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Exploring the relationship between student-perceived faculty encouragement, self-efficacy, and intent to persist in engineering programs

Hsien-Yuan Hsu [a], Yanfen Li [b], Suzanne Dugger [c] and James Jones[d]

[a]Department of Curriculum & Instruction, University of Massachusetts Lowell, Lowell, MA, USA; [b]Department of Biomedical Engineering, University of Massachusetts Lowell, Lowell, MA, USA; [c]Department of Counseling, Florida Gulf Coast University, Fort Myers, FL, USA; [d]Department of Leadership in Education, University of Massachusetts Lowell, Lowell, MA, USA

ABSTRACT
Copious research on Social Cognitive Career Theory has found student self-efficacy substantially related to persistence in engineering programs. The present exploratory study investigated the associations among faculty encouragement (a specific type of verbal persuasion in college context) and students' self-efficacy, outcome expectations, and intent to persist in engineering majors using a sample of first-semester engineering students at a mid-sized public university. Analytical data were collected from 205 first-year engineering students in the fall semester at a mid-sized public four-year university in the United States. Results show that students' perception of faculty encouragement can statistically significantly contribute to students' self-efficacy and outcome expectations, supporting the hypothesis that student-perceived faculty encouragement was a source of self-efficacy and outcome expectations. Further, although students' perception of faculty encouragement can influence students' intent to persist, the effect was not directly transmitted; rather, it was found only through an indirect path via self-efficacy.

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Engineering education; faculty encouragement; retention; self-efficacy; social cognitive career theory

1. Introduction

The demand for professional engineers in the US workforce is growing and remains urgent, with national projections of continued growth in engineering jobs (Sargent 2017) and the Manpower Group's (2020) most recent Talent Shortage Survey ranking engineering fourth in its list of the ten most difficult jobs to fill both within the United States and globally. As universities struggle to meet this need in the labour market, retention of students majoring in engineering is essential and greater efforts are needed to reduce attrition from engineering majors. Prior studies have shown that the first semester of college is critical to students' engineering degree completion (Shoulders, Simmons, and Johnson 2020; Shuman et al. 1999). Although some engineering faculty members consider student attrition in the freshman year as a desirable weeding out of under-prepared or unmotivated students (Holmegaard, Madsen, and Ulriksen 2016; Veenstra, Dey, and Herrin 2009), other researchers have found that some students who left engineering programs had higher grades in engineering courses than the students who persisted (Geisinger and Raman 2013; Hartman and Hartman 2006).

In response to this issue, extensive research has been conducted to identify factors relating to student persistence. A particularly promising line of research uses the Social Cognitive Career

CONTACT Hsien-Yuan Hsu HsienYuan_Hsu@uml.edu

Theory (SCCT) choice model (Lent, Brown, and Hackett 1994), which underscores that students' self-efficacy beliefs play an imperative role in Science, Technology, Engineering, and Mathematics (STEM) persistence regardless of students' race/ethnicity and gender (Lent et al. 2018). Self-efficacy, as applied to academia, characterises students' confidence in their ability to complete academic requirements in engineering majors and to cope with any barriers they might encounter (Bandura 1997; Lent et al. 2008). Studies have shown that students with higher levels of self-efficacy are more likely to (a) have more positive outcome expectations, (b) show higher interest in engineering-related activities, (c) hold stronger intentions to complete the STEM degree, and (d) persist in their completion of STEM programs (Lent and Brown 2019). On the other hand, students lacking self-efficacy tend to doubt their abilities and are more likely to transfer out of engineering programs.

In this regard, it behooves engineering educators to better understand the factors that could shape their students' self-efficacy. Investigations of factors related to the self-efficacy of engineering students may hold valuable implications for supporting persistence in engineering majors in order to better meet the growing need for professional engineers. The purpose of this study was to explore the extent to which faculty verbal persuasion (indicated by student-perceived faculty encouragement) was associated with first-year engineering students' self-efficacy beliefs and their intent to persist in engineering programs.

1.1. Verbal persuasion: an important source of self-efficacy beliefs

According to Bandura's social cognitive theory (1986) and self-efficacy theory (1991, 1997), self-efficacy beliefs are derived largely from four main sources: personal performance accomplishments (i.e. one's own previous attainment), vicarious learning (i.e. observation of social models), verbal persuasion (e.g. supportive messages from significant others), and affective states (e.g. anxiety, fatigue, and composure). The relationships among these four sources and self-efficacy beliefs have been widely investigated and conclusively summarised in prior literature. Specifically, in two meta-analyses, Byars-Winston et al. (2017) found that self-efficacy was strongly related to performance accomplishments, moderately to verbal persuasion and vicarious learning, and only weakly to affective arousal. Sheu et al.'s (2018) study focusing on the research in STEM domains found the same order of the predictive power of the four sources, and also showed that the relationship between the four sources and self-efficacy tended to be larger than that found by Byars-Winston et al. (2017).

Among the sources that show moderate to strong associations with self-efficacy beliefs in prior literature, students' previous performance attainments and vicarious learning are less easily controlled or changed by educators. In contrast, verbal persuasion is a manipulable source of self-efficacy that can be facilitated by faculty members who are significant to students. Particularly, in higher education, verbal persuasion from faculty members may be critical and especially influential to students because faculty are usually perceived by students as authority figures (Wong 2015).

1.2. Measuring faculty verbal persuasion in college context

In examining the measures of faculty verbal persuasion in college, we found existing instruments can only capture verbal persuasion in a more general fashion (e.g. persuasions from sources of all aspects such as high school teachers, parents, and friends jointly; Lent et al. 1996; Lent, Lopez, and Bieschke 1991; Loo and Choy 2013). However, to the best of our knowledge, verbal persuasion from faculty members in college has not been adequately measured due to a lack suitable of instruments. One contribution of this study is the identification of a possible measure of college faculty verbal persuasion. Specifically, this study used faculty encouragement as an indicator of faculty verbal persuasion in the college context and utilised the *Faculty Encouragement Scale* (see Section 2) as a measure with which to collect students' perception of faculty encouragement data. The rationale underlying the use of faculty encouragement as an indicator for measuring faculty verbal persuasion is presented below.

1.3. Faculty encouragement: an indicator to capture faculty verbal persuasion

Although verbal persuasion can be positive or negative (e.g. doubt in an individual's capabilities), past educational studies have focused on the positive side of verbal persuasion (e.g. Anderson and Betz 2001; Lent, Lopez, and Bieschke 1991; Loo and Choy 2013). Encouragement refers to the positive side of verbal persuasion that contains messages of affirmation and motivation enhancement (Wong 2015). Using encouragement as an indicator to capture verbal persuasion aligns with Bandura's self-efficacy theory and social cognitive theory (Bandura 1986, 1991, 1997). In the present study, we adopted the definition of encouragement provided in Wong's (2015) Tripartite Encouragement Model (TEM). The conceptual basis of TEM is drawn in part from the psychology of character strengths and virtues, Bandura's (1997) concept of verbal persuasion in self-efficacy theory, and some Adlerian conceptual insights on encouragement. According to the TEM, Encouragement was defined as 'the expression of affirmation through language or other symbolic representations to instill courage, perseverance, confidence, inspiration, or hope in a person(s) within the context of addressing a challenging situation or realising a potential' (Wong 2015, 180). We adopted Wong's (2015) definition of encouragement because their definition was in a line with Bandura's (1997) self-efficacy theory.

Recently, Wong et al. (2019) developed and tested an *Academic Encouragement Scale* to capture the students' general experience of encouragement within an higher education context. That is, Wong et al.'s (2019) research work not only conceptually defined the encouragement in college context but also suggested a means for operationally measuring encouragement. In our study, the definition and measurement of faculty encouragement in college context is based in part on Wong et al.'s (2019) prior work. Unlike Wong et al.'s (2019) study, though, we had a specific focus on faculty encouragement rather than a broad interest in academic encouragement. Particularly, in this study, the construct of 'faculty encouragement' refers to faculty members' positive messages by means of language or other symbolic representations to infuse courage, perseverance, confidence, inspiration, or hope in students within the context of overcoming a challenging situation or recognising a potential. In this sense, faculty encouragement in college can be challenge-focused (e.g. instilling hope in students when they feel like giving up on an academic task) or potential-focused (e.g. noticing that students are doing well in school and encouraging them to dream bigger and aim higher). Additionally, the research team has created a *Faculty Encouragement Scale* (FES), which was a modified version of Wong et al.'s (2019) *Academic Encouragement Scale* to measure both challenge-focused and potential-focused faculty encouragement. More information about the psychometric properties of FES was provided in Section 2.

1.4. Summary

The SCCT choice model has indicated students' self-efficacy is substantially related to persistence in engineering programs. Investigating the sources of students' self-efficacy beliefs can inform engineering educators and institutions nationwide with new insights into how to better promote students' self-efficacy, which in turn, enhance students' retention in engineering. Bandura's (1997) self-efficacy theory suggested four main sources of self-efficacy beliefs – personal performance accomplishments, vicarious learning, verbal persuasion, and affective states, and the first three sources have shown moderate to strong associations with self-efficacy beliefs in prior literature. The present study focused on faculty use of positive verbal persuasion (i.e. encouragement) because faculty members are usually perceived by students as authority figures and thus are influential on students' self-efficacy. In addition, faculty verbal persuasion is a malleable source in college comparing to other sources of self-efficacy.

In this study, we articulated a rationale to support our use of faculty encouragement as an indicator for measuring faculty verbal persuasion and provided the conceptual and operational definition of faculty encouragement. Specifically, faculty encouragement represents the positive aspect of faculty verbal persuasion that stems from the Bandura's self-efficacy theory and social cognitive theory (Bandura 1986, 1991, 1997). Using faculty encouragement as an indicator for measuring faculty verbal persuasion is a theoretically supported practice. Furthermore, our construct of faculty encouragement has a clear theoretical base [i.e. Wong's (2015) Tripartite Encouragement Model] and can be measured (see Section 2). That is, our study not only conceptually defined the faculty encouragement in the college context but also provided a means for operationally measuring faculty encouragement, allowing future studies to examine and validate the relationship between faculty verbal persuasion and students' self-efficacy across different research sites.

1.5. Conceptual model

In this section, we present the conceptual model that led our investigation into the relationships among variables of interest. The development of a conceptual model (shown in Figure 1) was guided by the SCCT choice model (Lent, Brown, and Hackett 1994). The SCCT choice model is built on the foundations of Bandura's self-efficacy theory and social cognitive theory (Bandura 1986, 1991, 1997) and has been widely tested in STEM domains to understand student academic and career development. The SCCT choice model provides a framework for studying the associations among source of social cognitive factors (i.e. faculty encouragement), social cognitive factors (i.e. self-efficacy and outcome expectations), and choice goal (i.e. intent to persist).

Specifically, one source of social cognitive factors investigated in present study was faculty encouragement, which represents the positive aspect of faculty verbal persuasion. The *Path A* was grounded in Bandura's (1997) self-efficacy theory that indicated verbal persuasion was one important source of self-efficacy beliefs. On the other hand, the *Path B* was based on prior research findings of the SCCT choice model that shown students' self-efficacy beliefs play an imperative role in STEM persistence regardless of students' race/ethnicity and gender (Lent et al. 2018; Lent and Brown 2019).

Note the multiplied path of *Path A* and *Path B* (*Path A*Path B*) suggested an indirect influence of faculty encouragement on students' intent through students' self-efficacy, meaning students' perceptions of faculty encouragement could mold their self-efficacy, which in turn, could affect their intent to persist into a second semester of their engineering program. Based on the SCCT choice model, we anticipated students' perception of faculty encouragement influenced students' intent through indirect paths via self-efficacy. As opposed to this anticipation, we included a direct path

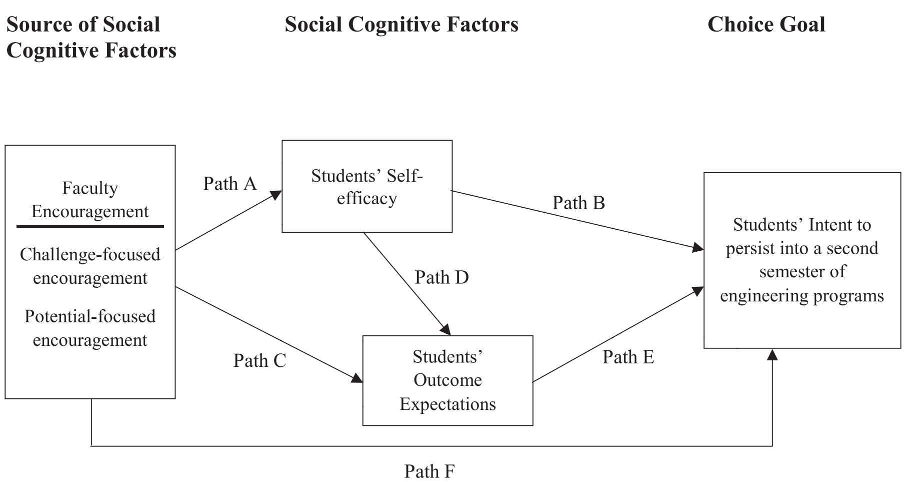


Figure 1. Conceptual model.

between students' perceived faculty encouragement and students' intent (*Path F*) to examine whether the aforementioned indirect influence of students' perceived faculty encouragement on intent was present. We expected *Path F* would not be supported by the data.

Note that we also considered a second social cognitive factor, outcome expectations (i.e. expecting an engineering degree would likely lead to positive outcomes) in our model for the following two reasons. First, a recent meta-analysis of SCCT research showed that verbal persuasion not only shapes self-efficacy, but also informs outcome expectations (Sheu et al. 2018). Therefore, we expanded our investigation by also exploring the relationship between faculty encouragement and outcome expectations (presented by *Path C*). Second, according to Bandura (1986), there is a positive relationship between self-efficacy and outcome expectations. That is, students who are confident in their performance capabilities (high self-efficacy) tend to have more positive outcome expectations (presented by *Path D*). Adding outcome expectations to the conceptual model allowed us to explore whether the influence of perceived faculty encouragement on intent to persist is through a more complex indirect path via self-efficacy as well as outcome expectations (*Path A*Path D*Path E*) or through a relatively simple indirect path through outcome expectations (*Path C*Path E*). The expanded inquiry will contribute to the literature on SCCT and engineering education regarding the role of outcome expectations in intent to persist.

1.6. Research questions

In the current study, we addressed two research questions that were derived from the conceptual model.

RQ1: To what extent does student-perceived faculty encouragement contribute to students' self-efficacy and outcome expectations among first-year engineering college students?

- *Hypothesis 1-1:* Students' perception of faculty encouragement in engineering programs can positively affect students' self-efficacy and outcome expectations.
- *Hypothesis 1-2:* Students' self-efficacy can positively influence their outcome expectations.

RQ2: To what extent does student-perceived faculty encouragement influence students' intent to persist via students' self-efficacy and outcome expectations.

- *Hypothesis 2-1:* Students' perception of faculty encouragement indirectly affects students' intent via students' self-efficacy and outcome expectations.

2. Method

2.1. Participants and setting

Eligible participants were first-year engineering students who were taking at least one core/required course that fulfilled their engineering program requirement (e.g. Intro to Engineering) in the fall semester at a mid-sized public four-year university classified as an R2 (Doctoral Universities: High Research Activity) research institution by the Carnegie Classification of Institutions of Higher Education in the United States. Data collection took place from October 31, 2019, to December 6, 2019. Eligible participants received a survey announcement and the survey link from Engineering Dean's office. Data were collected using the online survey tool Qualtrics. By the end of the data collection period, 205 first-year engineering students had completed the full survey. The response rate of the survey was 28.24%, which is typical in large-scale surveys (Sarraf 2019). Demographic information is reported in Table 1. As illustrated, samples were 64.88% male, with 68.30% of students identifying as White, 11.22% as Asian, 10.24% as Hispanic/Latino, 4.39% as Black/African American, and 5.85% as multiracial.

2.2. Measures

The survey consisted of measures of first-year students' perception of faculty encouragement, engineering self-efficacy, engineering outcome expectations, intent to persist into a second semester of engineering programs, as well as student characteristics.

Students' perception of faculty encouragement. The students' perceived faculty encouragement was measured by the *Faculty Encouragement Scale* (FES), which was a modified version of Wong et al.'s (2019) *Academic Encouragement Scale* (AES). Note items of AES, were drafted to refer broadly to a generic academic setting (e.g. *Someone I respect encouraged me to believe in myself when I doubted my academic abilities*). To adequately measure students' perception of faculty encouragement in college, we created the FES by modifying the wording in each item of AES (e.g. *An engineering professor I respect, or I am familiar with encouraged me to believe in myself when I doubted my academic abilities*). The intent of the FES is to measure engineering students' perceived encouragement from faculty in engineering programs.

The FES is provided in Appendix 2. Specifically, students were first asked to recall their interactions with an engineering professor whom they respect or are familiar with, and then were asked to indicate how accurately the 10 items in the scale describe their situations on a 6-point scale, from very untrue of me (1) to very true of me (6). Specifically, five items of the FES are devoted to challenge-focused encouragement (e.g. *Instilled hope in me when I felt like giving up on an academic task*); the remaining items describe potential-focused encouragement (e.g. *Said something positive to motivate me to consider a new academic goal*). A prior study (Authors, under review) showed the FES has sound psychometrics properties. In the present study, challenge-focused faculty encouragement had a

Table 1. Descriptive statistics of student demographic variables and analytical variables.

	Frequency	Mean	SD	Range
Gender				
Male	64.88%			
Female	35.12%			
Age				
18–20 years old	82.93%			
21–25 years old	12.20%			
26–30 years old	3.41%			
31–35 years old	0.49%			
> 35 years old	0.97%			
Primary language at home				
English	73.66%			
Not English	26.34%			
Race/ethnicity				
White	68.30%			
Asian	11.22%			
Hispanic	10.24%			
Black/African American	4.39%			
Multiracial	5.85%			
First-generation student				
Yes	22.93%			
No	77.07%			
Transfer student				
Yes	19.90%			
No	80.10%			
Challenge-focused faculty encouragement		3.59	1.33	1–6
Potential-focused faculty encouragement		3.42	1.36	1–6
Overall faculty encouragement		3.51	1.31	1–6
Self-efficacy		6.50	1.36	2.27–9
Outcome expectations		7.26	1.26	1–9
Plan to continue to second semester in engineering programs				
Yes (persisters)	85.37%			
No (non-persisters)	14.63%			

Note. $n = 205$.

mean of 3.59, a standard deviation (*SD*) of 1.33, and Cronbach's α equal to .96. The correlations (Pearson's *r*) among scores of five items measuring challenge-focused faculty encouragement ranged from .77 to .89. On the other hand, potential-focused faculty encouragement a mean of 3.42, a *SD* of 1.36, and Cronbach's α equal to .94. The correlations among scores of five items measuring potential-focused faculty encouragement ranged from .68 to .87. In addition, we found that challenge-focused encouragement and potential-focused encouragement were highly correlated ($\gamma = 0.89$, $p = .00$). Considering the high reliability of item scores and the high correlation between the two types of encouragement, we computed average scores to indicate the overall students' perceived faculty encouragement, which had a mean of 3.51 and a *SD* of 1.31. Cronbach's α of the whole FES (combining two subscales) was .97.

Engineering self-efficacy. This variable was measured using Lent et al.'s (2008) self-efficacy scale. The scale consists of 11 items: four items from an academic milestones scale (e.g. *How much confidence do you have in your ability to excel in your engineering major over the next semester?*) (Lent, Brown, and Larkin 1986) and seven items (e.g. *How much confidence do you have in your ability to cope with a lack of support from professors or your advisor*?) related to coping efficacy (Lent et al. 2001, 2003). All self-efficacy ratings were made along a 9-point scale, from no confidence (1) to complete confidence (9). The self-efficacy scale is provided in Appendix 2. Following Lent et al.'s study (2008), average scores were calculated, yielding a mean of 6.50 and a *SD* of 1.36. Cronbach's α value of this variable in the current study was 0.92.

Engineering outcome expectations. This variable was measured using Lent et al.'s (2008) outcome expectations scale. Specifically, outcome expectations were measured by asking students to indicate how strongly they agreed that an engineering degree would likely lead to each of 10 positive outcomes, such as 'earn an attractive salary'. Ratings were made along a 9-point scale, from strongly disagree (1) to strongly agree (9). The outcome expectations scale is provided in Appendix 2. Average scores were calculated, yielding a mean of 7.26 and a *SD* of 1.26. Higher scores imply stronger beliefs about positive outcomes. Cronbach's α value of this variable was 0.93.

Students' goals. This outcome variable was indicated by students' self-reported intent to persist to a second semester of engineering programs at the same university. Students responded to a question asking about their plan for the spring semester. Students who expressed intent to stay within the current major or transfer to another major in engineering at the same university were viewed as persisters (85.37%), whereas students who showed an intent to transfer to a major other than engineering, transfer out of the university, or had not decided yet were categorised as non-persisters (14.63%). We decided not to divide non-persisters into smaller subcategories for two reasons. First, data analysis of an outcome variable with small categories would lose the statistical power to detect the effects or cause difficulties in parameter estimation. Second, the category of non-persisters has a practical meaning, related to whether the engineering programs of the university can successfully retain the first-year college students.

Covariates. Six covariates considered in the analytical model consisted of students' gender, age, primary language at home, race/ethnicity, first-generation students, and transfer students. Table 1 presents the descriptive statistics of these covariates. Specifically, we found that for 26.34% of the sample their primary language at home was not English. This covariate was found to be related to students' educational opportunities (Schneider, Martinez, and Owens 2006). We included this variable as a covariate to control for the impact of students' perceived educational opportunities on the outcome variable of interest.

Moreover, because students' mastery experiences (e.g. high school GPA, math SAT scores) represent personal performance accomplishments that may influence students' self-efficacy beliefs (Byars-Winston et al. 2017; Loo and Choy 2013; Sheu et al. 2018), they ideally should be controlled in the analytical model. However, we encountered a high missing rate when collecting the information of mastery experiences. To address this concern, we included a covariate indicating whether the student was a first-generation student (from a family where neither of the parents or guardians have earned a bachelor's degree) because it was a good proxy of students' socioeconomic status (Moschetti and Hudley 2015) and high school academic performance (Atherton 2014). Results showed that 22.93% of the sample were first-generation students. In addition, 19.90% of the sample were transfer students who had transferred from another colleges or universities. We included this variable to account for the diversity of students' past learning experiences.

2.3. Data analyses

Structural equational modelling (SEM) was applied to examine the extent to which first-year students' perception of faculty encouragement contributed to students' self-efficacy and outcome expectations (Research Question 1) and persistence to a second semester (Research Question 2) while statistically controlling for the influence of covariates (e.g. gender, first-generation students). Based on our conceptual model presented in Figure 1, a statistical model (see Figure 2) was specified to address our research questions. Note that for simplicity, the model solution is also presented in Figure 2.

In our statical model, self-efficacy (i.e. *Path A*) and outcome expectations (i.e. *Path C*) were regressed on students' perceived faculty encouragement. In addition, the impact of self-efficacy on outcome expectations (i.e. *Path D*) was estimated. Furthermore, the ultimate outcome, students' intent to persist into a second semester of their engineering program, was hypothesised to be influenced by students' self-efficacy (i.e. *Path B*), outcome expectations (i.e. *Path E*), and perception of faculty encouragement (i.e. *Path F*). Paths on the statistical model were estimated in *Mplus,* and standardised coefficients and corresponding standard errors were reported. For the sake of simplicity, the covariates are not presented in Figure 2.

As described in the Measures section, results showed both challenge-focused and potential-focused faculty encouragement variables were highly correlated ($\gamma = 0.89$, $p = .00$). Therefore, including both challenge-focused and potential-focused faculty encouragement variables as predictors in a model could lead to a multicollinearity problem (Marsh et al. 2004). To avoid this issue, an overall faculty encouragement variable (the average scores of challenge-focused and potential-focused faculty encouragement) was analysed as a predictor.[1]

3. Results

Descriptive statistics of analytical variables by student gender and ethnicity/race. Table 2 presents mean and *SD*, or percentage of variables of interest. In terms of gender differences, results showed no statistically significant difference in challenge-focused faculty encouragement ($p = .82$),

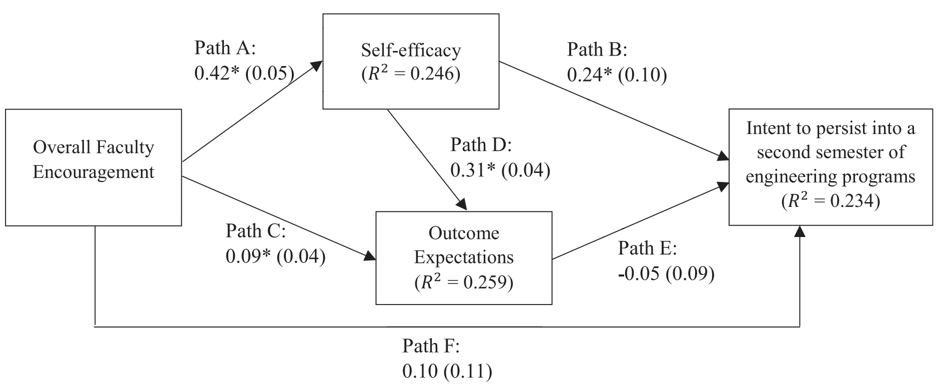


Figure 2. Statistical model and model solutions. The standardised coefficients (standard errors in parenthesis) are reported. Covariates and their impacts are not presented. *p<.05.

Table 2. Mean (standard deviation) or percentage of analytical variables by student gender and ethnicity/race.

	Gender			Ethnicity/Race[a]				
Variables	Male ($n = 133$)	Female ($n = 72$)	Mean Comparison	White ($n = 137$)	Asian ($n = 25$)	Hispanic ($n = 22$)	Black/African American ($n = 9$)	Multiracial ($n = 12$)
Challenge-focused faculty encouragement	3.61 (1.30)	3.56 (1.38)	$p = .82$ $d = 0.04$	3.58 (1.36)	3.61 (1.12)	3.53 (1.46)	3.80 (1.47)	3.68 (1.13)
Potential-focused faculty encouragement	3.48 (1.35)	3.33 (1.39)	$p = .45$ $d = 0.11$	3.47 (1.39)	3.39 (1.19)	3.07 (1.39)	3.33 (1.36)	3.65 (1.48)
Overall faculty encouragement	3.54 (1.29)	3.44 (1.35)	$p = .61$ $d = 0.07$	3.52 (1.34)	3.50 (1.11)	3.30 (1.39)	3.57 (1.38)	3.67 (1.28)
Self-efficacy	6.60 (1.29)	6.32 (1.48)	$p = .17$ $d = 0.20$	6.56 (1.36)	6.79 (1.14)	6.31 (1.17)	6.11 (1.96)	5.86 (1.58)
Outcome expectations	7.13 (1.36)	7.52 (1.03)	$p = .03$ $d = -0.31$	7.31 (1.26)	7.32 (1.36)	7.02 (1.35)	7.84 (0.53)	6.64 (1.15)
Plan to continue to second semester in engineering programs								
Yes (persisters)	85.71%	84.72%	Chi-squared	86.86%	92.00%	72.72%	77.78%	83.33%
No (non-persisters)	14.29%	15.28%	test: $p = .88$	13.40%	8.00%	27.28%	22.22%	16.67%

Note: [a]No statistically significant difference was found among ethnic/racial groups or between White and non-White groups. p = p-value. d = Cohen's d.

potential-focused faculty encouragement ($p = .45$), overall faculty encouragement ($p = .61$), self-efficacy ($p = .17$), or plans to continue into a second semester as an engineering major ($p = .88$). However, we found female students (mean = 7.52, $SD = 1.03$) had statistically significant ($p = .03$) higher outcome expectations than males (mean = 7.13, $SD = 1.36$). Regarding differences among ethnic/racial groups, we were unable to detect any statistically significant differences among ethnicity/race groups or between White and non-White groups, possibly due to a small sample size in some groups. In addition, among those ethnic/racial groups, Asian group had a relatively higher score of self-efficacy; the Black/African American group had a relatively higher score of outcome expectations; and the Asian group had a relatively higher percentage of planning to continue to a second semester in engineering programs.

Correlations among analytical variables. Table 3 presents the correlations among variables of interest. The correlation between challenge-focused faculty encouragement and potential-focused faculty encouragement was .89 ($p = .00$), suggesting students' perception of high challenge-focused faculty encouragement was in company with the perception of high potential-focused faculty encouragement. The overall faculty encouragement, which was the average of challenge-focused and potential-focused faculty encouragement, was highly and equally correlated to challenge-focused and potential-focused faculty encouragement ($r = .97$, $p = .00$), assuring the creation of the overall faculty encouragement was appropriately conducted. Self-efficacy was positively correlated with challenge-focused faculty encouragement ($r = .37$, $p = .00$), potential-focused faculty encouragement ($r = .39$, $p = .00$), and overall faculty encouragement ($r = .38$, $p = .00$), as we expected. Outcome expectations also had positive correlations with challenge-focused faculty encouragement ($r = .22$, $p = .00$), potential-focused faculty encouragement ($r = .23$, $p = .00$), and overall faculty encouragement ($r = .23$, $p = .00$). These results suggested students' perception of faculty encouragement could positively affect students' self-efficacy and outcome expectations, as stated in Hypothesis 1-1.

Furthermore, self-efficacy and outcome expectations were positively correlated ($r = .38$, $p = .00$). This positive correlation supported that students' self-efficacy could positively influence their outcome expectations, as stated in Hypothesis 1-2. On the other hand, students' intent (plan to continue to second semester) was only statistically significantly related to self-efficacy ($r = .19$, $p = .01$). This result supported the hypothesised path (as stated in Hypothesis 2-1) from students' perception

Table 3. Correlations among variables of interest.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Challenge-focused faculty encouragement	–					
(2) Potential-focused faculty encouragement	.89 $p = .00$	–				
(3) Overall faculty encouragement	.97 $p = .00$	.97 $p = .00$	–			
(4) Self-efficacy	.37 $p = .00$	.39 $p = .00$	.38 $p = .00$	–		
(5) Outcome expectations	.22 $p = .00$	.23 $p = .00$	.23 $p = .00$	.38 $p = .00$	–	
(6) Plan to continue to second semester in engineering programs	.10 $p = .17$	.13 $p = .06$	.12 $p = .10$	.19 $p = .01$	.08 $p = .24$	–

of faculty encouragement to intent through self-efficacy (i.e. faculty encouragement →self-efficacy → intent) examined in our conceptual model (see Figure 1). Conversely, the non-statistically significantly correlation between students' intent and outcome expectations ($r = .08$, $p = .24$) failed to support the hypothesised path from students' perception of faculty encouragement to intent through outcome expectations (i.e. faculty encouragement → outcome expectations →intent). Note the correlations presented in this section were simply bivariate statistics and cannot be directly used to address our research questions. Two research questions were addressed in the following section.

Overall model fit. The model solution is presented in Figure 2. The explained variance (R^2) of the ultimate outcome, intent to persist into a second semester of engineering programs at the same university, was 0.234. That is, the statistical model comprising students' perception of faculty encouragement, self-efficacy, outcome expectations, and covariates explained 23.4% of variance in students' intent in engineering program. In addition, the values of R^2 for self-efficacy and outcome expectations were 0.246 and 0.259, respectively, suggesting that approximately a quarter of the variance in these variables was explained by the statistical model. These values of R^2 suggest that our statistical model had a reasonable model fit.

Results for Research Question 1. The first research question addressed the extent to which faculty encouragement as perceived by first-year students contributed to students' self-efficacy and outcome expectations. Two research hypotheses were examined as follows.

- Hypothesis 1-1, students' perception of faculty encouragement in engineering programs can positively affect students' self-efficacy and outcome expectations, was supported by the data. As shown in Figure 2, the hypothesised path from student-perceived faculty encouragement to their self-efficacy (i.e. *Path A*) was statistically significant (standardised coefficient = 0.42, SE = 0.05, $p = .00$). In addition, the path from student-perceived faculty encouragement to outcome expectations was statistically significant (*Path C*, standardised coefficient = 0.09, SE = 0.04, $p = .04$). In other words, students who perceived greater faculty encouragement were more likely to experience greater feelings of self-efficacy and to hold higher outcome expectations.
- Hypothesis 1-2, students' self-efficacy can positively influence their outcome expectations, was also supported by the data. That is, the hypothesised path from self-efficacy to outcome expectations was statistically significant (*Path D*, standardised coefficient = 0.31, $SE = 0.04$, $p = .00$), meaning students experiencing a greater sense of self-efficacy tended to have higher outcome expectations.

Results for Research Question 2. The second research question investigated the extent to which students' perceived faculty encouragement influenced students' intent to persist to a second semester of their engineering program. One research hypothesis was examined as follows.

- Hypothesis 2-1, students' perception of faculty encouragement indirectly affects students' intent via students' self-efficacy and outcome expectations, was partially supported by the data. As shown in Figure 2, students' perceived faculty encouragement could indirectly affect students' intent through three routes: (a) faculty encouragement→self-efficacy→intent (*Path A*Path B*); (b) faculty encouragement→self-efficacy→outcome expectations→intent (*Path A*Path D*Path E*); and (c) faculty encouragement→outcome expectations→intent (*Path C*Path E*). Results showed that only route (a) was statistically significant. The standardised indirect effect of route (a) can be derived by multiplying the coefficients of *Path A* (standardised coefficient = 0.42, $SE = 0.05$, $p = .00$) and *Path B* (standardised coefficient = 0.24, $SE = 0.10$, $p = .02$), resulting a value of 0.10 ($SE = 0.05$, $p = .03$). That is, students' perception of faculty encouragement can indirectly influence students' intent via self-efficacy but not via routes involving outcome expectations. On the other hand, we found the hypothesised path from student-perceived faculty encouragement to their intent to persist to a second semester of engineering programs (i.e. *Path F*) was not statistically significant (standardised coefficient = 0.10, $SE = 0.11$, $p = .38$). The result suggested there was no direct effect of student-perceived faculty encouragement on students' intent.

In summary, results show that students' perception of faculty encouragement can statistically significantly contribute to students' self-efficacy and outcome expectations, supporting the hypothesis that student-perceived faculty encouragement was a source of self-efficacy and outcome expectations. Further, although faculty encouragement can influence students' intent to persist, the effect was not directly transmitted; rather, it was found only through an indirect path via self-efficacy.

4. Discussion and conclusion

In the present study, we investigated the extent to which first-semester students' perception of faculty encouragement, a specific form of verbal persuasion in the college context, contributed to the students' self-efficacy, outcome expectations, as well as intent to persist in their engineering program. This exploratory study is a pioneering work in that it conceptualised faculty encouragement based on a solid conceptual framework (i.e. TEM) and investigated students' perception of faculty encouragement within the SCCT framework.

Our results suggested that students' perception of faculty encouragement positively related to students' self-efficacy and outcome expectations. In other words, student-perceived faculty encouragement in the first semester informed their confidence in their ability to succeed in their engineering program and their expectations of positive outcomes after receiving an engineering degree. As mentioned earlier, verbal persuasion in the existing SCCT literature is often measured in an inclusive manner (e.g. measuring persuasions from high school teachers, parents, friends, and faculty jointly). The evidence showing a significant linkage between a specific type of verbal persuasion (faculty encouragement) and self-efficacy and outcome expectations in the present study indicates that student-perceived faculty encouragement was a source of self-efficacy (and outcome expectations) in college context. This finding contributes to the SCCT literature gap by extending our understanding of the determinants of engineering students' self-efficacy. Future studies are encouraged to examine whether the findings can be generalised to college students in other STEM majors.

Our finding regarding the positive association between students' perception of faculty encouragement and self-efficacy has a particularly meaningful implication for engineering educators. Specifically, students' self-efficacy has been recognised as a critical cognitive factor in SCCT that promotes students' intent to persist. In this vein, promoting students' self-efficacy has been advocated as a priority solution for persistence (Lent et al. 2016). However, prior SCCT studies have not systematically examined the role of faculty in fostering students' self-efficacy. Our exploratory findings explicitly reveal that faculty encouragement as perceived by students can significantly influence students' self-efficacy and intent to persist, thus providing an empirical foundation for explaining why institutional leaders and engineering faculty need to value encouraging and supportive environments.

In terms of pedagogical practice, recall that based on Wong's (2015) TEM, faculty encouragement in the academic context can be either challenge-focused encouragement or potential-focused encouragement. When students face academic problems or entertain doubts about their potential, faculty members' expressions of affirmation can significantly increase students' beliefs in their ability to successfully continue their engineering programs. It has been widely documented that process-oriented verbal persuasion is especially effective in promoting self-efficacy (Bandura 1997). For example, Wong (2015) suggested that, when encouraging students, faculty members should underscore process-oriented factors, including effort (e.g. 'I know you will succeed if you keep on working hard like you have been'.), strategy (e.g. 'I love how you use figures to present your findings. Keep doing it'.), and attitude (e.g. 'I know you'll succeed because you have a never-give-up attitude!'). Furthermore, faculty members should consider using sincere and realistic encouragement messages (Bandura 1997). Too large a disparity between faculty and student perceptions of students' abilities can result in ineffective encouragement. In contrast, an encouragement message based on information endorsed or provided by students has higher credibility (Wong 2015).

The results presented in Table 1 show that the average scores of students' perception of faculty encouragement was 3.51 ($SD = 1.32$) on a scale from 1 to 6, with 6 being the highest; that is, close to the middle point (3.5) of the scale. This finding strongly suggests there is still room for improving students' perception of faculty encouragement in engineering programs. However, not every engineering faculty member has been aware of the importance of faculty encouragement or has possessed the practical skills of providing encouragement. This finding, therefore, calls attention to an urgent need to improve faculty knowledge and practice of encouraging students during student–faculty interactions as a means by which to improve persistence in engineering programs. Although the existing literature has clearly identified the characteristics of effective encouragement (e.g. Bandura 1997; Wong 2015), to the best of our knowledge, the evidence-based findings in the existing literature have not been transformed into a faculty professional development program. In our review, we were able to identify relevant resources addressing the rationale or describing interventions for providing positive feedback and encouragement to reinforce students' self-efficacy. One such resource is the book 'The Science of Effective Mentorship in STEMM' published by National Academies of Sciences Engineering and Medicine (2019). However, through our informal conversation with STEM faculty members, we realised that faculty may prefer professional development programs over independent reading as a means by which to learn strategies for using encouragement with their engineering students. Future studies are warranted to design and test a faculty development program for enhancing faculty knowledge and practices of providing encouragement to students.

A few limitations of the current exploratory study provide a window into other future research needs. First, the response rate of the survey was 28.24% in the present study. Declining response rates for college survey participation have received extensive attention (Sarraf 2019). Although low response rates may or may not result in non-response bias (Fosnacht et al. 2017), the findings of this study should be verified by future replicated studies. In addition, an empirical-based strategy could be introduced to increase the response rate of online survey. For example, Brown et al. (2016) found that a post-paid incentive can significantly increase the response rate to an online survey and participants preferred a cash incentive over the e-certificate. Second, we focused on major cognitive factors (self-efficacy and outcome expectations) rather than measuring all the variables of SCCT choice model, such as students' interests (e.g. interest in solving complicated technical problems) or contextual factors. Future studies could comprehensively collect data on other variables of the SCCT choice model and extend the examination of the direct or indirect relation between students' perception of faculty encouragement and other SCCT variables.

Third, although we collected data from female and minority students who are traditionally underrepresented in the STEM fields, the sample size of underrepresented students in this study did not permit more extensive analysis. Specifically, we were under-powered to detect whether the magnitudes of paths presented in the conceptual model (see Figure 1) vary by gender or racial/ethnic groups – a topic critical to STEM education. For example, in a meta-analysis study, Byars-Winston et al. (2017) found that among college students in STEM disciplines, female students tended to demonstrate a weaker relationship between verbal persuasion and self-efficacy beliefs than males. Future study could collect multi-cohort data to increase the sample size and statistical power for an extensive examination.

Fourth, we did not test Wong et al.'s (2019, 821) hypothesis – 'challenge-focused encouragement might be most relevant to individuals who are struggling, while potential-focused encouragement might be more salient to high-performing people who have yet to realize their full potential', as academic performance/academic challenge data were not collected in the study. Future studies are encouraged to test Wong, Cheng, et al.'s potential distinction of the relevance of challenged-focused and potential-focused encouragement for different groups of students (struggling vs. high potential).

Last but not least, the present study focused only on one facet of encouragement in Wong's (2015) tripartite encouragement model, which posits two foci of encouragement – challenge-focused and potential-focused encouragement. Wong's (2015) tripartite model also describes two other facets of encouragement: features of effective encouragement (the second facet) and levels of encouragement (the third facet), which were not utilised in this study. The second facet denotes the features influencing the extent to which encouragement produces positive outcomes for recipients. For example, encouragement is more effective in fostering self-efficacy when it commutes recipient's effort or strategy. The second facet was not directly related to the investigation in the present study but could potentially inform the design of future investigations and/or the design of faculty development programs focusing on providing effective encouragement.

Additionally, the third facet of TEM distinguishes on three levels of encouragement – interpersonal communication, character strength (e.g. some people are more effective encouragers than others.), and group norms (some groups/settings are more encouraging than others). The present study focused on the first level of encouragement, which was students' perception of encouragement from faculty members. Encouragement at both character strength and group norm levels were out of scope of this study. Character strength suggests encouraging others is a trait that individuals possess in varying degrees (Wong 2015, 193). Future study could explore the relationship between faculty character strength of encouragement and students' perception of faculty encouragement. Also, it would be very important to explore whether there is a significant difference in character strength of encouragement between STEM faculty and non-STEM faculty. Group norm means 'group members' shared perceptions concerning the frequency and effectiveness with which encouragement is communicated by others in a group as well as the extent to which encouragement is valued by others in the group' (Wong 2015, 194). The current study did not measure faculty perceptions of group norms in terms of encouragement, which can be an indicator of how encouraging or discouraging a department climate may be for students. Future studies aimed at understanding how the group norms around encouragement differ across academic disciplines may yield insights regarding the relative need for faculty development programs in various units on campus.

In closing, the present exploratory study investigated the associations among faculty encouragement (a specific type of verbal persuasion in college context) and students' self-efficacy, outcome expectations, and intent to persist in engineering majors using a sample of first-semester engineering students at a mid-sized public university. This study adds to the SCCT literature by showing that students who perceived greater faculty encouragement in the first semester of college tended to experience higher level of self-efficacy and outcome expectations and indicated a stronger intent to persist in engineering programs. At a practical level, the findings offer new empirical support for the need to design faculty professional development programs that focus on faculty's knowledge and pedagogical skills of providing effective encouragement messages to students when students encounter academic challenges or question their potential to succeed in engineering programs.

Note

1. In response to a reviewer's comment, we conducted additional post hoc analyses that used challenge-focused faculty encouragement or potential-focused faculty encouragement as the predictor in separate models (i.e., Model A and Model B). The results of additional analyses were presented in Appendix 1. Because of high correlation between challenge-focused and potential-focused encouragement variables, we found the model solutions for the model with overall faculty encouragement (shown on Figure 2) were similar to those for model with challenge-focused encouragement (Model A in Appendix 1) or model with potential-focused encouragement (Model B in Appendix 1).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Hsien-Yuan Hsu is an Assistant Professor of Research and Evaluation in Education at the University of Massachusetts Lowell. His research interests include the development and retention of underrepresented groups in post-secondary institutions, multilevel modelling, model evaluation, and large-scale data analysis.

Yanfen Li is an Assistant Teaching Professor at the University of Massachusetts Lowell. Her current research is in engineering education with a focus on curriculum development and retention of female and minority students in engineering.

Suzanne Dugger is a Professor and Chair of the Department of Counseling at Florida Gulf Coast University. Her research interests include career counselling, counsellor education, LGBTQ issues in counselling, school counselling, and counselling with children.

James Jones is doctoral student of Leadership in Education at the University of Massachusetts Lowell. His research interest is mental health, equity for disadvantaged groups in secondary education, and school culture.

ORCID

Hsien-Yuan Hsu http://orcid.org/0000-0003-2155-2093
Yanfen Li http://orcid.org/0000-0002-9465-7147
Suzanne Dugger http://orcid.org/0000-0003-2730-8403

References

Anderson, S. L., and N. E. Betz. 2001. "Sources of Social Self-Efficacy Expectations: Their Measurement and Relation to Career Development." *Journal of Vocational Behavior* 58 (1): 98–117. doi:10.1006/jvbe.2000.1753.

Atherton, M. C. 2014. "Academic Preparedness of First-Generation College Students: Different Perspectives." *Journal of College Student Development* 55 (8): 824–829. doi:10.1353/csd.2014.0081.

Authors. Under review. Preliminary Psychometric Properties of the Faculty Encouragement Scale with First-Year Engineering College Students.

Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs.

Bandura, A. 1991. "Social Cognitive Theory of Self-Regulationemory." *Organizational Behavior and Human Decision Processes* 50: 248–287. doi:10.1016/0749-5978(91)90022-L.

Bandura, A. 1997. *Self-efficacy: The Exercise of Control*. Freeman.

Brown, J. A., C. A. Serrato, M. Hugh, M. H. Kanter, K. L. Spritzer, and R. D. Hays. 2016. "Effect of a Post-paid Incentive on Response to a web-Based Survey." *Survey Practice* 9 (1): 1–7. doi:10.29115/SP-2016-0001.

Byars-Winston, A., J. Diestelmann, J. N. Savoy, and W. T. Hoyt. 2017. "Unique Effects and Moderators of Effects of Sources on Self-Efficacy: A Model-Based Meta-Analysis." *Journal of Counseling Psychology* 64 (6): 645–658. doi:10.1037/cou0000219.

Fosnacht, K., S. Sarraf, E. Howe, and L. K. Peck. 2017. "How Important are High Response Rates for College Surveys?" *The Review of Higher Education* 40 (2): 245–265. doi:10.1353/rhe.2017.0003.

Geisinger, B. N., and D. R. Raman. 2013. "Why They Leave: Understanding Student Attrition from Engineering Majors." *International Journal of Engineering Education* 29: 914–925.

Hartman, H., and M. Hartman. 2006. "Leaving Engineering: Lessons from Rowan University's College of Engineering." *Journal of Engineering Education* 95 (1): 49–61. doi:10.1002/j.2168-9830.2006.tb00877.x.

Holmegaard, H. T., L. M. Madsen, and L. Ulriksen. 2016. “Where is the Engineering I Applied for? A Longitudinal Study of Students’ Transition Into Higher Education Engineering, and Their Considerations of Staying or Leaving.” *European Journal of Engineering Education* 41 (2): 154–171. doi:10.1080/03043797.2015.1056094.

Lent, R. W., and S. D. Brown. 2019. “Social Cognitive Career Theory at 25: Empirical Status of the Interest, Choice, and Performance Models.” *Journal of Vocational Behavior* 115: 103316. doi:10.1016/j.jvb.2019.06.004.

Lent, R. W., S. D. Brown, B. Brenner, S. B. Chopra, T. Davis, R. Talleyrand, and V. Suthakaran. 2001. *The Role of Contextual Supports and Barriers in the Choice of Math/Science Educational Options: A Test of Social Cognitive Hypotheses [doi:10.1037/0022-0167.48.4.474]*. American Psychological Association.

Lent, R. W., S. D. Brown, and G. Hackett. 1994. “Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance.” *Journal of Vocational Behavior* 45 (1): 79–122. doi:10.1006/jvbe.1994.1027.

Lent, R. W., S. D. Brown, and K. C. Larkin. 1986. “Self-efficacy in the Prediction of Academic Performance and Perceived Career Options.” *Journal of Counseling Psychology* 33 (3): 265–269. doi:10.1037/0022-0167.33.3.265.

Lent, R. W., S. D. Brown, J. Schmidt, B. Brenner, H. Lyons, and D. Treistman. 2003. “Relation of Contextual Supports and Barriers to Choice Behavior in Engineering Majors: Test of Alternative Social Cognitive Models.” *Journal of Counseling Psychology* 50 (4): 458–465. doi:10.1037/0022-0167.50.4.458.

Lent, R. W., F. G. Lopez, and K. J. Bieschke. 1991. “Mathematics Self-Efficacy: Sources and Relation to Science-Based Career Choice.” *Journal of Counseling Psychology* 38 (4): 424–430. doi:10.1037/0022-0167.38.4.424.

Lent, R. W., F. G. Lopez, S. D. Brown, and J. P. A. Gore. 1996. “Latent Structure of the Sources of Mathematics Self-Efficacy.” *Journal of Vocational Behavior* 49 (3): 292–308. doi:10.1006/jvbe.1996.0045.

Lent, R. W., A. M. Lopez, F. G. Lopez, and H.-B. Sheu. 2008. “Social Cognitive Career Theory and the Prediction of Interests and Choice Goals in the Computing Disciplines.” *Journal of Vocational Behavior* 73 (1): 52–62. doi:10.1016/j.jvb.2008.01.002.

Lent, R. W., M. J. Miller, P. E. Smith, B. A. Watford, R. H. Lim, and K. Hui. 2016. “Social Cognitive Predictors of Academic Persistence and Performance in Engineering: Applicability Across Gender and Race/Ethnicity.” *Journal of Vocational Behavior* 94: 79–88. doi:10.1016/j.jvb.2016.02.012.

Lent, R. W., H.-B. Sheu, M. J. Miller, M. E. Cusick, L. T. Penn, and N. N. Truong. 2018. “Predictors of Science, Technology, Engineering, and Mathematics Choice Options: A Meta-Analytic Path Analysis of the Social–Cognitive Choice Model by Gender and Race/Ethnicity.” *Journal of Counseling Psychology* 65 (1): 17–35. doi:10.1037/cou0000243.

Lent, R. W., H.-B. Sheu, D. Singley, J. A. Schmidt, L. C. Schmidt, and C. S. Gloster. 2008. “Longitudinal Relations of Self-Efficacy to Outcome Expectations, Interests, and Major Choice Goals in Engineering Students.” *Journal of Vocational Behavior* 73 (2): 328–335. doi:10.1016/j.jvb.2008.07.005.

Loo, C. W., and J. L. F. Choy. 2013. “Sources of Self-Efficacy Influencing Academic Performance of Engineering Students.” *American Journal of Educational Research* 1 (1): 86–92. doi:10.12691/education-1-3-4.

Manpower Group. 2020. *Closing the Skills Gap: Know what Workers Want*. https://workforce-resources.manpowergroup.com/white-papers/closing-the-skills-gap-know-what-workers-want.

Marsh, H. W., M. Dowson, J. Pietsch, and R. Walker. 2004. “Why Multicollinearity Matters: A Reexamination of Relations Between Self-Efficacy, Self-Concept, and Achievement.” *Journal of Educational Psychology* 96 (3): 518–522. doi:10.1037/0022-0663.96.3.518.

Moschetti, R. V., and C. Hudley. 2015. “Social Capital and Academic Motivation Mmong First-Generation Community College Students.” *Community College Journal of Research and Practice* 39 (3): 235–251. doi:10.1080/10668926.2013.819304.

National Academies of Sciences Engineering and Medicine. 2019. *The Science of Effective Mentorship in STEMM*. The National Academies Press.

Sargent, J. F. Jr. 2017. *The U.S. Science and Engineering Workforce: Recent, Current, and Projected Employment, Wages, and Unemployment*. https://fas.org/sgp/crs/misc/R43061.pdf.

Sarraf, S. 2019. *How are Survey Response Rates Changing? Findings from NSSE*. A. f. I. R. A. Forum. http://hdl.handle.net/2022/24059.

Schneider, B., S. Martinez, and A. Owens. 2006. “Barriers to Educational Opportunities for Hispanics in the United States.” In *Hispanics and the Future of America*, edited by M. Tienda and F. Mitchell, 179–227. National Academies Press.

Sheu, H.-B., R. W. Lent, M. J. Miller, L. T. Penn, M. E. Cusick, and N. N. Truong. 2018. “Sources of Self-Efficacy and Outcome Expectations in Science, Technology, Engineering, and Mathematics Domains: A Meta-Analysis.” *Journal of Vocational Behavior* 109: 118–136. doi:10.1016/j.jvb.2018.10.003.

Shoulders, C., L. Simmons, and D. Johnson. 2020. “Pre-entry Attributes and Freshman Satisfaction, Grades, and Engagement as Predictors of six-Year College Graduation.” *College Student Journal* 54: 327–338.

Shuman, L., C. Delaney, H. Wolfe, A. Scalise, and M. Besterfield-Sacre. 1999. *Engineering Attrition: Student Characteristics and Educational Initiatives*. Charlotte, NC: American Society of Engineering Education.

Veenstra, C. P., E. L. Dey, and G. D. Herrin. 2009. “A Model for Freshman Engineering Retention.” *Advances in Engineering Education* 1 (3): 1–31.

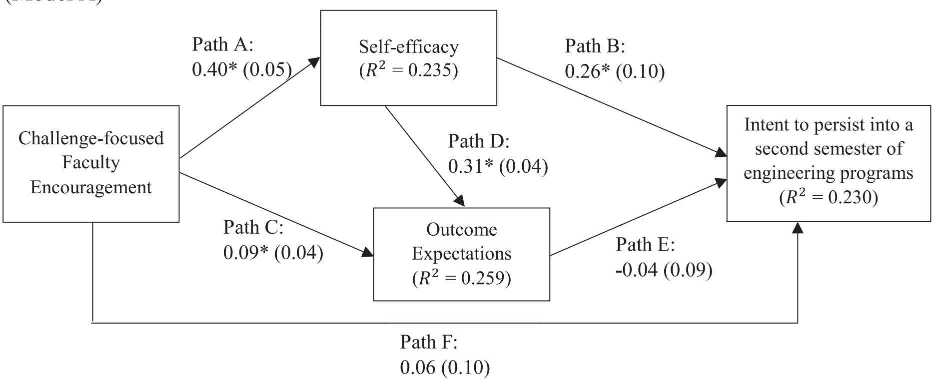
Wong, Y. J. 2015. “The Psychology of Encouragement: Theory, Research, and Applications.” *The Counseling Psychologist* 43 (2): 178–216. doi:10.1177/0011000014545091.

Wong, Y. J., H.-L. Cheng, R. C. McDermott, K. Deng, and K. M. McCullough. 2019. "I Believe in You! Measuring the Experience of Encouragement Using the Academic Encouragement Scale." *The Journal of Positive Psychology* 14 (6): 820–828. doi:10.1080/17439760.2019.1579357.

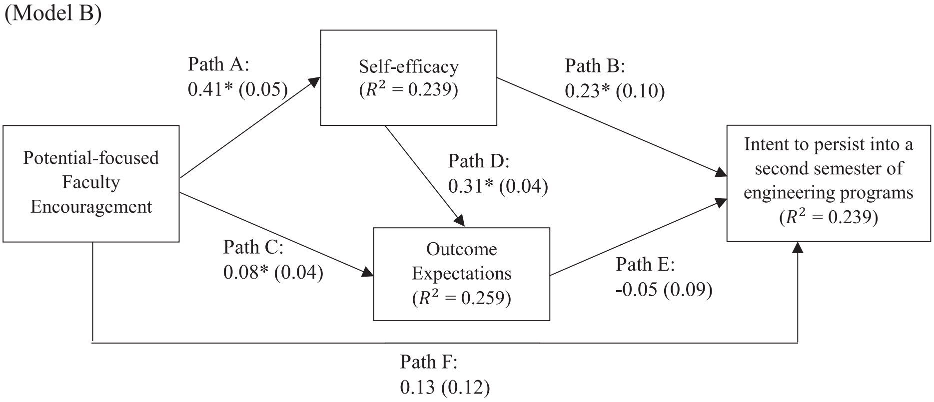
Appendices

Appendix 1. Model solutions for additional analyses.

(Model A)



(Model B)



Note: Model A included challenge-focused faculty encouragement as the predictor, while Model B included potential-focused faculty encouragement as the predictor. The standardised coefficients (standard errors in parenthesis) are reported. Covariates and their impacts are not presented. *p<.05.

Appendix 2. Instruments.

Faculty Encouragement Scale
Instructions/Items:
Please recall your experiences of interacting with engineering professors at [Name of University]. For each statement, please decide how accurately it describes your situation by checking the box that precedes it. An engineering professor I respect, or I am familiar with

______________.
(1 = very untrue of me; 6 = very true of me)

1. Encouraged me to believe in myself when I doubted my academic abilities.
2. Instilled hope in me when I felt like giving up on an academic task.
3. Reminded me of my strengths when I was discouraged about a challenging academic task.
4. Assured me that I was competent in dealing with my academic difficulties.
5. Expressed confidence in me and told me to keep trying in school even though it was hard.
6. Pointed out my strengths when she/he suggested I pursue a new academic opportunity.
7. Noticed I was doing well in school and encouraged me to dream bigger and aim higher.

8. Insisted that I should strive for higher academic standards because I was capable.
9. Explained why I had the skills to succeed in school at an advanced level.
10. Said something positive to motivate me to consider a new academic goal.

Note. The Faculty Encouragement Scale was a modified version of Wong et al.'s (2019) Academic Encouragement Scale (AES). The reference for the AES: Wong et al. (2019).
Lent et al.'s (2008) Self-efficacy Scale

Section 1. Instructions/Items:
The following is a list of major steps along the way to completing an engineering degree. Please indicate how much confidence you have in your ability to complete each of these steps in relation to the engineering major that you are most likely to pursue. Use the 0–9 scale below to indicate your degree of confidence.

Question: How much confidence do you have in your ability to ____________.
(1 = No Confidence at all; 9 = Complete Confidence)

1. Complete all of the 'basic science' (i.e. math, physics, chemistry) requirements for your engineering major with grades of B or better.
2. Excel in your engineering major over the next semester.
3. Excel your engineering major over the next two semesters.
4. Complete the upper level required courses in your engineering major with an overall grade point average of B or better.

Section 2. Instructions/Items:
Here we are interested in knowing how well you believe you could cope with each of the following barriers, or problems, that students could possibly face in pursuing an engineering major. Please indicate your confidence in your ability to cope with, or solve, each of the following problem situations.

Question: How confident are you that you could ____________.
(1 = No Confidence at all; 9 = Complete Confidence)

1. Cope with a lack of support from professors or your advisor.
2. Complete a degree in engineering despite financial pressures.
3. Continue on in engineering even if you did not feel well – liked by your classmates or professors.
4. Find ways to overcome communication problems with professors or teaching assistants in engineering courses.
5. Balance the pressures of studying for engineering courses with the desire to have free time for fun and other activities.
6. Continue on in engineering even if you felt that, socially, the environment in these classes was not very welcoming to you.
7. Find ways to study effectively for engineering courses despite having competing demands for your time.

Note: The reference for the Self-efficacy Scale: Lent et al. (2008).
Lent et al.'s (2008) Outcome Expectations Scale
Instructions/Items: Using the scale below, please indicate the extent to which you agree or disagree with each of the following statements.

Question: Graduating with a BS degree in engineering will likely allow me to ____________.
(1 = Strongly Disagree; 9 = Strongly Agree)

1. To receive a good job offer.
2. To earn an attractive salary.
3. To get respect from other people.
4. To do work that I would find satisfying.
5. To increase my sense of self-worth.
6. To have a career that is valued by my family.
7. To do work that can 'make a difference' in people's lives.
8. To go into a field with high employment demand.
9. To do exciting work.
10. To have the right type and amount of contact with other people (I.e. 'right' for me).

Note: The reference for the Outcome Expectations Scale: Lent et al. (2008).