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How much does readiness matter? An examination of student persistence intention and engineering identity

Mr. Syahrul Amin, Texas A&M University

Syahrul Amin is a PhD candidate in Curriculum and Instruction at Texas A&M University. He is Experienced in conducting numerous STEM education research projects and skilled in working in collaborative environments to collect and evaluate research data for a variety of STEM education projects. He is also experienced in K-16 teaching for over 8 years. His research interests focus on science education, engineering education, GT education, and international comparisons in STEM education.

Miriam Marie Sanders, Texas A&M University

Miriam Sanders is a PhD student studying Curriculum and Instruction with an emphasis in Mathematics Education at Texas A&M University. Through her research she seeks to address issues of equity and diversity in STEM education with a focus in mathematics

Aaron E. Kidd, Texas A&M University

Aaron Kidd is a doctoral candidate at Texas A&M University and the Program Coordinator for an NSF grant-funded program in the Department of Integrative Biology at Oklahoma State University. His research interests revolve around teacher-specific behaviors that drive science instruction and the preparation of new science teachers to integrate such behaviors into their own teaching.

Dr. Karen E. Rambo-Hernandez, Texas A&M University

Karen E. Rambo-Hernandez is an associate professor at Texas A & M University in the College of Education and Human Development in the department of Teaching, Learning, and Culture. In her research, she is interested in assessing the effect of curricular interventions on student career development.

How much does readiness matter? An examination of student persistence intention and engineering identity

Syahrul Amin, Miriam Sanders, Aaron Kidd, Karen Rambo-Hernandez
Texas A&M University

Abstract

This complete research paper will describe the relationship between first-year engineering students' intentions to persist and their engineering "readiness" to embark on their educational endeavors within their engineering program upon constructing their identity as an engineer. Typically, first-year students are eligible to take engineering coursework immediately once they have already taken the prerequisite courses. However, some students may not have taken the prerequisite courses, which could disqualify them from immediately taking their engineering coursework. At the university where the data were collected, students are admitted to engineering in a general track with or without having the prerequisite courses (e.g., being calculus ready). However, those who do not have the prerequisite courses must complete them before enrolling in engineering classes. In this study, we use Social Cognitive Career Theory (SCCT) framework and Identity Development framework to investigate whether these relationships differ between (a) students who entered as first-year students with the prerequisites to immediately begin taking engineering course work (*on-track students*) or (b) students who were delayed in beginning their engineering coursework (*off-track students*). Specifically, we examine the persistent intentions and engineering identity development for the two groups of students. To address our research questions, we employ Hierarchical Linear Models (HLM) in which 280 engineering students (*n* =152 on-track, *n*= 128 off-track) are clustered within 25 engineering classes (*n*=12 on-track, *n*=13 off-track). The results indicate that: (1) student biological sex and outcome expectations are statistically significant predictors of persistence intentions amongst engineering undergraduates—specifically, students who identify as male have higher intentions to persist than those who identify as female, and (2) these effects do not differ between on-track or off-track students. Additionally, (3) the moderation effect of biological sex on self-efficacy is not statistically significant when predicting student engineering identity—indicating that neither male nor female students perceive their engineering identity and self-efficacy differently. Finally, the effect of self-efficacy on engineering identity formation does not differ between on-track and off-track students. Implications and future research directions are discussed.

Introduction

Despite efforts to bolster the science, technology, engineering, and mathematics (STEM) career pipeline, the underrepresentation of historically marginalized groups such as women and People of Color (POC) persists [1] - [3]. The continuation of the diversity deficit in STEM is concerning due to the skill, vitality, and imagination that is sieved from the STEM professional field. Moreover, disproportionate persistence in STEM fields is not the result of a lack of interest of underrepresented student groups [4]. The 2012 report from the President's Council of Advisors on Science and Technology, reports that of students entering undergraduate degree programs under 40% enter a STEM degree program. In the last 60 years, nearly half of the engineering students in U.S. institutions abandoned their majors before graduation [1]. Furthermore, from

2015-2016, 18% of conferred undergraduate degrees were in STEM fields [2]. Less than 50% of undergraduate degrees in STEM fields were earned by non-white and non-Asian students [2]. Moreover, only 36% of undergraduate degrees in STEM fields were earned by female students [2]. As such, undergraduate students entering college arrive with varying levels of readiness. Students' college readiness can impact their timeline to graduation with increased remedial course loads as well as their abilities to successfully complete competitive degrees such as engineering. Thus, to mitigate the diversity deficit and high attrition rates in engineering, factors that influence students' persistence in engineering undergraduate degree programs and engineering identity development are increasingly studied.

Theoretical Framework

Earning undergraduate engineering degrees holds the direct implication that students with these conferred degrees are eligible for employment in the engineering field post-graduation [5]. As such, the acknowledgment of undergraduate engineering students' intent to enter professional engineering roles has spurred research into the process of how students become engineers and subsequently how students develop engineering identities [5] - [8]. In this study, we utilize Social Cognitive Career Theory [9] and Engineering Identity Development framework [6] to examine students' persistent intentions and engineering identity development.

Social Cognitive Career Theory (SCCT) framework

SCCT [9] is a comprehensive framework that accounts for the career development process [10] and expands Bandura's [11] social cognitive theory, asserting that interests arise from self-efficacy and outcome expectations. Lent et al. [9] posit that student matriculation into a career is a function of multiple constructs (e.g., self-efficacy for engineering-specific tasks, and outcome expectations for the engineering field) and the relationships between them which are situated within a socially constructed environment. Due to its utility for the analysis of students' collegiate decision-making, SCCT [9] is widely used in STEM persistence research and more specifically applied to engineering students [12] - [14]. Garriott et al. [15] further support this with findings including that outcome expectations and self-efficacy were the predictors of engineering persistence intentions in first-generation college students. Moreover, SCCT assists in understanding career interests and major choice goals of racially diverse students in engineering [12], [16].

Engineering identity development framework

An individual's professional identity includes personal identification with elements of the professional role such as duties, responsibilities, and knowledge [17]. As such, undergraduate engineering students may develop their engineering identities by engaging with engineering learning experiences, forming a definition of the profession, intra- and interpersonal identification as an engineer, and assimilating their existing identities with their professional ones [8], [17], [18]. However, current U.S. accredited engineering programs and ABET learning outcomes primarily emphasize the development of students' professional skills for future careers. Thus, Atadero et al. [6] proffer that engineering curricula or faculty do not always intentionally facilitate educational opportunities for students to engage in engineering identity development.

Recent research highlights the “uncomfortable” or “unwelcoming” climate in engineering programs for historically marginalized groups such as women and people of color [19] - [22]. Facing instances of sexism and/or racism in engineering programs can interfere with the students’ engineering identity development, as they may not feel recognized as an engineer.

The Present Study

Hence, we utilize the two frameworks: (1) Social Cognitive Career Theory (SSCT) framework; (2) engineering identity development framework to investigate the relationships between biological sex, self-efficacy, outcome expectations, and students’ intentions to persist in engineering and their engineering identity. A well-known predictor of student intent to remain within engineering is outcome expectation [15], [23]. Moreover, the strength of outcome expectation on intent to persist in engineering is stronger for individuals from minoritized ethnic and racial groups [10], [24]. As such, the interplay between outcome expectations and self-efficacy has been shown to hold important roles in ultimate academic and career success [25]. Some studies examining biological sex have observed significant differences in persistence intentions between male and female engineering students [26] - [31]. However, the extant literature has not consistently detected the effects of biological sex, self-efficacy, and outcome expectations on students’ persistence intentions as well as their engineering identity. Additionally, a positive engineering identity has a significant, positive effect on persistence in effort [32]. To this end, this study investigates whether self-efficacy, outcome expectations, and biological sex predict students’ persistence intentions in engineering and engineering identity.

Furthermore, we examine whether students in two different engineering introductory courses at the sample university differed in relation to their persistence intentions and engineering identity. At the university, there are two introductory courses in engineering: 1) Engineering 1 is for students who were delayed in beginning their engineering coursework (*off-track students*); and 2) Engineering 2 for students who entered as first-year students with the prerequisites to immediately begin taking engineering coursework (*on-track students*). To this end, we seek to answer the following research questions:

Persistence Intentions

1. Does the effect of engineering students’ self-efficacy and outcome expectations on their intentions to persist in engineering vary depending on biological sex?
2. Do “off-track” engineering students’ self-efficacy, outcome expectations, and biological sex relate to their intentions to persist in engineering in the same way as “on-track” students?

Engineering Identity

3. Does the relationship between engineering students’ self-efficacy and their engineering identity vary depending on biological sex?
4. Do the “off-track” engineering students’ self-efficacy relate to their engineering identity in the same way as “on-track” students?

Methods

Participants

The sample of this study includes engineering students from a large R1 university in the Mid-Atlantic Region. At the time of the data collection in Spring 2021, participants were enrolled in either one of two types of engineering introductory courses: Engineering 1 & Engineering 2. Engineering 1 is for students who were delayed in beginning their engineering coursework (*off-track students*). Engineering 2 is for students who entered as first-year students with the prerequisites to begin taking engineering coursework (*on-track students*) immediately. The total sample size is 280 engineering students (*n* =152 on-track, *n*= 128 off-track) who are clustered within 25 sections of Engineering 1 or 2 (*n*=12 on-track, *n*=13 off-track) with approximately 74% of students self-identifying as biological males (Table 3).

Study Procedures

After receiving IRB (Institutional Review Board) approval, surveys were administered to engineering students in both two introductory but sequential engineering courses. Thus, some students were in the first course and others were in the second. We employed non-probability sampling in which engineering students taking the engineering course were required to take two online surveys (pre- and post-surveys) as this assignment constituted approximately 1% of their total grade. However, students were provided the option to opt-out of the research. Only individuals who provided proper consent were included in this dataset. We utilize data collected from identical items on the pre- and post-surveys. The pre-survey was administered within the first two weeks of class and the post-survey was administered two weeks before final exams.

Measures

There were three items measuring outcome expectations for engineering adapted from Lent et al. [13], six items measuring intentions to stay in engineering adapted from Lent at al. [13], three items measuring self-efficacy adapted from Lent et al. [13], and five items measuring engineering identity adapted from Chemers et al. [33] & Estrada et al. [34]. Table 1 provides the sample survey items for all four surveys used in this study. Table 2 provides the summary of descriptive statistics of continuous predictors and categorical variables. The Cronbach's alpha coefficients across all subscales were also estimated with values ranging from 0.85 to 0.89 indicating acceptable internal consistency (Table 2).

Missing Data

Prior to analysis, the dataset was examined for missing data. Missing rates in the current dataset were deemed fair (1.07 - 30.0%). Of 280 cases, 194 cases had completed data on all measurement occasions. Little's test of missing completely at random (MCAR) was statistically significant (χ^2 [27] = 55.99, *p*=0.0009), indicating that missingness of one variable (e.g., persistence intentions) is not related to other variables (e.g., self-efficacy, outcome expectations, engineering identity). To address the missingness issue in our dataset, the listwise deletion approach was employed using STATA version 17.0 software.

Table 1
The four surveys used in this study

Type of Survey	Sample Survey item
Outcome expectations	Graduating with a BS degree in engineering will likely allow me to do work that I would find satisfying (Likert scale: 1-7)
Persistence Intentions	I intend to major in an engineering field (Likert scale: 1-7)
Self-efficacy	How much confidence do you have in your ability to excel in your engineering major over this current semester (Likert scale: 1-5)
Engineering identity	In general, being an engineer is an important part of my self-image (Likert scale: 1-7)

Note. Outcome expectations, persistence intentions, self-efficacy items were created based upon Lent et al. [13] and engineering identity survey items were created based on Chemers et al. [33] & Estrada et al. [34].

Data Analysis

Plan of Analysis

All statistical analyses of this study were conducted utilizing STATA version 17.0 statistical software. Prior to running the HLM model analyses, normality of continuous variables was pre-screened (skewness and kurtosis), and the ICC (Intraclass Correlation Coefficient) was estimated to confirm whether employing two-level hierarchical linear models (HLM) was necessary to address our research questions. Model predictors (self-efficacy, outcome expectations, biological sex, course type, and their interactions) were selected based upon current literature suggesting their role in predicting engineering persistence and engineering identity. Continuous variables (self-efficacy and outcome expectations) were grand-mean centered, and multiplicative terms were formed for the examination of same-level moderation effects. Categorical variables (biological sex and course type) were dummy-coded. Outlier screening occurred following initial model construction by examining the residuals to identify the potential outliers by indicating cases with the large residuals. The boxplots of residuals were employed with the cutoff values of ± 3 based upon their standardized residuals. Cases identified as outliers were removed from the analyses. To answer all four research questions, the following final models were selected, constructed, and estimated:

<u>Persistence Intentions</u>

1. *Does the effect of engineering students' self-efficacy and outcome expectations on their intentions to persist in engineering vary depending on biological sex?*

Level 1: $\text{Engineering Persistence Intentions}_{ij} = \beta_0 + \beta_{1j}\text{SelfEfficacy}_{ij} + \beta_{2j}\text{Outcome Expectations}_{ij} + \beta_{3j}\text{Male}_{ij} + \beta_{4j}\text{OutcomeExpectationsXMale}_{ij} + \beta_{5j}\text{SelfEfficacyXMale}_{ij} + e_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta_{1j} = \gamma_{10} + u_{1j}$

$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30}$
$\beta_{4j} = \gamma_{40}$
$\beta_{5j} = \gamma_{50}$

2. *Do "off-track" engineering students' self-efficacy, outcome expectations, and biological sex relate to their intentions to persist in engineering in the same way as "on-track" students?*
   Level 1: $\text{Engineering Persistence Intentions}_{ij} = \beta_0 + \beta_{1j}\text{SelfEfficacy}_{ij} + \beta_{2j}\text{OutcomeExpectations}_{ij} + \beta_{3j}\text{Male}_{ij} + e_{ij}$
   Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\text{CourseType}_{ej} + u_{0j}$
   $\beta_{1j} = \gamma_{10} + \gamma_{11}\text{CourseType}_{ej} + u_{0j}$
   $\beta_{2j} = \gamma_{20} + \gamma_{21}\text{CourseType}_{ej}$
   $\beta_{3j} = \gamma_{30} + \gamma_{31}\text{CourseType}_{ej}$

Engineering Identity:

3. *Does the relationship between engineering students' self-efficacy and their engineering identity vary depending on biological sex?*
   Level 1: $\text{Engineering Identity}_{ij} = \beta_0 + \beta_{1j}\text{SelfEfficacy}_{ij} + \beta_{2j}\text{Male}_{ij} + \beta_{3j}\text{SelfEfficacyXMale}_{ij} + e_{ij}$
   Level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$
   $\beta_{1j} = \gamma_{10} + u_{1j}$
   $\beta_{2j} = \gamma_{20}$
   $\beta_{3j} = \gamma_{30}$

4. *Do the "off-track" engineering students' self-efficacy relate to their engineering identity in the same way as "on-track" students?*
   Level 1: $\text{Engineering Identity}_{ij} = \beta_0 + \beta_{1j}\text{SelfEfficacy}_{ij} + e_{ij}$
   Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}\text{CourseType}_{ej} + u_{0j}$
   $\beta_{1j} = \gamma_{10} + \gamma_{11}\text{CourseType}_{ej} + u_{1j}$

Rationale for Hierarchical Linear Modeling

Intra-Class Correlation Coefficients (ICC) were estimated prior to analysis, utilizing the null model to test for variability between engineering courses. Though ICC estimates were low (~0), students were grouped into distinct engineering courses in which the classroom environment, course instructor, pace of the classroom, etc. may have an unidentified impact upon student self-efficacy, engineering identity, outcome expectations, and persistence intentions. Further, though ICC indicates low variability between classes, and instead that the variability exists within classes, the clustered nature of this study design suggests that HLM was an appropriate strategy for analysis [35].

Model Selection

Model construction occurred through an identical model selection approach for each research question. Due to our small sample size, initial models were estimated using the restricted maximum likelihood (REML) method, with an unstructured framework in which variances and covariances were uniquely estimated. Subsequent models reduced complexity by first removing covariances, then removing random effects for each individual predictor. Model fit was examined utilizing model performances indices: Akaike Information Criteria (AIC) and Bayes Information Criteria (BIC) and final models were selected according to lowest reported values. Significance for fixed effects was examined using *t*-tests with the Satterthwaite approximation utilized for the computation of degrees of freedom.

Assumption Checking

We examined the assumptions for our HLM models by checking the correct specification of the form of relationship among the variables, normality of the residuals, as well as the homoscedasticity of the residuals. Results indicated that the residual variance was similar for off-track (course type =1) and on track (course type=0). The multivariate normality of level-2 random effects was also met (i.e., skewness and kurtosis were still within an acceptable range). The homoscedasticity of level-2 random effects indicated the variance of u_{0j} was greater for on track than that of off-track.

Results

Summary of descriptive statistics and residual analyses generally indicated that there were no violations of normality and homoscedasticity of the data for linear statistical models (Table 2 & Table 3). Although the intraclass correlation (ICC) indicated low variability between classes, and that the variability exists within classes, the clustered nature of this study design suggests that HLM is still an appropriate strategy for analysis [35]. Consistent with SCCT, student outcome expectations and self-efficacy were strongly correlated with intentions to persist, and self-efficacy was also correlated with engineering identity (Table 4).

Table 2
Descriptive statistics of continuous variables

Variable	N	α	Mean	SD	Min	Max	Skewness	Kurtosis
Student level								
Self-efficacy	280	0.89	3.91	0.74	2.00	5.00	-0.1970	2.4438
Outcome expectations		0.86	6.02	0.93	1.00	7.00	-1.5381	7.2610
Persistence intentions		0.85	6.01	1.09	1.00	7.00	-1.7627	6.9248
Engineering identity		0.93	5.27	1.41	1.00	7.00	-0.7953	3.1295

Table 3

Descriptive statistics of categorical variable

Variable	*N*	Percent
Student level		
Student biological sex		
Male	208	74.29
Female	72	25.71
School level		
Engineering course type		
Engineering 1	128	45.71
Engineering 2	152	54.29

Note. N represents the number of students within each group. There were 25 engineering classes in total (engineering 1: 13 classes and engineering 2: 12 classes).

Table 4

Correlation matrix among variables

	1	2	3	4	5	6
Persistence intentions	1.0000					
Self-efficacy	0.2306***	1.0000				
Outcome expectations	0.6364***	0.2874***	1.0000			
Engineering identity	0.5601***	0.2281***	0.7130***	1.0000		
Male	0.1113	0.0517	-0.0055	0.0090	1.0000	
Course type	-0.0285	-0.0325	0.0267	0.0484	0.0642	1.0000

Note. *** indicates $p<0.001$

Research Question 1: *Does the effect of engineering students' self-efficacy and outcome expectations on their intentions to persist in engineering vary depending on biological sex?*

Our final HLM model analysis indicated that biological sex ($t(185.3) = 2.51$, $p<.05$, 95% CI =[0.07, 0.57]) and outcome expectations ($t(179.7) = 7.46$, $p<.001$, 95% CI = [0.72, 1.24]) were statistically significant predictors of persistence intentions among engineering undergraduates. Specifically, students who identified as male have higher intentions to persist than those who identified as female. However, the moderation effect of biological sex upon either self-efficacy or outcome expectation was not statistically significant (Table 5). Estimation of Bryk-

Raudenbush R^2 suggests that this model explains approximately 44.71% of the variance within classes (student-level).

Table 5
HLM analysis results for RQ1

Parameters	Estimates	*SE*	*z*	*p*	95% CI
Intercept	5.77	0.11	51.91	<0.001*	[5.56, 5.99]
Male	0.32	0.13	2.51	0.012*	[0.07, 0.57]
Self-Efficacy	0.29	0.16	1.83	0.067	[-0.02, 0.60]
Outcome Expectations	0.98	0.13	7.46	<0.001*	[0.72, 1.24]
Male*Self-Efficacy	-0.26	0.18	-1.46	0.144	[-0.60, 0.08]
Male*Outcome Expectations	-0.29	0.15	-1.92	0.054	[-0.58, 0.00]
Random-Effects					
Var (Self-Efficacy)	0.06	0.52			[0.01, 0.31]
Var (cons)	0.00	0.02			[0.00, 1.84]
Var (level-1 residuals)	0.59	0.06			[0.48, 0.74]

Note. N individuals = 195, N groups = 25. * indicates statistically significant. Male was coded 1, female was coded 0.

Research Question 2: *Do "off-track" engineering students' self-efficacy, outcome expectations, and biological sex relate to their intentions to persist in engineering in the same way as "on-track" students?*

Our final HLM model analysis revealed that outcome expectations was the only statistically significant predictor of persistence intentions among engineering undergraduates ($t(183.1) = 8.61$, $p<.001$, 95% CI =[0.60, 0.96]). Biological sex, self-efficacy, and course type were not statistically significant predictors. Further, the interaction effects between student course type and their self-efficacy, biological sex, and outcome expectations were not statistically significant (Table 6). That is, these effects did not differ between on-track or off-track engineering students. In addition, estimation of Bryk-Raudenbush R^2 suggested that this model explains approximately 45.11% of the variance within classes.

Table 6
HLM analysis results for RQ2

Parameters	Estimates	*SE*	*z*	*p*	95% CI
Intercept	5.96	0.16	37.02	<0.001*	[5.64, 6.28]

Male	0.08	0.17	0.50	0.615	[-0.26, 0.44]
Self-Efficacy	-0.03	0.14	-0.23	0.818	[-0.30, 0.23]
Outcome Expectations	0.78	0.91	8.61	<0.001*	[0.60, 0.96]
Course Type	0.06	0.14	0.37	0.711	[-0.25, 0.37]
Male*Course Type	-0.47	0.26	-1.82	0.069	[-0.98, 0.04]
Self-Efficacy*Course Type	0.28	0.21	1.35	0.176	[-0.13, 0.68]
Outcome Expectations*Course Type	-0.04	0.13	-0.33	0.744	[-0.30, 0.21]
Random-Effects					
Var (Self-Efficacy)	0.62	0.57			[0.01, 0.38]
Var (cons)	0.03	0.03			[0.00, 0.30]
Var (level-1 residuals)	0.60	0.07			[0.48, 0.75]

Note. N individuals = 195, N groups = 25. * indicates statistically significant. Male was coded 1, female was coded 0. On-track was coded 0, off-track was coded 1.

Research Question 3: *Does the relationship between engineering students' self-efficacy and their engineering identity vary depending on biological sex?*

Based on the final HLM model analysis, neither biological sex nor self-efficacy were statistically significant predictors for the development of an engineering identity. Similarly, the moderation effect of biological sex upon self-efficacy was not a statistically significant predictor of student engineering identity (Table 7). That is, the moderation effect of biological sex on self-efficacy was not statistically significant when predicting student engineering identity—indicating that neither male nor female students perceive their engineering identity and self-efficacy differently. Additionally, Bryk-Raudenbush R^2 suggested that this model explains approximately 5.27% of the variance within classes.

Table 7
HLM analysis results for RQ3

Parameters	Estimates	*SE*	*z*	*p*	95% CI
Intercept	-0.01	0.19	-0.03	0.972	[-0.37, 0.36]
Male	-0.03	0.22	-0.14	0.892	[-0.46, 0.40]
Self-Efficacy	0.80	0.25	0.32	0.751	[-0.41, 0.57]
Male*Self-Efficacy	0.53	0.30	1.80	0.072	[-0.05, 1.11]

Random-Effects					
Var (Self-Efficacy)	0.04	0.11			[0.00, 6.23]
Var (cons)	0.01	0.00			[0.00, 0.00]
Var (level-1 residuals)	1.87	0.20			[1.52, 2.30]

Note. N individuals = 194, N groups = 25. * indicates statistically significant. Male was coded 1, female was coded 0.

Research Question 4: *Do the "off-track" engineering students' self-efficacy relate to their engineering identity in the same way as "on-track" students?*

Regarding our last research question, we estimated an HLM model in which we found that student self-efficacy was a statistically significant predictor of student engineering identity ($t(12.0) = 2.32$, $p<.05$, 95% CI =[0.07, 0.83]). Conversely, the effect of self-efficacy on engineering identity formation among engineering undergraduates did not differ between on-track and off-track students (Table 8). In addition, Bryk-Raudenbush R^2 suggested that this HLM model explains approximately 4.37% of the variance within classes, and approximately 0% of the variance between classes.

Table 8
HLM analysis results for RQ4

Parameters	Estimates	*SE*	*z*	*p*	95% CI
Intercept	-0.11	0.14	-0.84	0.404	[-0.38, 0.15]
Self-Efficacy	0.45	0.19	2.32	0.021*	[0.07, 0.83]
Course Type	0.22	0.20	1.10	0.271	[-0.17, 0.61]
Self-Efficacy*Course Type	0.03	0.30	0.12	0.905	[-0.54, 0.61]
Random-Effects					
Var (Self-Efficacy)	0.05	0.13			[0.00, 10.63]
Var (cons)	0.00	0.00			[0.00, 0.00]
Var (level-1 residuals)	1.89	0.20			[1.54, 2.33]

Note. N individuals = 194, N groups = 25. * indicates statistically significant. Male was coded 1, female was coded 0. On-track was coded 0, off-track was coded 1.

Discussion & Implications

The current study amplifies the extant literature on SCCT by examining the relationships between the SCCT constructs (i.e., self-efficacy, outcome expectations) as well as student biological sex on both their engineering persistence and engineering identity. Furthermore, we expand the model by factoring the different types of engineering introductory courses (i.e., Engineering 1 and Engineering 2) into our statistical models. The study findings highlight the statistically significant correlation between student self-efficacy, outcome expectations, intentions to persist in engineering as well as their engineering identity (Table 5). This finding is consistent with existing literature on how these constructs affect one another [9], [12], [14]- [15], [25], [36] - [38]. Conversely, the correlation matrix suggests that there was no correlation between students' biological sex and their engineering introductory course with other SSCT constructs (Table 5).This particular finding is not consistent with current literature in which student biological sex was found to be associated with SCCT constructs [39] - [40].

In summation, the HLM analysis results highlight that: (*RQ1*) student biological sex (*n* female = 72; *n* male=208) and outcome expectations are statistically significant predictors of persistence intentions amongst engineering undergraduates—specifically, students who identify as male have higher intentions to persist than those who identify as female, and (*RQ2*) these effects do not differ between on-track or off-track students. The significance of the predictor of biological sex on persistence in an undergraduate engineering program with students who identify as male demonstrating higher intentions to persist than their female counterparts further support the findings of [41]-[42]. However, there has been mixed evidence with respect to persistence intentions and student biological sex, highlighting that female and male engineering student demonstrate the same persistence intentions [43]. Moreover, our findings regarding outcome expectations are consistent with the extant literature [15], [23]. Further, although there was no statistical difference between on- and off-track students in terms of intent to persist in engineering, Van Dyken et al. [44] found that less than 12% of graduating engineers started in a non-college level mathematics course. Due to the low percentage of engineering students graduating with a course sequence that includes remedial courses, further research should be conducted to additionally examine the relationship between remedial course completion and persistence in engineering over time. Additionally, (*RQ3*) the moderation effect of biological sex on self-efficacy is not statistically significant when predicting student engineering identity—indicating that neither male nor female students perceive their engineering identity and self-efficacy differently. Previous studies have found that engineering students' self-efficacy predicted their engineering identity [45]. However, our non-statistically significant findings on this moderation do not support Buontempo et al.'s [46] findings that self-efficacy of female and male students varied in relation to their engineering identity. Finally, (*RQ4*) the effect of self-efficacy on engineering identity formation does not differ between on-track and off-track students. Conversely, Marshman et al. [47] reported that college students in different introductory STEM courses had different self-efficacy, noting that female students had lower self-efficacy compared to their male counterparts. However, with regard to students' engineering identity, we did not find any significant differences between self-efficacy of students who were in Engineering 1 and Engineering 2.

These results may provide support for admitting students into engineering tracks without the necessary prerequisite courses because once prerequisite courses were in place, students' engineering identity and intentions to persist were indistinguishable from their on-track peers. This recommendation should be taken with caution as engineering colleges and their departments should be cognizant of the importance of other courses that should be counted as graduation requirements rather than core entry requirements. For instance, chemistry and physics may not be as important for early entry into engineering programs, but calculus is still important for success in engineering majors for all students [48]. Furthermore, engineering students who come in with less readiness can utilize a myriad of opportunities and resources provided by their institution such as peer-mentoring programs, faculty-student mentoring, as well as on-campus organizations that aim to assist students who may be academically challenged. Inda et al. [49] contended that female engineering undergraduates tend to seek support from their peers compared to their male counterparts. By the same token, Alshahrani et al. [50] suggested that female students' success in the STEM field is contingent upon the social support from their mentors, peers, faculty, and family members. To heighten female students' persistence intentions in engineering and broaden women participation in engineering, Kilgore et al. [51] asserted that engineering departments should focus on revamping their curriculum by integrating context-oriented approaches earlier in their engineering curriculum. Similarly, colleges of engineering can also make an all-out effort to improve retention by restructuring their first-year general engineering curriculum by allowing students to take Calculus I in the second semester [52]. Engineering curricula that foreground personal importance of diversity may serve many practical purposes related to fostering persistence in engineering [53].

Of note, students who identify as male continue to indicate higher intentions to persist than those who identify as female, which may indicate extensive work still needs to be done to foster positive environments where female students can see themselves staying and flourishing in the engineering field. Specifically, studies have shown that a chillier campus climate, poor academic quality provided by the institution, as well as students' beliefs and sense of belonging were the contributing factors that affected engineering student retention [1], [23], [54] - [56]. Therefore, to cultivate a favorable atmosphere and inclusive environment for engineering students to persist in their majors, colleges of engineering and departments as well as their faculty should mull over the aforementioned contributing factors before making decisions that pertain to student academic success. Atadero et al. [6] expand professional identity development to explicitly connect to inclusive engineering identity development as diversity, equity, and inclusion are essential components of the identity development process. Further, Atadero et al. [6] outline the criteria of engineering identity development: 1) integrating career-relevant diversity and inclusion curricula and instruction; 2) broadening students' perspectives of who can be an engineer; and 3) facilitating opportunities for majority group students to recognize their peers from underrepresented groups as fellow engineers. Moreover, the equity perspective of undergraduate engineering students provides means to affirm and support all students' professional identity development and in turn their intent to persist in engineering career trajectories.

Only 41% of bachelor's degree seekers at 4-year institutions earn a degree within 4 years and slightly more than half (60%) complete a degree within 6 years [57]. As such, complex stratification of factors that influence a student's ability to compete in engineering programs and subsequently in the engineering field makes this phenomenon particularly difficult to understand. For instance, education is historically regarded as a great equalizer to social and economic opportunity. However, students entering undergraduate programs do not begin on equal playing fields in regard to socioeconomic status (SES), educational experiences, social capital, and cultural capital [58]. These aforementioned stratification factors influence students' abilities to successfully complete and compete in engineering programs. For instance, controlling for previous school achievement, the gross effect of parental education level is a significant factor for graduation from a program [59]. Moreover, contextual knowledge regarding academics or careers shared by students' families (e.g., parents, siblings) can help students navigate their program and contribute to their decision making [60]. Further, access to STEM role models has a positive effect on students' perceptions of their identity compatibility between the self- and STEM-identities as well as self-efficacy and sense of belonging [61]. To this end, stratification factors complicate this phenomenon as well as the analysis of student retention in engineering. Our study captures a subset of the phenomenon. However, further research is necessary to establish a more comprehensive understanding of student persistence intentions and engineering identity development.

Limitations & Future Directions

Even though most of the moderating effects in our study were not statistically significant, current study should inform future research to consider our study limitations. First, our sample size was fairly small (*N* = 280) and clustered within 25 engineering classes. That said, some engineering classes were composed of a small number of engineering students. Future studies with a much larger sample size may elicit new findings that shed light on our current study. Second, our female students' proportion in the overall sample was only one-third of that of male students. This may account for the non-significant findings when the biological sex variable was measured in the subsequent HLM models. Future studies can and should replicate our current study by increasing the number of participants, particularly for female students. Finally, the current study is a non-randomized study, which is prone to threats to internal validity. Hence, our findings should in no way be generalized without proper interpretation.

Conclusion

The present study further examines the effects of factors associated with students' intentions to persist in engineering and engineering identity (i.e., biological sex, self-efficacy, outcome expectations). More specifically, our findings support the positive effect of outcome expectations on students' engineering identities and intentions to persist in engineering. The disparity of intentions to persist in engineering between male and female students warrants further action in regard to developing inclusive, welcoming climates in engineering programs to support and sustain diversity. As such, our study provides findings that shed light on the stratification factor of prerequisite course completion. The parity of engineering identity and intentions to persist in engineering between "off track" and "on track" students provide considerations for re-evaluating admissions criteria for engineering programs and introductory course pathways. Therefore, cultivating inclusive department climates and degree plans for engineering students are auspicious pathways to encouraging persistence and engineering identity development.

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