in E/CS can be defined as a students' choice to stay in an engineering major or complete an engineering degree [15]. Enough motivation and self-efficacy are needed to overcome several adversities faced during their engineering programs [16]. To this effect, researchers have spent a considerable about of resources to know the completion rates of engineering majors and the cause of attrition from engineering /computer science degrees [17, 18]. There are several factors that affects a student's persistence in their respective degrees including student identity [19], interest, recognition, and support (either financial or otherwise) from family and friends.

Methods

Participants

Respondents were five hundred and thirty-one undergraduate students (156 females, 333 males, age range from 18 to 65) enrolled in two land grant universities in the western United States.

Students from the two land grant universities responded to an engagement survey developed by the research team. The study was deemed exempt by the ' 'university's institutional review board.

Material

The survey solicited responses on different forms of high impact engagement and was used to investigate the possible links between student demographics, success measures, and participation in High Impact Engagement Activities (HIEA). The survey data were categorized into program-level reports with E/CS programs such as electrical engineering, materials science engineering, mechanical engineering, aerospace engineering, computer science, computer engineering, bioengineering, chemical engineering, civil engineering, and construction management. We extracted twenty questions ($\alpha = .74$) from the survey to investigate factors that predict academic achievement goals in E/CS. Students answered these questions on a 5-point Likert scale ranging from *1 = strongly disagree to 5 = strongly agree*.

Results and Discussion

The purpose of this study is to investigate factors that predict academic achievement goals in engineering and computer science. First, we conducted Exploratory Factor Analysis (EFA) to derive the latent factors from the survey. We extracted factors using Principal Component Analysis (PCA) and the rotation method using the Direct Oblimin procedure. Kaiser-Meyer-Okin measures of sampling adequacy were 0.835, which suggests the suitability of our data for EFA. Further, Barlett's Test of Sphericity was X^2 (78) = 3726.78, $p < 0.001$, indicating pattern relationship existed between items. The four factors derived from the EFA analysis are (1) academic achievement goals, (2) course motivation, (3) HIEP, and (4) confidence at completing a degree. The four factors explained about 76.3% of the cumulative variance of the 'participants' responses.

Academic Achievement Goals. The EFA generated five items that sought to measure how students persevere to attain academic goals (for example, "I will be able to achieve most of the goals that I have set for myself"","," or "I believe I can succeed at almost any endeavor to which I set my mind", etc.). The internal reliability estimate (α) for the five items measuring academic achievement goals was .88.

Course motivation. The EFA generated two items that measure how students enjoy engaging in their course activities. The students responded to the following statements "I only take engineering and computer science courses because they are required" and "I only take engineering or computer science course as long as I have to". The reliability estimates (α) for course motivation was .82.

Confidence at completing a degree. Four items measure students' perceived confidence towards achieving the desired success at completing their degree. These included "How confident are you that you will graduate with a computer science or engineering degree"?" and "How confident are you that you will complete a computer or engineering degree"? The internal reliability (α) for the four items measuring confidence at completing a degree was .92.

High Impact Engagement Practices (HIEP). Two items measure how 'students' participation in high impact engagement practices enhance their learning performance. Students responded to the following statements: "Participation in high impact engagement activities has improved my performance in my classes"," and "Participation in high impact activities helps me explain my

thoughts better". The internal reliability estimate (α) measuring the items on high impact engagement practices was .74.

Second, we conducted a bivariate correlation to examine the relationship between the EFA derived factors in engineering and computer science education. We observed small to medium relationships between academic achievement goals, course motivation, high impact engagement practices, and confidence at completing a degree (see Table 1). The highest correlation observed was between academic achievement goal and course motivation (r = 0.42). Our results contribute to the literature, which suggests that achievement goal is related to student motivation. For example,[20] found that achievement goal is positively related to student motivation in a physical education setting. [21] posited that the achievement goal is a significant concept derived from motivational research. Results also show a medium correlation between confidence at completing an engineering/computer science degree and students' achievement goals. Besides, there exists a relationship between high impact engagement practices and academic achievement goal. Our results suggest that students who participate in high impact engagement practices, i.e., internship, capstone experiences, and learning communities, are likely to achieve academic goals, despite facing difficult academic tasks. The positive relationship between course motivation and degree completion indicates that students who are motivated and enjoy instructional activities might feel more confident in completing their engineering program.

Table 1. Correlations between EFA extracted factors

		1	2	3	4
1	Academic achievement goals	1	0.42**	0.32**	0.20**
2	Course motivation		1	0.28**	0.12**
3	Degree completion confidence			1	0.09**
4	HIEP				1

**p <0.05

Lastly, we conducted multiple regression analyses to examine the proportion of the variation in the dependent variable (academic achievement goals) explained by the independent variables (i.e., high impact engagement practices (HIEP), course motivation, and confidence at completing a degree). The linearity assumption was assessed by partial regression plots and a plot of studentized residuals against predicted values. The independence of residuals was assessed by Durbin-Watson statistics of 1.773. Homoscedasticity was examined by a plot of studentized values versus unstandardized predicted values. There was no evidence of multicollinearity as assessed by tolerance values greater than .01. There were no studentized residuals greater than ± 3 standard deviation, no leverage values greater than 0.2, and values for ' 'Cook's distance above 1. Also, the assumption of normality was reasonable, as evident by the inspection of the Q-Q plot.

We hypothesized that (1) high impact engagement practices will predict academic achievement goals; (2) course motivation will predict academic achievement goals; (3) confidence at completing a degree will predict academic achievement goals. The regression results indicated that the model explained 23.9% of the variance and that the model statistically predicted

academic achievement goals, $F(3, 489) = 52.45$, $p = .001$, adjusted $R^2 = .24$. This result indicates a linear relationship in the population, and the multiple regression model is a good fit for the data. All three variables added statistically significantly to the prediction, $p < .05$. Regression coefficients and concomitant statistics can be found in Table 2 (below).

Table 2. Multiple regression results for Academic achievement goals

Academic achievement goals	*B*	95% CI for *B*		SE *B*	β	R^2	ΔR^2
		LL	*UL*				
Model						.49	.24***
(Constant)	5.16***	2.57	7.76	1.32			
Academic motivation	.899***	.69	1.11	.11	.35***		
Confidence at completing a degree	.316***	.20	.44	.06	.21***		
HIEP	.273***	.12	.43	.08	.14***		

Note. Model = "Enter" method in SPSS Statistics; *B* = unstandardized regression coefficient; CI = confidence interval; *LL* = lower limit; *UL* = upper limit; *SE B* = standard error of the coefficient; β = standardized coefficient: R^2 = coefficient of determination, R^2 = adjusted ΔR^2.

*$p < .001$.

Findings show that confidence at completing a degree is significantly predictive of academic achievement goals. Besides, course motivation is a strong predictor of academic achievement goals. Specifically, the result shows that an increase in high impact engagement activity is associated with an increase in 'students' academic achievement goals. In sum, these findings suggest that student participation in High Impact Engagement Practices might influence academic achievement goals and course motivation.

Conclusion and Future Directions

One significant contribution of the present study is that it extends existing research on the relationship between achievement goals and student motivation. Our findings show that course motivation is related to achievement goals and is significantly predictive of academic achievement goals. Further, this study shows that an increase in high impact engagement activity is associated with an increase in academic achievement goals. Our results highlight the importance of motivation for instructors. Hence, instructors and educational administrators should encourage more participation in high impact engagement activities for engineering and computer science students. In sum, our findings provide new insights into factors that influence student achievement goals and how student participation in high impact engagement practices could play a role in facilitating course motivation and academic achievement goals.

Future research should investigate other factors that influence academic achievement goals. Future research should also examine, using a moderator analysis, the degree to which course motivation moderates the relationships between high impact engagement practices and achievement goals.

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