Abstract

A Faculty Encouragement Scale (FES) was created to measure students' perception of faculty encouragement (challenge-focused and potential-focused encouragement) in college. This paper reports the psychometric properties of scores from the FES using a sample of 237 first-year engineering undergraduate students in a suburban public university. Analyses were conducted in both confirmatory factor analysis (CFA) and exploratory structural equation modeling (ESEM) frameworks, where CFA constrains all cross-loadings to be zero, but ESEM estimates all cross-loadings. Both CFA and ESEM analyses suggested two-factor models had better goodness-of-fit than one-factor models. However, we discovered a high factor correlation in CFA model that could result from forced-zero cross-loadings. We chose the ESEM model over CFA model because the estimate of factor correlation in CFA model might be inflated. Moreover, we found one item was closely loaded on both encouragement factors. Considering a high communality of this item, we did not suggest a further revision.

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Psychometric Properties of the Faculty Encouragement Scale with First-year Engineering Undergraduate Students

The culture of highly competitive classrooms can create a harsh learning environment that discourages first-year engineering students from pursuing of an engineering degree (National Academies of Sciences Engineering and Medicine, 2016). Not surprisingly, one of the most pressing concerns in engineering education is that the percentage of engineering students who persist beyond the first year has remained stagnant (American Society for Engineering Education, 2016). To address this issue, extensive research has been conducted to identify factors relating to student persistence. The Social Cognitive Career Theory (SCCT) choice model (Lent et al., 1994) built on the foundations of Bandura's (1986, 1991, 1997) social cognitive theory is a theoretical framework developed to reveal the persistence of racial/ethnic minorities in STEM (science, technology, engineering, and mathematics; Lent & Brown, 2019; Lent et al., 2018). As summarized by Lent and Brown (2019), previous meta-analyses of the SCCT choice model has consistently found that both self-efficacy and outcome expectations can promote students' interest (e.g., interest in performing various engineering-related activities), choice goal (e.g., intent to declare engineering degree), and action (e.g., persistence to the second year). Therefore, a better understanding of the sources of self-efficacy and outcome expectations may hold valuable implications for persistence among engineering majors.

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In the SCCT choice model, self-efficacy refers to beliefs about one's ability to successfully perform particular behaviors or courses of action, while outcome expectations are beliefs about the consequences of given actions (Lent et al., 2008). Both self-efficacy and outcome expectations are informed by four types of sources: (a) previous personal performance accomplishments; (b) vicarious learning (or modeling); (c) verbal persuasion (e.g., supportive messages from significant others); and (d) physiological and affective states (Bandura, 1997; Lent & Brown, 2006; Sheu et al., 2018). Prior meta-analyses (Byars-Winston et al., 2017; Sheu et al., 2018) have found that performance accomplishments — strongly influential, vicarious learning and social persuasion — were moderately compelling, while affective arousal was only weakly related to self-efficacy and outcome expectations. Among these strongly or moderately impactful sources, verbal persuasion has received increasing attention in engineering education because it is a manipulable factor that can be facilitated by people who are significant to students (Bandura, 1991, 1993). Particularly, in college context, faculty are usually perceived as authority figures by students. Verbal persuasion from faculty is considered a critical source of students' self-efficacy beliefs (Garriott et al., 2021; Wong, 2015; Wong et al., 2019).

At present, current instruments do not allow researchers to measure verbal persuasion from faculty as an independent construct. In most existing instruments, verbal persuasion is considered a single-faceted construct, measured by asking students whether they received encouraging messages about their academic capabilities from multiple significant others, such as parents, teachers, peers, and other adults (Usher & Pajares, 2008). For example, the verbal persuasion scale proposed by Lent et al.'s (1991), one of the most popular instruments for measuring verbal persuasion, seeks college students' level of agreement with 10 statements on a 5-point scale (1 = strongly disagree; 5 = strongly agree). Two statements in the scale are related to friends (e.g., "My friends have discouraged me from taking math classes"), two are related to parents (e.g., "My parents have encouraged me to be proud of my math ability"), two are related to high school teachers (e.g., "Teachers have discouraged me from pursuing occupations that require a strong math background"), three are related to unspecified significant others (e.g., "Other people generally see me as being poor at math."), and only one statement is related to faculty (e.g., My adviser has singled me out as having good math skills and has encouraged me to take college math courses."). Because verbal persuasion is conceptually defined as a single-faceted construct, a composite score is computed to indicate students' perception of verbal persuasion. Other instruments, developed to capture college students' verbal persuasion in the SCCT framework, also adopted a similar measuring approach [e.g., Schaub's (2004) *Learning Experiences Questionnaire* and Garriott et al.'s (2021) *Engineering Learning Experiences Scale*].

An instrument for measuring verbal persuasion from faculty in college environments has not been well developed. This study attempts to close this gap by creating a scale that permits researchers to measure verbal persuasion from faculty.

Yet, an instrument for measuring verbal persuasion from faculty in college environments has not been well developed. This study attempts to close this gap by creating a scale that permits researchers to measure verbal persuasion from faculty. Specifically, this study used faculty encouragement as an indicator of verbal persuasion. The rationale underlying the use of faculty encouragement as an indicator for measuring faculty verbal persuasion is presented below.

Verbal Persuasion from Faculty can be Measured as an Independent Construct

Prior studies using samples of middle school students have shown verbal persuasions from specific informants (e.g., parents, teachers, peers) can be measured and distinguished. Specifically, Falco and Summers (2021) modified Usher and Pajares' (2009) measure of middle school students' verbal persuasions by clearly specifying the informants (e.g., teachers, peers, and adult family members) rather than using confusing language (e.g., other or adult). Falco and Summers found verbal persuasions from teachers, peers, and family members were distinguishable and that three verbal persuasions exert distinct and unique impact on the math self-efficacy of middle school students. Similarly, Gebauer et al. (2020) reworked items in Lent et al.'s (1991) verbal persuasion scale by asking 7th graders to explicitly answer items with reference to their parents, teachers and classmates, and friends who are not classmates, respectively. Results from Gebauer et al. (2020) established that the multifaceted structure of verbal persuasions from different informants showed unique positive effects on student academic self-efficacy. These findings support the notion that students can differentiate between informants of verbal persuasion, and verbal persuasion from faculty can be measured as an independent construct.

Use Encouragement as an Indicator of Verbal Persuasion

As in previous studies (e.g., Anderson & Betz, 2001; Lent et al., 1991; Loo & Choy, 2013), we expected the measure of verbal persuasion from faculty would focus on the positive side of verbal persuasion even though the verbal persuasion could be positive or negative (e.g., doubt in an individual's capabilities). Thus, we proposed to use *encouragement* as an indicator of verbal persuasion. Encouragement refers to messages of affirmation and motivation enhancement (Wong, 2015). The construct of encouragement from faculty has been used and studied in previous engineering education research. However, it was ambiguously defined, and the measures were not necessarily about positive verbal persuasion. For example, Branch et al. (2015) viewed perceived faculty encouragement as a form of social support that provides students with positive feedback regarding their belonging and performance, while some statements measuring encouragement from faculty were actually asking students to rate the resources provided by faculty (e.g., "I've been provided with opportunities to pursue research").

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The Definition of Encouragement and Wong et al.'s (2019) Academic Encouragement Scale

Unlike previous studies, 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, and some Adlerian conceptual insights on encouragement (Wong, 2015). Wong's (2015) TEM describes three facets of encouragement: (1) foci of encouragement, (2) features of effective encouragement, and (3) levels of encouragement. The first facet posits two foci of encouragement—challenge-focused encouragement and potential-focused encouragement—providing a theorical framework for the two-factor structure of encouragement in the academic context. The second facet describes the features influencing the extent to which encouragement produces positive outcomes for recipients (e.g., encouragement is more effective in fostering self-efficacy when it commutes recipients' effort or strategy). The third facet of TEM distinguishes 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). Note the second and third facets are not directly related to the factor structure of encouragement nor to the definition of the encouragement, but they could potentially inform the design of future investigations and/or the design of faculty development programs focusing on providing effective encouragement. In TEM, Wong (2015) defined encouragement 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 realizing a potential" (p.180).

Based on foci of encouragement, Wong et al. (2019) further developed the *Academic Encouragement Scale* (AES) to measure college students' perception of encouragement. AES proposes five statements to measure challenge-focused encouragement (e.g., instilling hope in students when they feel like giving up on an academic task) and five to measure potential-focused encouragement (e.g., noticing that students are doing well in school and encouraging them to dream bigger and to aim higher). Using a sample of 714 undergraduate students, Wong et al. (2019) found both exploratory factor analysis and confirmatory factor analysis (CFA) favored the two-factor structure of academic encouragement. The Cronbach's alpha coefficients of the challenge-focused encouragement and potential-focused encouragement were .93 and .90, respectively. The correlation between two encouragement factors was extremely high (.94). Wong et al. (2019) also regressed college students' academic self-efficacy (i.e., student's degree of confidence on successfully completing a college-related task such as taking notes or asking a question in class) on two encouragement factors. Wong et al. (2019)

found academic self-efficacy was positively and significantly predicted by both challenge- and potential-focused encouragement after controlling for each other's effects. It should be noted that AES was designed to measure students' perception of encouragement from their significant others in a generic academic setting. In other words, AES did not specify the informants of encouragement and, thus, cannot be used to measure encouragement from faculty.

The Creation of Faculty Encouragement Scale

The intent of the present study is to report the psychometric properties of scores from the FES using a sample of first-year engineering undergraduate students in a suburban public university.

Because we specifically focused on encouragement from faculty rather than a broad interest in academic encouragement, we created a modified version of AES, the *Faculty Encouragement Scale* (FES). More specifically, items of AES were drafted to measure encouragement from significant others in a generic academic setting (e.g., *Someone I respect encouraged me to believe in myself when I doubted my academic abilities*). We created the FES by specifying the informant of encouragement as faculty members 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*). Although the intent of the current version of FES specified "engineering professor" as the informant of encouragement, the FES could be used to measure encouragement from faculty in different disciplines (e.g., changing "engineering professor" to "chemistry professor"). The FES is provided in Figure 1.

Figure 1
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 ______________.

FE_C1. Encouraged me to believe in myself when I doubted my academic abilities.

FE_C2. Instilled hope in me when I felt like giving up on an academic task.

FE_C3. Reminded me of my strengths when I was discouraged about a challenging academic task.

FE_C4. Assured me that I was competent in dealing with my academic difficulties.

FE_C5. Expressed confidence in me and told me to keep trying in school even though it was hard.

FE_P1. Pointed out my strengths when she/he suggested I pursue a new academic opportunity.

FE_P2. Noticed I was doing well in school and encouraged me to dream bigger and aim higher.

FE_P3. Insisted that I should strive for higher academic standards because I was capable.

FE_P4. Explained why I had the skills to succeed in school at an advanced level.

FE_P5. Said something positive to motivate me to consider a new academic goal.

Note. FE_C = Challenge-focused faculty encouragement. FE_P = Potential-focused faculty encouragement.

Purpose of This Study

The intent of this study is to report the psychometric properties of scores from the FES using a sample of first-year engineering undergraduate students in a suburban public university. Researchers hypothesized that there would be two underlying factors (challenge-focused and potential-focused encouragement) as stated in TEM (Wong, 2015). Regarding criterion validity, it was hypothesized that both factors would demonstrate significantly positive relationships with students' self-efficacy, as posited by the SCCT (Lent & Brown, 2019). Since the FES was the first attempt to measure encouragement from faculty based on TEM, we did not have any expectation that one of the encouragement from faculty would exhibit a stronger relationship with self-efficacy than the other encouragement; however, we did expect challenge-focused encouragement and potential-focused encouragement would differently correlate with self-efficacy if the two encouragements were distinct.

Contribution of The Study

Our study not only contributes to the SCCT literature but also has meaningful implications in engineering education. Because of the absence of instruments for measuring verbal persuasion from faculty, the existing SCCT literature still lacks rigorous evidence illustrating the specific role of verbal persuasion from faculty members on students' self-efficacy. The availability of the instrument could extend our understanding of the determinants of engineering students' self-efficacy beyond current SCCT studies. On the other hand, some engineering faculty members consider student attrition in the first year of an engineering program to be the result of weeding out under-prepared or unmotivated students. Consequently, these faculty members continue to overlook or denigrate their influence on student persistence. Clearly, identifying the relationship between verbal persuasion from faculty and students' self-efficacy beliefs would provide an empirical foundation for explaining why and how verbal persuasion from faculty matters. In turn, these understandings could change faculty attitudes towards their role in student persistence and, ultimately, inform faculty actions accordingly.

Method

Participants and Procedures

The present study was conducted at a midsized public four-year university in Massachusetts, USA. Institutional review board approval has been obtained from the institution research team. Data were collected using the Qualtrics online survey tool. First-year engineering students enrolled in the fall 2019 semester were eligible for the study. The data collection period was from October 31, 2019 to December 6, 2019. The FES was completed by 237 students. Diversity breakdown of the sample was 34.05% female, with 63.98% of students identifying as White, 11.44% Asian, 8.90% Hispanic/Latinx, 4.66% Black/African American, and 11.02% multiracial.

Measures

Faculty Encouragement Scale (FES). The FES was designed to measure students' perception of faculty encouragement in college contexts. The FES comprises 10 items: five items devoted to challenge encouragement (e.g., *Instilled hope in me when I felt like giving up on an academic task*), and five describing potential encouragement (e.g., *Said something positive to motivate me to consider a new academic goal*). In this study, the intent of the FES is to measure engineering students' perceived encouragement from engineering faculty. The FES asks students to recall their interactions with an engineering professor whom they respect or are familiar with and to indicate how accurately the 10 items in the FES describe their situations on a 6-point scale (1 = very untrue of me; 6 = very true of me).

Identifying the relationship between verbal persuasion from faculty and students' self-efficacy beliefs would provide an empirical foundation for explaining why and how verbal persuasion from faculty matters. In turn, these understandings could change faculty attitudes towards their role in student persistence and, ultimately, inform faculty actions accordingly.

Self-efficacy Scales. In this study, two types of self-efficacy beliefs (Lent et al., 2008) were measured. The academic milestone self-efficacy scale, measuring students' confidence in their ability to complete academic requirements, comprises four items (e.g., How much confidence do you have in your ability to excel in your engineering major over the next semester). On the other hand, coping self-efficacy, which assesses students' confidence in their ability to cope with a variety of barriers that engineering students might experience, was measured on a 7-item scale (e.g., How confident are you that you could find ways to overcome communication problems with professors or teaching assistants in engineering courses?). Both self-efficacy scales were measured on a 9-point scale, from no confidence (1) to complete confidence (9).

In this study, the mean and standard deviation of the academic milestones self-efficacy composite scores were 6.551 and 1.587, respectively, and those of coping efficacy composite scores were 6.448 and 1.391, respectively. Cronbach's α estimates for academic milestones efficacy and coping efficacy were .91 and .88, respectively. In addition, we also found that the two-factor structure of self-efficacy was supported by a two-factor confirmatory factor analysis model, where academic milestone self-efficacy and coping efficacy loaded on corresponding items [$\chi^2(df)$= 63.074(42), p <.05, *CFI*=.979, *TLI*=.973, *RMSEA*=.046, *SRMR*=.043]. The correlation between academic milestones efficacy and coping self-efficacy in CFA was 0.732 (SE = 0.045, $p < .05$).

Data Analysis

The FES was predicted to have a two-factor structure (challenge-focused and potential-focused encouragement). To examine the factor structure of FES, data were fitted to both a one-factor model (a competitive model) and two-factor model. The model fit was evaluated by using chi-square (χ^2) statistics and fit indices-comparative fit index (CFI), Tucker-Lewis Index (TLI), root-mean-square-error-of-approximation (RMSEA), and standardized root mean squared residual (SRMR) with cutoff values (CFI, TLI ≥ .95; RMSEA ≤ .06; SRMR ≤ .08; Hu & Bentler, 1999). Additionally, χ^2 difference ($\Delta\chi^2$) tests were conducted to compare relative fit of a one-factor model versus a two-factor model (Satorra & Bentler, 2010). Further, Akaike's Information Criterion (AIC; Akaike, 1973), Bayesian IC (BIC; Schwarz, 1978), and sample-size adjusted BIC (SABIC; Sclove, 1987) were applied to assist model selection. A model with relatively smaller values of IC indices is preferred.

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Analyses were conducted in both CFA and exploratory structural equation modeling (ESEM) frameworks, where CFA constrains all cross-loadings to be zero, but ESEM estimates all cross-loadings. If the ESEM solution is not clearly superior, the CFA solution, which is more parsimonious (fewer free parameters), is adopted to determine the factor structure of FES (Morin et al., 2013). However, previous studies have shown that forcing cross-loadings to zero in CFA might result in inflated factor correlations (Hsu et al., 2014; Liang et al., 2020). Therefore, when the CFA model fit is good and approaches that of the ESEM, "the sizes of the factor correlations are a primary justification for choosing ESEM over CFA" (Marsh et al., 2020, p. 114). As presented in the results section, we used Marsh et al.'s (2020) recommendation because we experienced a similar model fit in two-factor CFA and ESEM, but the factor correlation in CFA was unusually high, which persuaded us to choose a two-factor ESEM. Detailed information about model selection is provided in the next section. Table 1 presents the means, standard deviations (SDs), and correlations of 10 FES items that were used for CFA and ESEM analyses. Note the target rotation method was applied in ESEM analysis (Marsh et al., 2020).

We evaluated the criterion validity by regressing academic milestone self-efficacy and coping self-efficacy on challenge-focused encouragement and potential-focused encouragement, controlling for students' demographic information (gender, age, English is the primary language at home, first-generation students, and transfer students) in one regression model using SEM. Criterion validity was supported when the slopes of challenge-focused encouragement and potential-focused encouragement were positive and statistically significant. All analyses were conducted using the structural equational modeling method in *Mplus* 8. Score reliability was indicated by Cronbach's α.

Results

Table 2 presents values of model fit indicators for one-factor and two-factor models, as well as model comparison results in CFA and ESEM frameworks. Both CFA and ESEM analyses suggested two-factor models had better goodness-of-fit than one-factor models (i.e., greater *CFI* and *TLI*, smaller *RMSEA* and *SRMR*, and smaller AIC, BIC, and saBIC). Results of model comparison ($\Delta\chi^2$) showed that the one-factor model demonstrated a model fit significantly worse than that of the two-factor model in CFA ($\Delta\chi^2(df)$=23.589(1), p<.05) and in ESEM (($\Delta\chi^2(df)$=91.958(1), p<.05). The two-factor factor structure of FES was supported in this study.

Results showed the two-factor CFA model [χ^2(df)= 84.669(34), p <.05, *CFI*=.960, *TLI*=.948, *RMSEA*=.079, *SRMR*=.027] and the two-factor ESEM model [$\chi^2(df)$= 71.082(26), p <.05, *CFI*=.965, *TLI*=.939, *RMSEA*=.086, *SRMR*=.015] had an adequate and similar model fit. Both two-factor CFA model and ESEM model had an *RMSEA* value slightly greater than .06, which is still considered an indication of fair fit (MacCallum et al., 1996). Table 3

Table 1
Descriptive Statistics and Correlations for Items of Faculty Encouragement Scale

Item	Mean (*SD*)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) FE_C1	3.597(1.465)	-									
(2) FE_C2	3.534(1.471)	.878	-								
(3) FE_C3	3.415(1.463)	.851	.827	-							
(4) FE_C4	3.540(1.442)	.808	.809	.794	-						
(5) FE_C5	3.591(1.466)	.805	.832	.827	.833	-					
(6) FE_P1	3.264(1.487)	.746	.741	.772	.703	.790	-				
(7) FE_P2	3.284(1.532)	.731	.716	.757	.646	.760	.782	-			
(8) FE_P3	3.366(1.522)	.758	.776	.775	.760	.774	.761	.859	-		
(9) FE_P4	3.302(1.472)	.796	.788	.821	.748	.773	.765	.817	.863	-	
(10) FE_P5	3.708(1.572)	.731	.765	.792	.743	.818	.695	.714	.777	.780	-

Note. n = 235. All correlation coefficients were statistically significant ($p < .05$). FE_C = Challenge-focused faculty encouragement. FE_P = Potential-focused faculty encouragement.

Table 2
Model Fit of One-factor and Two-factor Model in CFA and ESEM and Model Comparison Results

Model	$\chi^2(df)$	*CFI*	*TLI*	*RMSEA*	*SRMR*	AIC	BIC	saBIC	$\Delta\chi^2$ (*df*): One-factor versus two-factor
CFA									
One-factor	125.827(35), p <.05	.929	.909	.105	.030	5879.879	5983.920	5888.831	23.589(1), p <.05
Two-factor	84.669(34), p <.05	.960	.948	.079	.027	5792.729	5900.239	5801.980	
ESEM									
One-factor	125.827(35), p <.05	.929	.909	.105	.030	5879.879	5983.920	5888.831	91.958(9), p <.05
Two-factor	71.082(26), p <.05	.965	.939	.086	.015	5754.335	5889.590	5765.973	

presents two-factor CFA model and ESEM model solutions. In the CFA model, standardized factor loadings of challenge-focused encouragement ranged from 0.881 to 0921, while those of potential-focused encouragement ranged from 0.847 to 0.925. The communalities of indicators (i.e., proportion of indicator's variance that can be explained by the factor) ranged from 0.717 to 0.856. The factor correlation in CFA (γ= 0.935, γ^2= 87.42%) was exceptionally high, suggesting the two factors were not distinguishable. The size of factor correlation in CFA could be overestimated due to fix- to-zero cross loadings.

Table 3
Two-factor CFA Model and ESEM Model Solutions

	CFA Solution Standardized Factor Loadings (and *SE*)			ESEM Solution Standardized Factor Loadings (and *SE*)		
	Challenge-focused Encouragement	Potential-focused Encouragement	Communalities	Challenge-focused Encouragement	Potential-focused Encouragement	Communalities
FE_C1	0.920(0.015)*	-	0.846	0.710(0.100)*	0.280(0.104)*	0.844
FE_C2	0.921(0.015)*	-	0.848	0.729(0.066)*	0.264(0.066)*	0.855
FE_C3	0.915(0.022)*	-	0.837	0.611(0.052)*	0.387(0.057)*	0.834
FE_C4	0.881(0.024)*	-	0.776	0.734(0.098)*	0.214(0.096)*	0.792
FE_C5	0.908(0.018)*	-	0.825	0.618(0.079)*	0.375(0.077)*	0.827
FE_P1	-	0.847(0.031)*	0.717	0.357(0.094)*	0.573(0.095)*	0.724
FE_P2	-	0.889(0.025)*	0.790	0.055(0.131)	0.895(0.139)*	0.869
FE_P3	-	0.925(0.017)*	0.856	0.215(0.113)	0.773(0.116)*	0.862
FE_P4	-	0.923(0.016)*	0.852	0.328(0.104)*	0.663(0.103)*	0.834
FE_P5	-	0.848(0.033)*	0.718	0.488(0.105)*	0.449(0.106)*	0.728
	Factor correlation = 0.935 (*SE* = 0.016, p<.05, γ^2 = 87.42%)			Factor correlation = 0.657 (*SE* = 0.030, p<.05, γ^2 = 43.16%)		

Note. *p<.05. FE_C = Challenge-focused faculty encouragement. FE_P = Potential-focused faculty encouragement.

Based on Marsh et al.'s (2020) recommendation, we chose the ESEM model over CFA model because the estimate of factor correlation in CFA model might be inflated. As a result, the two-factor ESEM model was selected as a final model.

Alternatively, in the ESEM model, indicators FE_C1 to FE_C5 were mainly loaded on challenge-focused encouragement with standardized factor loadings ranging from 0.611 to 0.724, and were cross-loaded on potential-focused encouragement with relatively smaller and statistically significant standardized factor loadings (ranging from 0.214 to 0.387). On the other hand, FE_P1 to FE_P4 were mainly loaded on potential-focused encouragement with standardized factor loadings ranging from 0.573 to 0.895, whereas only FE_P1 and FE_P4 were statistically significantly cross-loaded on challenge-focused encouragement (standardized factor loading was 0.357 to 0.328, respectively). Note FE_P5 was closely loaded on challenge-focused encouragement (loading = 0.488) and potential-focused encouragement (loading = 0.449). The communalities of indicators ranged from 0.724 to 0.862. The factor correlation in ESEM was moderate (γ= 0.657, γ^2= 43.16%).

Although the two-factor CFA model was more parsimonious (i.e., cross-loading were constrained to zero) than two-factor ESEM model, we found the factor correlation in CFA was close to 1, which could result from fixed-to-zero cross loadings. Based on Marsh et al.'s (2020) recommendation, we chose the ESEM model over CFA model because the estimate of factor correlation in CFA model might be inflated. As a result, the two-factor ESEM model was selected as a final model. Cronbach's α results for challenge-focused and potential-focused encouragement were 0.959 and 0.946, respectively. In order to examine the criterion validity of FES, we further regressed academic milestones self-efficacy and coping self-efficacy on challenge-focused faculty encouragement and potential-focused faculty encouragement, controlling for students' demographic information.

Particularly, challenge-focused faculty encouragement demonstrated statistically significant predictive power to academic milestones self-efficacy and coping self efficacy. In contrast, potential-focused faculty encouragement could not statistically significantly predict academic milestones self-efficacy.

Note that in the regression model, self-efficacy factors were specified as CFA model and encouragement factors were specified as ESEM model. Table 4 presents the results of regression analysis and descriptive statistics of two self-efficacy variables and two encouragement variables. Results suggested that the regression model had a satisfactory model fit [$\chi^2(df)$= 421.199 (287), p <.05, *CFI*=.962, *TLI*=.955, *RMSEA*=.046, *SRMR*=.054]. R^2 academic milestones self-efficacy (0.227) was similar to that of coping self-efficacy (0.223). Two encouragement factors predicted self-efficacy variables in different patterns. Particularly, challenge-focused faculty encouragement demonstrated statistically significant predictive power to academic milestones self-efficacy (standardized slope = 0.392) and coping self-efficacy (standardized slope = 0.216). In contrast, potential-focused faculty encouragement could not statistically significantly predict academic milestones self-efficacy (standardized slope = 0.083) but was able to predict coping self-efficacy (standardized slope = 0.219).

Table 4
Regression Results and Descriptive Statistics

Regression Results	Outcome = academic milestones self-efficacy	Outcome = coping self-efficacy
Predictor	Standardized slope (and *SE*)	Standardized slope (and *SE*)
FE_C	0.392(0.090)*	0.216(0.109)*
FE_P	0.083(0.094)	0.219(0.110)*
R^2=	0.227	0.223

Descriptive Statistics

	Mean (*SD*)	(1)	(2)	(3)	(4)
(1) FE_C	3.521(1.349)	-			
(2) FE_P	3.385(1.375)	.658*	-		
(3) Academic milestones efficacy	6.551(1.587)	.429*	.324*	-	
(4) Coping self-efficacy	6.448(1.391)	.337*	.329*	.733*	-

Note. *p<.05. FE_C = Challenge-focused faculty encouragement.
FE_P = Potential-focused faculty encouragement.

Discussion

In this study, the Faculty Encouragement Scale was created for measuring encouragement received by students from a specific informant (i.e., faculty). The design of FES was built on Wong's (2015) Tripartite Encouragement Model that articulates two foci of encouragement – challenge-focused and potential-focused encouragement. According to SCCT choice mode, encouragement from faculty captured by the FES is a positive side of verbal persuasion received from faculty and thus was hypothesized to be correlated to students' self-efficacy beliefs.

Factor analysis results (Table 2) suggested that one-factor model demonstrated a model fit significantly worse than two-factor. That is, the two-factor structure in FES was better supported by the data. This finding echoes Wong's (2015) TEM that proposes encouragement in the academic context can be either challenge-focused encouragement or potential-focused encouragement. When determining the final two-factor model, we found the correlation between challenge-focused encouragement and potential-focused encouragement in CFA was extremely high (γ= 0.935, γ^2= 87.42%), while that in ESEM was moderate (γ= 0.657, γ^2= 43.16%), although both two-factor CFA and ESEM models had similar model fit. In this case, as Marsh et al. (2020) suggested, it was very likely that the factor correlation in CFA model was inflated due to fixed-to-zero cross-loadings. Therefore, we choose a two-factor ESEM model as our final model. This finding suggested that researchers should not blindly ignore cross-loadings. In fact, as pointed out by Hsu et al. (2014), constraining cross-loadings to zero might become a model misspecification when cross-loadings were not ignorable. Our two-factor ESEM model results (Table 3) suggested only two indicators had non-significant cross-loadings and forced zero cross-loadings. Future studies are needed to investigate whether ESEM model is preferred using data collected from other samples.

Our findings could be used to explain the reason why Wong et al. (2019) derived a high correlation between challenge-focused encouragement and potential-focused encouragement (γ= 0.94) when using the Academic Encouragement Scale to measure two encouragement factors in a generic academic setting. High factor correlation in Wong et al.'s (2019) work was derived by using CFA model, which could lead to inflated factor correlation, thus, raising a concern that the two factors might be redundant.

In general, the two-factor ESEM model solution presented a simple factor structure, where all indictors were mainly loaded on one factor except for FE_P5 ("*Said something positive to motivate me to consider a new academic goal*"). Specifically, FE_P5 was statistically significantly loaded on both challenge-focused encouragement (loading = 0.488) and potential- focused encouragement (loading = 0.449) with comparable loadings. The communality of FE_P5 was 0.728, meaning 72.8% of variance in FE_P5 can be explain by two encouragement factors jointly. This result suggested FE_P5 was not a unidimensional indicator, however; two encouragement factors explained most variance. This finding made sense because "considering a new academic goal" can mean either adjusting the goal when students encounter a challenge or setting up a higher goal as a recognition of a student's potential. Considering a high communality of FE_P5, we did not suggest revising this item. Instead, we recommend ESEM be utilized for FES data so that cross-loadings could be appropriately modeled.

These findings not only supported the criterion validity of FES, but also suggested challenge-focused faculty encouragement and potential-focused faculty encouragement were distinguishable factors.

Furthermore, we found challenge-focused faculty encouragement statistically significantly predicted both academic milestones self-efficacy (standardized slope = 0.392) and coping self-efficacy (standardized slope = 0.216). Potential-focused faculty encouragement only statistically significantly predicted coping self-efficacy (standardized slope = 0.219). Those findings not only supported the criterion validity of FES, but also suggested challenge-focused faculty encouragement and potential-focused faculty encouragement were distinguishable factors. Future studies are needed to investigate this issue further.

A few limitations of the current study provide a window into other future research needs. First, the findings of this study were derived from a small sample size (n = 237). Future studies are encouraged to validate our findings using a larger sample size. Increasing the sample size not only enhances the quality of parameter estimates in data analysis but also permits more extensive analysis (e.g., testing the measurement invariance of FES among gender groups and racial/ethnic groups). Second, suggested by SCCT choice model, two students' self-efficacy beliefs were collected to test the criterion validity of FES. Future studies are needed to better validate evidence to foster understanding of the discrimination and validity of two types of encouragement in FES.

Third, each of the measures, including FES and two self-efficacy scales, used a self-reported Likert-scale. Although the data were collected through an anonymous online survey, it is possible students hid true feelings when replying to the survey. Future studies need to ensure a safe and secure space for students when measuring these psychological factors. Fourth, nesting in data could occur due to groups of students taught by the same faculty members. This study did not ask students to identify the names of faculty giving the encouragement. Future studies could take into account the nesting in data by applying multilevel analytical approaches (Stapleton et al., 2016). Finally, the generalizability of the findings was limited to engineering first-year students studying in universities similar to our research site. Future studies are encouraged to replicate our study with samples in other STEM fields or other institutes of higher education (e.g., two-year colleges, private universities) and compare the findings with ours.

Conclusion

The results based on a sample of engineering students suggested the two-factor structure in FES was better supported by the data, which was aligned with Wong's (2015) Tripartite Encouragement Model. Both two-factor CFA model and ESEM model had similar model fit. However, we discovered a high factor correlation in CFA model which could result from forced- zero cross-loadings. Following Marsh et al.'s (2020) recommendation, the two-factor ESEM model was selected as the final model. In general, FES had good psychometric properties. The indicators of FES were reasonably loaded on theoretically corresponding factors except for item FE_P5, which was loaded on both encouragement factors. Notwithstanding, considering the high communality of FE_P5 (0.728), we did not recommend revising this item.

Future studies are encouraged to replicate our study with samples in other STEM fields or other institutes of higher education (e.g., two-year colleges, private universities) and compare the findings with ours.

The criterion validity of FES was supported by the results that encouragement factors can predict students' self-efficacy beliefs. Nevertheless, the prediction patterns of two encouragement factors were different – challenge-focused faculty encouragement statistically significantly predicted both academic milestones self-efficacy (standardized slope = 0.392) and coping self-efficacy (standardized slope = 0.216), while potential-focused faculty encouragement could only predict coping self-efficacy (standardized slope = 0.219). Prediction patterns suggested two faculty encouragement factors were distinguishable. Future studies are encouraged to verify our findings using participants in other STEM-related fields.

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