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Exploring the Role of STEM Content, Professional Skills, and Support Service Needs in Predicting Engineering Students' Mid-College Academic Success*

KADIR KOZAN
School of Engineering Education, Purdue University, West Lafayette, IN, USA. E-mail: kkozan@purdue.edu

MUHSIN MENEKSE
School of Engineering Education, and Department of Curriculum and Instruction, Purdue University, West Lafayette, IN, USA.
E-mail: menekse@purdue.edu

SAIRA ANWAR
Department of Engineering Education, University of Florida, Gainesville, FL, USA. E-mail: sairaanwar@ufl.edu

This study explored the prediction of undergraduate engineering students' mid-college academic performance by their perceived needs as they relate to science, technology, engineering and mathematics content, professional skills, and support service. To this end, hierarchical multiple regression analyses were employed controlling for college admission test performance, residency, gender, and underrepresented minority status ($N = 2834$). Results revealed that college admission test performance was the strongest predictor, and perceived needs contribute to the prediction of mid-college academic success statistically significantly above and beyond the controlled predictors with a relatively small effect size. Furthermore, perceived needs played a significant role in the medium-size prediction of mid-college academic success in tandem with other predictors. Accordingly, it is reasonable to suggest engineering departments and higher education institutions pay attention to their incoming engineering students' perceived needs and address those needs before they may negatively impact their academic success and potentially retention in their major.

Keywords: academic success; engineering education; mid-college; student needs

1. Introduction

The graduation rate for first- and full-time undergraduate students in the United States starting their college education in 2011 and completing it in the same four-year institution in the following six years was about 60%, which was higher for female students (i.e., 63%) compared to males (i.e., 57%) [1]. The percentage of first- and full-time undergraduate students coming back to the same institution the next fall semester was 81% in Fall 2016 [1]. These statistics indicate that a significant amount of these students switch to other institutions before graduation. It is crucial for universities or colleges to address this issue in any field, including engineering, to survive better in a competitive higher education market. Accordingly, increasing the quality of undergraduate education has become vitally important for higher education institutions.

Due to the increasing demand and need for more engineers in the upcoming years, e.g., [2–5], declining interest levels of secondary school students in becoming an engineer in post-industrial countries, e.g., [6], decreasing enrollment rates in US engineering programs, e.g., [7], and the crucial role of engineering in the knowledge economy, e.g., [8], it becomes significant to explore the predictors of engineering students' academic success at different levels of college education including the relatively more under-explored mid-college period. Specifically, the predictors of mid-college academic success, where a mid-college crisis is more likely to happen, can be of utmost importance and need to be investigated. To serve this purpose, the present study purported to examine how well engineering students' STEM content, professional skills, and support needs at the beginning of their college years would predict their mid-college academic success.

1.1 Engineering Students' First Two Years at College: Perceived Needs, Retention and Academic Success

A perceived need is "an individual's own judgment about the necessity and benefits of a particular service" [9, p. 331] and "need has a multitude of elements depending on a wide array of conditions and circumstances" [10, p. 4]. Thus, perceived needs assessment before and after orientation is a common way of evaluating its effectiveness [11]. Further, different individuals may have different needs since needs represent the internal states of people [12], just like different student profiles may have different needs [13]. For instance, non-traditional students who can be classified based on their

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age, enrollment, and living status can have their own needs [13] that are different from first-generation students who might have conflicts with their family and/or friends on enrolling in college [14]. Likewise, student needs can also differ across gender, race, and in- or out-of-state residency status [11]. Of particular interest for the present study are the perceived needs of engineering students upon entering college and their predictive relation with mid-college academic success.

Goodman et al. [15] reported that female engineering students are most likely to quit their engineering programs in the first and second college years. Likewise, prior research on engineering students' attrition in the freshman year suggested that the first semester is crucial for student success and those who quit "reported disliking engineering" [16, p. 7]. Tseng et al. [17, p. 20] suggested that dissatisfaction with coursework in the first two college years may substantially affect decisions of staying or not in an engineering major, and further stated: "The critical period of transition between the end of the freshman year into the sophomore year is a particularly opportune time to intervene."

Likewise, Meyer and Marx [18, p. 545] highlighted the importance of departmental outreach to engineering students "during their vulnerable first and second years in an engineering program." Tsui [19] reported that a significant number of students leave science, technology, engineering, and mathematics (STEM) during their first two years at college. This finding is not surprising since Holmegaard et al. [20] found that first-year engineering students also face a gap between their expectations and what they experience in their engineering program. Similarly, a lack of understanding of the relationship between theoretical coursework and engineering in the first two college years is a contributor to quitting an engineering program [21]. Accordingly, Ulriksen et al. [22, p. 424] stated that "students' first-year experiences and *the relation* between the students and the institution" have started to gain more attention as a cause for attrition in STEM than students' pre-college readiness.

Perceived needs appear to be directly relevant to academic performance or success as well. Daddona and Cooper [11] found that academic and career-related needs may outweigh emotional and social ones. According to Svanum and Bigatti [23], the main assumption of theories influencing investigations on college success has been that students' level of engagement is a determining factor, and student engagement is closely linked to the quality of higher education, e.g., [24] and need satisfaction, e.g., [25]. Lower success or poorer performance is also closely linked to attrition among engineering students [18] that has traditionally been crucial for universities in the US, e.g., [21]. After all, attrition rates in engineering deserve attention since they can be relatively high in comparison to other disciplines [26].

Previous research identified early academic performance as a robust predictor of engineering students' willingness to continue and complete their engineering program. For instance, Garcia-Ros et al. [26] found that academic achievement in the first year is one of the strongest predictors of student retention in engineering programs in Spain. Therefore, given the increasing number of students who either do not graduate or graduate later than expected [27], the challenges emanating from "the adaptation to university life" [28, p. 573], and that the dropout and degree change rates can become highest in the first college year [29], achieving higher academic performance that promotes student retention is crucial. Of note, Araque et al. [28] also highlighted that academic performance and dropout rates are negatively associated.

Furthermore, even early academic success defined as cumulative grade point average (GPA) seems to be directly related to student retention in engineering in the initial years and later, e.g., [13, 30]. For instance, Burgette and Magun-Jackson [13] highlighted that first semester college GPA can be the strongest predictor of staying for the second year compared to gender, race, and high school GPA. Interestingly, this tendency continued to exist until the fifth year, even though the predictive power of college GPA decreased to a certain degree [13]. In other words, academic performance or success operationalized in the form of cumulative GPA was strongly linked to retention or persistence in every following college year. Likewise, French et al. [30] identified cumulative GPA as the strongest predictor of persistence in engineering. In this regard, Mendez et al. [31] found that high school GPA can be the strongest predictor of college engineering retention, while the first-year GPA can predict STEM persistence most strongly. Another example is Garcia-Ros et al. [26] showing that first year GPA is closely linked to persistence in the sophomore year in engineering. Lastly, Svanum and Bigatti [23] found that mid-career college GPA is mainly related to degree attainment and final GPA, and that mid-career GPA and admission exam scores provide the most insights into future grades. After all, "grades are one of the most extensively used measures of academic success" [32, p. 719].

Overall, the studies discussed above strongly suggest that the first two-year experience is crucial for undergraduate engineering students in which their perceived needs upon entering college may play a key role: As the amount of incoming engineering students' perceived needs increase, their mid-college academic success would decrease. Accordingly, it is reasonable to expect STEM content, professional skills, and support service needs to negatively predict engineering students' mid-college academic success after controlling for their standardized exam scores. Following previous research such as Beck and Davidson [32] who took into account scholastic assessment test scores and high school percentage rank, the present study controlled for standardized exam scores (i.e., the American College Testing [ACT] scores) and explored any possible predictive relationships between the STEM content, professional skills, and support needs of incoming engineering students and their mid-college academic success by addressing the following research question:

- How well can incoming engineering students' STEM content, professional skills, and support service needs predict their mid-college academic success after controlling for standardized exam scores?

2. Methods

2.1 Research Context

This study was conducted in a large, research-focused, Mid-western US university that has 13 engineering majors in which students take the same courses in the first college year before selecting specific engineering majors. Mid-college academic success data were collected after the participants completed their second-year elective or required undergraduate courses with three or four credits, each focusing on fundamental topics ranging from modern mechanics to engineering design thinking and practical applications through various projects and assignments.

2.2 Participants

The participants were 2834 undergraduate engineering students. Specifically, there were 813 female (28.7%) and 2021 male (71.3%) participants consisting of 2421 (85.4%) domestic and 413 (14.6%) international students. Of the domestic ones, 949 (33.5%) participants were residents of the state, while 1885 (66.5%) participants were non-resident. There were also 208 (7.3%) participants who indicated belonging to historically underserved or underrepresented minority (URM) groups. Furthermore, there were 1770 (62.5%) participants who designated themselves as White, while 268 (9.5%) participants as Asian, 125 (4.4%) participants as Hispanic-Latino, 53 (1.9%) participants as African American, 3 (0.1%) participants as American Indian or Alaska Native, and 3 (0.1%) participants as Hawaiian or Pacific.

2.3 Instrument: Student Information Form

The research data emanated from an institutional student information form (SIF) that is a pre-matriculation survey developed by undergraduate academic advisors to collect data from all students upon entering the university so that they know about incoming students before introductory meetings are held at the university orientation and classes start. The SIF included 21 questions mainly asking for personal background (e.g., *What other things do you want your advisor to know about you?*), academic interests and activities at high school (e.g., *What high school experiences would you like your advisor to know about?*), and expectations and career interests (e.g., *Which of the following career areas are of interest to you?*). All the questions required either a *yes* or *no* answer to indicate existence or non-existence or agreeing or disagreeing. Of particular interest for the present study was the SIF question focusing on incoming engineering students' perceived needs or the areas in which they think they would need further assistance in upcoming college years. Specifically, one overarching *check all that apply* type of question (i.e., *During my first year at university, I anticipate needing assistance in the following areas:*) with a blank *other* option to enter text responses provided the research data.

2.4 Procedures

2.4.1 Data Collection

After the institutional review board approval, the data were requested in collaboration with the relevant university offices. The data were collected first in 2015 and 2016 summers prior to the start of classes in fall, and GPA data were collected in 2017 and 2018 summers. An electronic copy of the SIF form created using Qualtrics was distributed to all incoming students via email during the summer before academic orientation. Perceived needs data were collected before the participants started their college engineering life since the induction of engineering students into higher education is crucial, e.g., [33].

2.4.2 Data Preparation

Because the data emanated from a multidimensional dichotomous question asking for a *yes* or *no* response to 12 need areas, the second author, who is an academic expert with substantial experience in science education and engineering education, categorized the 12 need areas into three broader need categories (i.e., STEM content, professional skills, and support services) with an equal number (i.e., four) of need areas per each category: (a) STEM content needs included biology, chemistry, mathematics, and physics; (b) professional skills needs included organization skills, computer skills, reading skills, and writing skills; and (c) support service needs included career counseling, personal counseling, study support, and test anxiety. Each *yes* answer to a need area was assigned one point, and each *no* answer was not assigned any points. Then, researchers calculated the total ratings for each broader need category by adding *yes* (i.e., 1) or *no* (i.e., 0) answers to each other thereby leading to a score range of zero to four.

Originally, there were 2924 cases in the data set; however, 36 of them did not have their GPAs reported, and nine of them had no college admission exam scores or ACT scores, while six reported negative standardized test scores. These 51 cases were eliminated, leading to a total of 2873 cases. There were no missing values in the whole data set. Since the research data violated the normality assumption (the Kolmogorov-Smirnov was significant, $p < 0.001$) and relevant transformations did not work, the data were left as they were. 5% trimmed means did not refer to any substantially extreme scores or outliers. Finally, 39 multivariate outliers were eliminated, resulting in a total of 2834 final cases.

2.4.3 Data Analysis

This study used non-parametric statistics to determine any statistically significant differences. The main analyses used to answer the research question included two hierarchical multiple regression analyses, including theoretically sound predictors (i.e., STEM content, professional and support service needs) and a dependent variable (i.e., mid-college academic success). In the first hierarchical multiple regression analysis, ACT performance was controlled for. Relevant non-parametric tests indicated statistically significant effects of gender, URM status, and residency status on the mid-college academic success that was operationalized as GPAs of engineering students at the end of their sophomore year. Therefore, in the second hierarchical regression analysis, in addition to ACT scores, gender, URM status, and residency status were also controlled for. Finally, all analyses were done using IBM Statistical Package for the Social Sciences or SPSS version 26.

3. Results

The current research examined whether engineering students' STEM content, professional skills, and support service needs can predict their mid-college academic performance after controlling for their ACT scores, gender, URM status, and residency status. This section presents the results of the relevant statistical analyses employed.

3.1 Descriptive Findings

Table 1 indicates that, on average, participating engineering students did not report a high level of perceived needs regarding STEM content, professional, and support needs categories. A Friedman's test comparing levels of these needs yielded statistically significant differences among STEM content, professional, and support needs, χ^2 (2, n = 2834) = 25.5, $p < 0.001$. Following Wilcoxon Signed Ranks Tests showed that while the level of support needs was higher than professional needs (z = 3.52, $p <$ 0.001) there was no difference between (a) STEM content and support needs (z = 1, $p > 0.05$); and (b) STEM content needs and professional needs (z = 2, $p > 0.05$).

3.2 Correlational Findings

Table 2 presents both Pearson (r) and Spearman's rho (r_s) suggesting statistically significant correlations between STEM content needs and GPA, and between ACT and GPA scores. The correlations between ACT scores and GPA turned out to be the largest ones, as shown in Table 2.

3.3 Prediction of Engineering Students' Mid-college Academic Success

A hierarchical multiple regression examined if STEM content, professional, and support service needs as perceived by incoming engineering students improved the prediction of their mid-college

Table 1. Descriptive Findings (N = 2834)

Variables	Possible Minimum	Minimum	Possible Maximum	Maximum	*M*	*SD*
STEM content need	0	0	4	4	0.76	1
Professional need	0	0	4	4	0.71	0.85
Support need	0	0	4	4	0.78	0.83
ACT	1	22	36	36	31.3	2.85
GPA	0	0.182	4	4	3	0.76

Table 2. Correlational Findings (N = 2834)

	1 r (r_s)	2 r (r_s)	3 r (r_s)	4 r (r_s)	5 r (r_s)
1 STEM content needs	–				
2 Professional needs	0.068[a] (0.078[a])	–			
3 Support needs	0.087[a] (0.080[a])	0.281[a] (0.273[a])	–		
4 ACT	–0.217[a] (–0.222[a])	0.063[a] (0.050[a])	–0.042[b] (–0.033[b])	–	
5 GPA	–0.149[a] (–0.181[a])	0.018 (0.008)	–0.017 (–0.010)	0.401[a] (0.417[a])	–

Note. [a]p < 0.01. [b]p < 0.05 (1-tailed).

GPA in addition to their ACT scores. Table 3 displays the initial results, including the constant, the unstandardized regression coefficients (B), and standard errors (SE B), the standardized regression coefficients (β), t values, and the semi-partial correlations (sr^2).

The first model, including only the ACT scores, led to an R^2 value of 0.161 (0.160 adjusted). That is, ACT scores could explain 16.1% of the variance in GPA scores, which was statistically significant, F(1, 2832) = 541.44, p < 0.001. The second model including all the predictor variables produced an R^2 value of 0.165 (adjusted R^2 = 0.163), F(4, 2829) = 139.31, p < 0.001. After controlling for ACT scores in the second model, the perceived needs could explain 0.4% of the variance in GPA, F_{change} (3, 2829) = 4.60, p < 0.004. In other words, adding perceived needs to the model indicated a statistically significant increment in R^2. Lastly, only STEM content needs could negatively relate to mid-college academic success, thus partially confirming our hypothesis that perceived needs would negatively predict mid-college academic success.

Following Mann-Whitney U tests showed that male participants (M = 3.07, SD = 0.75) reported higher GPA compared to female ones (M = 2.83, SD = 0.77), z = –8.20, p < 0.001, and non-URM participants (M = 3.02, SD = 0.76) reported higher GPA than URM ones (M = 2.70, SD = 0.77), z = –5.84, p < 0.001. Further, a Kruskal-Wallis test indicated statistically significant GPA differences among in-state, out-of-state and international students, χ^2 (2) = 46.60, p < 0.001. Relevant pairwise comparisons detected statistically significant GPA differences between in-state (M = 3, SD = 0.77) and international (M = 3.20, SD = 0.74) (z = –6.50, p < 0.001), and between out-of-state (M = 3, SD = 0.75) and international students (z = –6.22, p < 0.001), but not between in-state and out-of-state students (z = –0.86, p > 0.05). Namely, international students reported higher GPA compared to US students. Therefore, two levels of the residency variable, in-state and out-of-state were coded into one single level (i.e., national) while keeping the international level the same. Then, a Mann-Whitney U test confirmed that international students reported higher GPA than US students (M = 3, SD = 0.76), z = –6.80, p < 0.001. Similar Mann-Whitney U tests also showed that residency (z = –5.60), gender (z = –8.85) and belonging to an URM group (z = –9.20) had statistically significant effects on ACT scores (p's < 0.001). Specifically, on average, male (M = 31.65, SD = 2.73), international (M = 32, SD = 2.72) and non-URM (M = 31.50, SD = 2.82) students had higher ACT scores compared to female (M = 30.55, SD = 3), domestic (M =

Table 3. Initial Results: The First Hierarchical Regression (N = 2834)

Model		B	SE B	β	t	sr^2
1	Constant	–0.361	0.145		–2.50	
	ACT	0.107	0.005	0.401[a]	23.70	0.16
2	Constant	–0.210	0.152		–1.38	
	ACT	0.104	0.005	0.387[a]	21.90	0.14
	STEM cont.	–0.050	0.014	–0.065[a]	–3.70	0.004
	Professional	–0.003	0.016	–0.004	–0.20	–
	Support	0.005	0.016	0.006	0.75	–

Note. [a]p < 0.001. Model 1: R = 0.401. R^2 = 0.161. ΔR = 0.160.
Model 2: R = 0.406. R^2 = 0.165. ΔR = 0.163. R^2 change = 0.004.
STEM cont. = STEM content needs. Professional = Professional needs.
Support = Support needs.

Table 4. Final Results: The Second Hierarchical Regression (N = 2834)

Model		*B*	*SE B*	*β*	*t*	sr^2
1	Constant	–0.144	0.152		–1	
	ACT	0.100	0.005	0.375[a]	21	0.13
	Gender	–0.134	0.029	–0.079[a]	–5	0.0060
	URM	–0.130	0.051	–0.044[b]	–3	0.0018
	Residency	0.027	0.020	–0.023	1.33	–
2	Constant	–0.043	0.157		–0.300	
	ACT	0.098	0.030	0.366[a]	20	0.11
	Gender	–0.119	0.040	–0.070[a]	–4	0.0046
	URM	–0.29	0.051	–0.044[b]	–3	0.0018
	Residency	0.026	0.020	0.022	1.30	–
	STEM cont.	–0.041	0.014	–0.053[c]	–3	0.0025
	Professional	–0.003	0.016	–0.004	–0.208	–
	Support	0.008	0.017	0.009	0.500	–

Note. [a]$p < 0.001$. [b]$p < 0.005$. [c]$p < 0.015$. Model 1: $R = 0.411$. $R^2 = 0.169$. $\Delta R^2 = 0.167$. Model 2: $R = 0.414$. $R^2 = 0.171$. $\Delta R^2 = 0.169$. R^2 change = 0.003.
STEM cont. = STEM content needs. Professional = Professional needs.
Support = Support needs. URM = Underrepresented minority.

31.22, SD = 2.86) and URM students (M = 29.54, SD = 2.70) respectively. In order to see whether these statistically significant effects would impact the prediction of mid-college engineering students' GPAs, we employed a second hierarchical multiple regression controlling for ACT scores, gender, URM status, and residency. Table 4 presents the findings.

The first model comprising ACT scores, gender, URM status, and US residency resulted in an R^2 value of 0.169 (0.167 adjusted). In other words, ACT performance, gender, URM status, and US residency status could explain almost 17% of the variance in GPA scores, which was statistically significant, F (4, 2829) = 143.5, $p < 0.001$. In the second model including all the independent variables, there was an R^2 value of 0.171 (adjusted R^2 = 0.169), F (7, 2826) = 83.42, $p < 0.001$. Upon controlling for ACT performance, gender, URM status, and US residency, the perceived needs explained 0.3% of the variance in GPA, F_{change} (3, 2826) = 3, $p < 0.05$. These findings suggest that adding perceived needs to the first model, including ACT scores, gender, URM status, and residency status, showed a statistically significant increment in R^2. Among the perceived needs, only STEM content needs could negatively predict mid-college academic success, which partially confirmed our hypothesis, expecting a negative relationship between perceived needs and mid-college academic success.

4. Discussion

According to Rumpel and Medcof [34, p. 27], "Firms that fully address the needs of their engineers and scientists will be better able to attract, retain, and motivate them." Partly aligning with this claim, the present results suggest that engineering students' perceived needs, as measured upon entering college, may relate to or predict their mid-college academic success. However, not all perceived needs have the same level of relationship with mid-college academic success. As the third strongest predictor, only STEM content needs significantly predicted mid-college academic success, while professional skill needs and support service needs did not have any predictive power. Interestingly, despite the quiet low levels of all needs, including STEM content needs, and the finding that level of support service needs was higher than professional skill needs but was equal to STEM content needs, STEM content need level turned out to be the only predictor of mid-college academic success. Given that success in engineering majors could highly depend on STEM content knowledge, this finding would not be very surprising; however, the negative relationship between even low levels of STEM content needs and mid-college academic success seems to deserve attention.

Parts et al. [35] asserted that engineering students' or graduates' perceived needs might not cover the importance of non-technical competencies before they actually start working as engineers. Therefore, it may not be surprising that the participants, who were incoming engineering students, reported low levels of STEM content, professional skills, and support service needs in the present study. However, a low level of STEM content need negatively predicted mid-college academic success, which suggests that the negative predictive relationship between STEM content needs and mid-college academic success may increase dramatically as the level of such needs increase. Consequently, the identification of engineering students' perceived needs upon entering college would proactively inform engineering education efforts spent on making engineering education more welcoming and effective. In this regard, Haase et al. [36, p. 711] claimed that paying attention to engineering students' entry characteristics is crucial to design "more effective and impactful educational strategies that address the specific needs of these students." Among such entry characteristics, the present study highlights the importance of STEM content needs.

Although professional and support needs did not turn out to be statistically significant predictors of mid-college academic success, it is important to note that they were a part of the group of variables having a medium-size predictive power on the mid-college academic success. Thus, they still deserve attention as complementary factors in addition to academic capability and STEM content. Loyalka [37] highlighted that even though engineering graduates in Brazil, Russia, India, and China now outnumber their counterparts in the US and other developed countries, what would be problematic regarding global competitiveness is not the number but the quality of those engineering graduates. Still, the largest four emerging economies seem to be educating proportionally more quality engineering graduates compared to the developed world, which covers academic achievement, including subject matter knowledge and professional skills [37]. Accordingly, increasing the quality of engineering education would entail caring about engineering students, thereby paying attention to their professional skills, support service, and STEM content needs. This strategy would even work at the course level. For instance, Tendhar et al. [38] reported that instructors' caring about engineering students' success in a first-year undergraduate course could significantly contribute to their engineering identification, perceptions of success and interest in the course. Given that engineering identification is significantly related to engineering students' major and career intentions [38], caring about especially first-year engineering students could be a strong precursor for it. Specifically, because students who have socio-economical disadvantages may be more inclined to leave their major [39], caring about students' needs and success would also help them more.

It is also important to note here that most of the predictive relationships reported here have a small to medium practical significance. Depending on "Cohen's (1988) guidelines for effect sizes (small effect $R^2 = 0.03$ [3%], medium effect $R^2 = 0.10$ [10%], large effect $R^2 = 0.30$ [30%])" [40, p. 673], the predictive power of ACT performance on mid-college academic success has a medium effect size. Together with perceived needs, ACT performance still has a medium-size predictive ability, which suggests that adding perceived needs did not increase the variance explained in mid-college academic success dramatically. In other words, even though perceived needs were associated with a statistically significant increase in the percentage of variance explained in mid-college academic success above and beyond ACT performance, it was a small increase. Adding gender, URM membership, and residency variables in the final hierarchical regression analyses did not change these findings, which implies that the relationship between ACT and mid-college academic success and the contribution of the perceived needs to it may be quite strong.

The results above also align with previous studies. For instance, Beck and Davidson [32] implemented an academic orientation survey with first-semester freshmen students, and the survey scores were able to incrementally predict the participants' end-of-the-first-semester grades in addition to their scholastic assessment test scores and high school percentage rank. The current study added that even insights, which are gained from an authentic orientation survey used by practitioners working at a relevant university office, into incoming engineering students' needs could have predictive power on their sophomore-year cumulative GPAs. Beck and Davidson [32] also claimed that such tools as their academic orientation survey would provide proactive or early warning insights into who can end up with lower grades. The current study also showed that paying attention to first-year incoming students' needs would also help identify who could be at the risk of achieving lower mid-college grades.

As for individual predictors, ACT performance turned out to be the strongest predictor of mid-college academic success in all analyses. In other words, higher ACT performance would predict higher mid-college academic success, thus listing the ACT performance as an important variable. This finding aligns with the earlier results referring to the role of prior knowledge and/or success in different content areas, e.g., [41, 42], and the relationship between ACT performance and selecting a major including engineering [43]. This is also in line with the finding that STEM content need was the only significant predictor of mid-college academic success: Increases in STEM content need level would be associated with decreases in mid-college academic success. Consequently, increasing K-12 students' STEM content knowledge would pay off in the form of increased standardized test performance and mid-college academic success.

After ACT performance, the next strongest predictor of mid-college academic success was gender, which refers to another mid-college success gap in that female students reported lower academic success. This finding complies with studies referring to gender-related discrepancies as they relate to engineering education, e.g., [44, 45]. Therefore, through different interventions such as summer bridge programs, e.g., [46] and peer mentoring, e.g., [47], high schools and engineering colleges can strive to prepare female students for college-level engineering education. The gender discrepancy detected in the present study requires engineering colleges to pay close attention to any possible factors that may lead to females' relatively lower mid-collage academic success. In this respect, Fox et al. [48] claimed that science and engineering programs that associate issues pertaining to female students with contextual or institutional aspects would lead to better results. After all, the calls for not focusing on gender differences but on other factors such as more favorable meaning and experience or familiarity to enhance success expectancy for all students has been around for quite a long time, e.g., [49].

The last predictor was belonging to a historically underserved group or not, which aligns with the research showing problems such student groups would have, e.g., [50, 51] including those existing in the first college year, e.g., [52, 53]. Specifically, belonging to a historically underserved group predicted less mid-college success, which deserves special attention on the part of engineering colleges to focus on other possible underlying reasons whose solutions would bring up long-term beneficial results. However, it is important to note here that historically underserved group membership had the weakest link with mid-college academic success in a selective but diverse institutional context that encourages collaborative work among engineering students.

Statistical tests also showed that there were gender, residency, and URM status differences in terms of not only mid-college academic success but also ACT scores. In other words, the categorical predictors of engineering students' mid-college academic success had mid-college academic GPA and ACT score differences among their levels, which indicates that college admission exam performance may deserve attention. More specifically, removing college admission exam score differences or prior readiness in a sense and increasing it to a certain level for all learners would also eliminate the negative predictive power of residency, gender, and belonging to a historically underserved group, thereby bridging the existing gaps among certain groups and increasing their mid-college academic success. One might still argue that what ACT and similar instruments test and what GPA measures relate to each other closely; therefore, it is not surprising to find such predictive relationships. Addressing such an argument is completely beyond the current study; however, this study does not deny the need for alternate measures and GPA regimes. Overall, the present results suggested that incoming engineering students' perceived needs pertaining to especially STEM content would negatively relate to their mid-college academic success even in selective engineering programs and higher education institutions offering a wide range of student support.

Given the limitations of the study, the present results should be approached carefully. First, Litzler and Young [54] emphasized including student experiences and perceptions ranging from academic confidence to interaction with others in research on attrition in engineering as they strongly influence GPA. Similarly, Litzler et al. [55] stated that even some minority groups' lower levels of STEM confidence might disappear after taking into account other factors ranging from student experiences to perceptions. However, such variables were not included in the present study, and this study did not have persistence, drop-out, and final degree GPA data either. Accordingly, future research may look at more complex models of the relationships, including those that happen both until mid-college and after it to gain deeper insights into how to enhance academic success optimally in a given context. To illustrate, Clifton et al. [56] identified few differences between male and female college students regarding their academic achievement and claimed that all students could enhance their coping strategies and academic control. Similarly, Flynn [57] revealed that academic and social engagement could directly influence degree attainment of undergraduate students at four-year institutions independent of individual and institutional factors while Fosnacht et al. [58] yielded that first-year students' time use would impact their level of engagement. After all, ACT does not seem to be the only indicator of prior academic performance, and further research can use other indicators, including high school class rank and semester GPAs together with it [59].

In other words, this study explored the prediction of second-year cumulative GPA only since its focus was on mid-college academic success, and a longitudinal prediction research design can be employed to see the extent to which current predictors and more could contribute to the prediction of college-level academic success over the whole undergraduate engineering education. Specifically, more longitudinal and follow up studies could focus on the prediction of end-of-year GPA in a year-by-year fashion to picture the evolution of the predictive relationships over time, which would provide more specific insights into what would work in what year.

Further similar research can also be run to predict engineering students' retention or permanence in addition to their academic success levels over their undergraduate years.

Multiple regression analyses provide relationship insights, not causality [60], and different results can be achieved with different variables in different samples [61]. Tabachnick and Fidell [60] further claimed that even a strong relationship could emanate from some other variables not included in a regression model. These points strongly suggest robust cross-validations of the present multiple regression results using different variables in different samples and contexts even though they align with similar results in computer science, e.g., [62]. Finally, another factor impacting the current regression results would be the type and nature of the student information form. It had not been originally developed for research purposes and had been used for collecting descriptive data purposes by a specific university office and its experts. Consequently, further research is more than welcome to use other types of instruments calibrated to collect relevant data in more statistically appropriate ways.

5. Conclusions

The current results diagnosed college admission exam performance, gender, URM status, and STEM content needs as predictors of mid-college academic success, thereby leading to some valuable practical conclusions and implications. From a practical perspective, higher education institutions would be better off paying attention to their incoming engineering students' prior readiness including STEM content needs and taking precautions on time to address any possible disadvantages students with possible lower levels of readiness would have. While doing so, institutions and relevant authorities should not forget that what underlies the negative predictive relationships between demographic variables and mid-college academic success can be directly related to incoming students' prior readiness for college education or other possible variables. This point is crucially important in order not to assign any innate or unchangeable aspects to academic success differences, and to detect the main underlying reasons in a given context without developing any biases against any group of learners. Overall, as a crucial component of incoming engineering students' readiness, their STEM content needs would need to be addressed as early as possible so that they would have higher readiness and mid-college academic success, which would further determine whether they will continue their engineering programs and/or pursue STEM careers. Otherwise, the current results concluded that as the STEM content needs increase, engineering students' mid-college academic success would decrease over time.

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Kadir Kozan is now a Research Associate coordinating research and online program development in the Department of Educational Studies at Purdue University with a main research interest focusing on the design, development and evaluation of evidence-informed learning experiences and technology integration as well as the factors impacting students' learning and academic performance. His research has been published in top-tier journals, which has also directly informed his teaching experiences at K-12, middle school, and university levels for more than 12 years. Dr. Kozan has also been part of various professional development, learning design, and performance improvement projects in which he has managed community and/or research partnerships with different stakeholders.

Muhsin Menekse is an Assistant Professor at Purdue University with a joint appointment in the School of Engineering Education and the Department of Curriculum & Instruction. Dr. Menekse's primary research focus is on exploring K-16 students' engagement and learning of engineering and science concepts by creating innovative instructional resources and conducting interdisciplinary quasi-experimental studies in and out of classroom environments. Dr. Menekse is the recipient of the 2014 William Elgin Wickenden Award by the American Society for Engineering Education. Dr. Menekse also received three Seed-for-Success Awards (in 2017, 2018, and 2019) from Purdue University's Excellence in Research Awards programs in recognition of obtaining three external grants of $1 million or more during each year. His research has been funded by grants from the Institute of Education Sciences (IES), Purdue Research Foundation (PRF), and National Science Foundation (NSF).

Saira Anwar is an Assistant Engineer at the Department of Engineering Education, University of Florida. Dr. Anwar has over 12 years of teaching experience, primarily in the discipline of computer science and software engineering. Her research focuses on studying the unique contribution of different instructional strategies on students' learning and motivation. Also, she is interested in designing interventions that help in understanding conceptually hard concepts in STEM courses. Dr. Anwar is the recipient of the 2020 outstanding researcher award by the School of Engineering Education, Purdue University. Also, she was the recipient of the "President of Pakistan Merit and Talent Scholarship" for her undergraduate studies.