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Development of a Scale for Measuring Students' Attitudes Towards Learning Professional (i.e., Soft) Skills

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Abstract Employers lament that science graduates, particularly engineering students, lack professional skills, despite increasing emphasis on teaching professional skills in their curriculum. Using the Theory of Planned Behavior as an overarching framework, one explanation for skill development gaps may be students' attitude towards learning professional skills. Our study purpose was to create a scale that accurately and consistently measures engineering students' attitudes towards learning professional skills. To create the scale, we used a rigorous measurement development methodology, beginning with survey item generation and critical review by subject matter experts. Data from a sample of 534 engineering college students were split into two sets to provide (1) a development sample upon which exploratory factor analyses and parallel analyses were conducted to form the initial scale, and (2) a confirmatory sample whereby we verified the scale structure and obtained initial validity evidence for distinct dimensions. A five-factor scale of 25 items for assessing engineering students' attitudes towards learning professional skills (ATLPS) obtained high-reliability estimates. Validity evidence supported five distinct dimensions in leadership in teams, communication, civic and public engagement, cultural adaptability, and innovation. The ATLPS can be used to facilitate improvements in engineering education and research by understanding students' attitudes towards learning professional skills. Furthermore, researchers can expand the scale to include additional dimensions of professionalism and modify items to fit STEM disciplines where professional skill training is essential.

Keywords Attitudes · Professional skills · Scale development · STEM · Engineering

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Introduction

There is little doubt that science is critical to the world economy, and engineering, in particular, serves an essential function in the global economy. Engineering operates as a backbone to society through enabling economic growth in nearly every sector, from communication to healthcare, to manufacturing and construction. For example, reports from the UK indicate that in 2011, engineering contributed upwards of 20% or more (roughly £280 billion) to the total gross value added, an indicator of economic output (Royal Academy of Engineering 2015). Statistics in the USA tell a similar story. For instance, estimates derived from the Bureau of Economic Analysis indicate engineering contributed about 17% of the US gross domestic product in 2016. The only other industry that came close to and actually exceeded engineering in its value added to the gross domestic product was finance, insurance, and real estate (considered a single industry) at 21%. Given the impact of engineering, we aimed our study at this scientific discipline, while acknowledging that many others (e.g., biology, chemistry) also serve important functions, as well.

In their ongoing efforts to promote better education in the engineering profession within the USA, the National Academy of Engineering (NAE) brought together 35 experts across various disciplines to develop a vision of engineering in 2020 (see www.NAE.edu). The meeting was called *The Engineer of 2020 Project* and consisted of two phases: the first focused on developing the vision, and the second focused on necessary educational reform to support the vision. The project launched a new era in engineering education, one not only focused on technical skill development for solving technological challenges anticipated in 2020 but also on the inclusion of critical social skills that engineers would need to be successful in an increasingly diverse workplace (National Academy of Engineering 2004, 2005). Those social skills, referred to as soft skills or professional skills, included written and oral communication, global awareness and flexibility, involvement with the community and public service, ethical decision-making, innovation, leadership, and teamwork. NAE is not the only group recognizing the need for professionalism skill development—employers lament the lack of such skills in entry-level engineers (e.g., Katz 1993), and of science graduates in general (Jaschik 2015).

Although engineering programs around the world have implemented curricula to develop these professional skills in their students (e.g., University College London in the United Kingdom, University of Waterloo in Canada, University of Iowa in the USA, and Shantou University in China, to name a few), the *effectiveness* of these programs hinges on the adequacy of training, but *more importantly on students' desire to learn the skills*. Unless students develop a positive attitude about learning professional skills, they are unlikely to master them (Ajzen 1991; Fredrickson 2001), regardless of the effectiveness of instruction.

In this study, we created a self-report measure to evaluate engineering college students' attitudes towards learning professional skills, a valuable step in identifying potential roadblocks to engineering students' developing these essential skills. Attitudes are central to everyday life; they are an affective and cognitive evaluation of a person, place, event, or object that is based on beliefs, past experiences, or sometimes on information from others (Fishbein 1963; Salancik and Pfeffer 1978). According to the Theory of Planned Behavior (Ajzen 1991), students' attitudes towards learning professional skills play a vital role in whether they actually learn those skills. Furthermore, attitudes can be modified (Petty and Cacioppo 1981), which means if engineering programs can identify whether, and to what extent, students' attitudes need changing, they can develop appropriate interventions (e.g., Loraas and Diaz 2011). Thus, increasing students' positive attitudes towards learning professional skills can increase the probability they will master the skills before graduation.

Literature Review

Although data provided previously suggest engineers are valuable, concerns about US engineering focus on recent graduates' inability to do more than just apply their technical knowledge (Baytiyeh and Naja 2010). To date, engineering education has primarily emphasized science, technology, and mathematics within the core content of engineering course work (Farr and Brazil 2010). Thus, students entering engineering programs, as well as many other science programs, have been steeped in the tradition that technical skills are foremost. It is not that professionalism skills are completely ignored—rather, learning "people skills" is considered extra or secondary to technical skills. However, professional skills, such as communication and showing cultural awareness, are becoming more important as engineers are expected to work in multigenerational, multicultural, and interdisciplinary teams to tackle engineering problems in the global marketplace (see www.aaes.org).

Efforts to Advance Professional Skill Development

The Accreditation Board for Engineering and Technology (ABET) recognizes the shortcoming of the emphasis on technical skills at the expense of professional skills. For instance, in 2001, members of ABET revised the standards for engineering schools to require student learning outcomes in (1) ability to communicate with diverse audiences, (2) teamwork, and (3) an understanding of professional and ethical responsibility (see www.ABET.org/accreditation). In response, since 2006 the Division of Engineering Education and Centers (EEC) at the National Science Foundation has awarded nearly US$585 million in research grants directed towards improving engineering education, some of which have specifically targeted incorporating professionalism skill development into US engineering curriculum (see www.nsf.gov/awards).

Though these efforts are commendable and present a valuable step towards increasing engineering graduates' capabilities to thrive, students' ability to learn professional skills depend on them having a positive attitude towards learning those skills. Changing accreditation criteria and integrating professional skill building into traditional engineering curriculum is not enough to teach students the professional skills they need for 2020. Students *must have a positive attitude towards developing these skills*.

The Role of Attitudes in Learning Professional Skills

We use the Theory of Planned Behavior (Ajzen 1991) to make sense of our assertion. The theory proposes that one's intention to adopt or enact a behavior requires three psychological investments: (1) a positive attitude towards the behavior (i.e., *attitude*), (2) belief the behavior is valuable based on whether others approve or disapprove of the behavior (i.e., *subjective norm*), and (3) feeling capable of behaving in that new way, either due to our own competency or because of a lack of contextual constraints (i.e., *behavioral control*). Additionally, the predictive power of the theory is increased with the correspondence of the three components—attitude, subjective norms, and behavior control focused on the same behavior.

Although they did not use the Theory of Planned Behavior as a theoretical framework, researchers in engineering education have explored concepts similar to subjective norms and behavioral control in relation to professional skills. For example, in studies comparing the perceptions of students, academics, and industry personnel on the most important skills for engineers, students and academicians rated the importance of technological knowledge and skills far above industry personnel, and industry personnel rated the importance of communication skills far above the ratings of students and academicians (e.g., Nguyen 1998). Recent studies of undergraduate engineering students' ratings of the importance of technical versus professional skills show similar findings. Specifically, these studies indicate that students enter the major with the assumption that technical skills are the most important skills required for success after graduation (Forman and Freeman 2013; Winters et al. 2013). Importance ratings reflect how deeply one cares about the focal item and are considered distinct from attitudes (Krosnick et al. 1993). Indirectly, importance ratings convey the value of a focal item—in this case, having technical skills is valuable because the lack of them results in disapproval from others in the engineering community. Hence, if we frame these results within the Theory of Planned Behavior, we can say the research suggests that engineering students have low subjective norms for learning professional skills relative to learning technical skills.

Other studies have provided insight into the behavioral control component of the theory, through examining students' perceived competence in various skills, including professional skills. Specifically, self-perceptions of skill competence convey the extent to which one thinks one has the ability or proficiency in the skill (e.g., Chan et al. 2017). Chan et al. (2017) developed a measure of engineering students' perceptions of competence on 35 generic skills combined into eight dimensions, including academic and problem-solving, interpersonal skills, community and citizenship knowledge, leadership, professional effectiveness, information and communication literacy, critical thinking, and self-management skills. Like previous studies, Chan et al. did not frame their study within the theoretical umbrella of the Theory of Planned Behavior. However, their results showed students, on average, felt they possessed only a moderate level (3–3.8 on a 5-point scale) of competence on each skill. Through the lens of the Theory of Planned Behavior, Chan et al.'s results suggest students have low behavioral control for learning generic skills, which included some engineering professional skills.

Assessing Attitudes Is Essential One could argue that given prior research on at least two of the three aspects of the Theory of Planned Behavior should be adequate, that it should not be necessary to understand students' attitudes towards learning professional skills. However, we assert that attitudes, the affective component of the model, may be the most essential element of the model. The Broaden-and-Build Theory of Positive Emotions (Fredrickson 2001) proposes that positive emotions (i.e., affect) expand our thinking and sense of possibilities, which in turn results in our ability to learn new skills. Positive emotions, tied to expression of positive attitudes (Davidson et al. 1994), create interest, curiosity, and exploration, thereby broadening intellectual capabilities. In contrast, negative emotions narrow our thinking, causing a reliance on preset scripts or actions that shut down curiosity, though offer emotional protection from uncertainty (Fredrickson 2001). Relying on preset scripts has adaptive benefits especially in threatening situations, but shutting down curiosity and expansive thinking creates a disadvantage when the situations present little real threat, such as learning opportunities. Thus, not only is a positive attitude towards learning professional skills necessary for mastery, it is essential for broadening students' capacity to learn all skills, both technical and professional, and become curious, innovative engineers ready to tackle the challenges of the twenty-first century.

Substantial evidence supports the application of the Broaden-and-Build Theory of Positive Emotions and the Theory of Planned Behavior to student learning (e.g., Chiang et al. 2009; Fredrickson et al. 2008; Kok et al. 2013), yet the application of these theories to understanding and predicting the success of infusing professionalism skills into the engineering education remains scarce. One reason may be the lack of a measurement instrument of attitudes towards learning professional skills in engineering education. Without a measure to assess these attitudes, researchers are unable to address the key component of the Theory of Planned Behavior and educators may struggle to identify whether students' attitudes are functioning as a potential roadblock to their learning professional skills.

After an extensive search, we found no measures in existence for assessing attitudes towards learning professional skills. Researchers have examined students' satisfaction with their academic experiences, understanding of engineering, and confidence in knowledge, calling them all attitudes (e.g., Besterfield-Sacre et al. 1998); however, scholars assert that attitudes are summary evaluations about specific people, objects, or events (Ajzen 1991; Ajzen and Fishbein 1977). Hence, self-report measures of students' feelings towards general content knowledge provide little information about student *attitudes* (e.g., Cialdini et al. 1981; Furnham 1992).

The paucity of attitude measures in engineering contrasts with the medical field, for example, where the measurement of students' attitudes towards professionalism has been the focus of attention for several years (e.g., Blue et al. 2009; Morreale et al. 2011; O'Flynn et al. 2014). Both fields require professional skills. However, given the different foci of the fields, the direct use of medical measures in engineering education is inappropriate (i.e., these assessments are clinical and patient oriented). Instead, we draw inspiration from the medical research to develop a measure appropriate for engineering.

The Current Study

The purpose of the current study is to develop a measure of students' attitudes towards learning professionalism skills that can be used in implementing the Theory of Planned Behavior to predict students' intention to learn professional skills offered in the engineering curriculum. If engineering educators identify a lack of positive attitudes towards learning professional skills, they could employ frameworks, such as the Elaboration Likelihood Model of Persuasion (ELM; Petty and Cacioppo 1981) to encourage students to change their attitudes. ELM suggests that attitudes can be changed when people are motivated and have time to consider the strengths and weaknesses of the arguments presented in favor of the attitude change.

To develop the content domain, we drew inspiration from the *Engineer of 2020 Project* (National Academy of Engineering 2005), 21st Century Skills (Fisher 2014), the American Society of Engineering Education's TUEE Workshop report of 2013, and ABET's criteria for professional skills. Specifically, we chose the following professional skills: communication, ethical decision-making, cultural adaptability, leadership, teamwork, innovation, and civic and public engagement. We followed best practices in scale development, such as those reported in the *Standards for Educational & Psychological Testing* (2014), Gardner (1995), and DeVellis (2012), and focused on developing an initial measure of attitudes towards learning professional skills with reliability of scores, and initial supporting construct validity evidence.

Method

Participants

We invited 2628 undergraduate engineering students at a medium-sized public university located in western United States to participate in an online survey. Of the 2628, 735 completed the survey for a response rate of 28%. We believe the low response rate was due to several factors. First, college administrators originally told us they would announce offering a monetary incentive to students to complete the survey and they would send emails of college-level sponsorship for the project to all undergraduate engineering students; however, neither was forthcoming. Research shows that sponsorship and monetary incentives increase survey response rates (Anseel et al. 2010; Dillman et al. 2014; Sauermann and Roach 2013). Second, because of administrators' delays in responding to our requests for survey item review, incentives, and the sponsorship emails, the survey was launched much later than planned, causing scheduling conflicts relative to student mid-semester exams and assignments.

Of the 735 who responded, 201 were missing responses; 10% of the 201 missing responses on at least three of the seven scales, and 74% were missing four scales or more. Missing response analyses showed the percentage of missing scores increased as the survey continued, indicating potential survey fatigue, feeling the survey was taking too long to complete, or stopping and forgetting to come back to finish the survey. Because of the high percentage of missing responses in those 201 participants, we chose to remove their respondents treating them as non-response cases instead, leaving 534 valid responses. Using analysis of variance, we determined there were no substantive demographic differences between those who completed the entire survey and those who started but did not finish.

The 534 participants who completed the survey were 70% male, 30% female; predominantly Caucasian (76%); and distributed across years in college (1st year, 16.3%, 2nd year 19.7%, 3rd year 18.9%, and 4th–5th year 45.1%). Most participants were based in mechanical engineering (33%), civil and environmental (14%), electrical and computer (13%), and chemical and biological (10%). The rest reported engineering sub-disciplines in combination degrees (e.g., biomedical with chemical and biological), engineering science, space, and/or general systems.

Participants were proportionately representative of the overall college population (N = 2628) in terms of grade level (1st year, 20.9%, 2nd year 22.7%, 3rd year 21.4%, and 4th–5th year 35%), sex (74.6% male, 25.4% female), race (74.3% Caucasian), and engineering sub-discipline (mechanical 33.4%, civil 14.5%, electrical and computer 14%, and chemical and biological 10.9%, with the remaining sub-disciplines as noted previously).

Procedures

We obtained permission from the Dean of the engineering college to offer an online survey to all engineering students for the development of our attitudes towards learning professional skills scale. With approval from regulatory compliance for the study, we received a database of engineering student emails and demographic information from the university institutional research group. At the end of September 2016, students were sent an email invitation to voluntarily complete a confidential online survey about their attitudes towards learning professional skills. The software used for collecting the data provided a unique survey link with each email invitation, allowing us to later match which email belonged to which survey response, without placing identifying information in the actual responses. Thus, names were not associated with the survey responses. Participants read the consent form online and provided implied consent by continuing. Students were given 2 weeks to complete the survey. No incentives were given.

Measures

Item Pool Development We wrote items to assess students' attitudes towards the categories of professionalism. We drew inspiration for the style of items from Rees et al. (2002), who developed a measure to assess medical students' attitudes towards learning communication skills. For our communication factor, we rephrased three of their items (e.g., "Developing good communication skills is just as important as mastering technical content in engineering"). For innovation, we modeled five items after de Jong and den Hartog (2010). The rest of the items in the pool were developed based on our review of the literature (e.g., American Society for Engineering Education 2013; Fisher 2014; National Academy of Engineering 2005). We originally developed eight items for communication, six for ethics, seven for cultural adaptability, ten for leadership, eight for teamwork, and five for civic and public engagement.

The initial pool of items totaled 49. All items were assessed on a 1 = *strongly disagree*, to 6 = *strongly agree* response scale, with no neutral mid-point. The lack of a neutral anchor was intentional, as attitudes are either positive or negative (Fishbein 1963), negligible differences in Likert-type scales using versus not using a mid-point have been shown (Armstrong 1987), and mid-points are often used to respond in a socially desirable manner by avoiding endorsement in one direction or another (Garland 1991).

Review by Experts The items were reviewed by six subject matter experts, including a full professor in electrical and computing engineering, the director for professional learning in engineering, a retired IBM executive, and three academic coordinators/advisors for undergraduate education in mechanical, civil and environmental, and electrical and computer engineering. We modified several questions based on the feedback.

Demographics We obtained students' contact information, grade level, sub-discipline, sex, and ethnicity from institutional research.

Results

Development and Confirmatory Files

To develop and initially confirm a resultant scale, we used the random selection mechanism embedded within SPSS (statistical package for social sciences) to create two separate data files out of the 534 responses (DeVellis 2012). The first file, which we labeled the development sample, was created by the program and resulted in 56% of the original respondent records. The second file, which we call the confirmatory sample, was created by deleting those records retained for the development file out of the original. Hence, the files did not contain duplicate participant records.

The development sample had 294 participants, of which 68% were male, 32% female, 76% white, and distributed across years in college (1st year, 15.6%, 2nd year 17%, 3rd year 23.5%, and 4th–5th year 43.9%). The majority of participants were based in mechanical engineering (33%), followed by civil (17%), electrical and computer (13%), and chemical/bio (9%). The rest reported the same remaining sub-disciplines within engineering as the initial total sample.

The confirmatory sample had 240 participants of which 71% were male, 29% female, and distributed across years in college (1st year, 17.1%, 2nd year 22.9%, 3rd year 13.3%, and 4th–

5th year 46.7%). The majority of participants were based in mechanical engineering (32.5%), followed by electrical and computer (13.3%), civil (11.3%), and chemical/bio (10%). The rest reported the same remaining sub-disciplines within engineering as the initial total sample.

Selecting Items for the Scale

Using the development sample, we examined the factor structure of the attitudes towards learning professional skills scale using principal component analyses with oblique rotation (Conway and Huffcutt 2003) with the intent of reducing the item pool and finding distinct factors within the set of items. Following Stevens (1996), we considered any factor loading above .40 as acceptable and sought to remove cross-loadings based on both their loading and on phrasing (i.e., clarity). We removed several items with significant cross-loading and that upon visual inspection were not clearly in one factor versus another. For example, “Learning how to be a good team member is something I can do after I graduate” was an item we developed for teamwork. However, upon reflection the item fails to capture whether the student has a positive or negative attitude about teamwork; instead, reflecting whether this is a skill that can or cannot be developed after college. Therefore, we dropped this item from the scale. We used the same logic to evaluate which items to retain or drop from the scale. We followed the principal component analyses with exploratory factor analysis using principal axis factoring with oblique rotation on the same matrix to estimate the latent variable that the variables supposedly indicate, the ultimate goal in scale development. The results were similar except two items were dropped from the leadership factor. Differences in structure coefficients can be expected by the different ways in which PCA and PAF set up and estimate the communality coefficients (Thompson 2004). After examining results we retained the outcome of the principal factor analyses, which indicated we keep seven factors comprising 27 items.

Scholars in psychometrics suggest using multiple methods for deciding which factors and how many to retain (Ford et al. 1986); therefore, we used parallel analysis using principal axis factoring with 500 random data sets (Crawford et al. 2010; Green et al. 2012) and the resulting scree plot. Parallel analysis uses Monte Carlo simulations to generate a specified number of data sets using the same number of variables and sample size as the observed data. Factor structures are estimated on each data set using principal axis factoring, and mean eigenvalues are reported. The number of factors to retain is determined by the number of eigenvalues in the observed data that are larger than those in the generated data (see Humphreys and Montanelli 1975). Using the 27 items as the input to the parallel analysis, the results along with the resulting scree plot indicated we should retain six factors (see Table 1), which was less than the

Table 1 Results from principal axis factoring and parallel analysis

Factor	Initial eigenvalues from principal axis factoring	Percentage variance explained from principal axis factoring	Raw data eigenvalues from parallel analysis	Percentile random data eigenvalues from parallel analysis
1	8.24	30.53	8.46	.841
2	1.96	7.25	1.95	.717
3	1.38	5.11	1.45	.639
4	1.03	3.82	1.03	.572
5	.800	2.96	.792	.516
6	.693	2.57	.679	.462
7			.395	.411

principal axis factoring suggested. Therefore, we carefully examined the factors from the principal axis factoring to determine their value added and relevance to the construct domain. Despite including some interesting items (e.g., “Being a good engineer includes knowing how to make decisions that balance safety vs. quality vs. cost”), they did not reflect an *attitude* about professionalism in the occupation. Rather they captured what behaviors/skills make a good engineer. Therefore, we removed two items from the attitudes towards learning professional skills scale, which after another parallel analysis confirmed a final scale of 25 items within five factors (Table 2). Items removed from the original questionnaire appear in Table 3. Contrary to our original list of skills, we did not extract a teamwork or ethics factor.

Confirming the Scale Structure

We conducted confirmatory factor analysis on the scale using Mplus 6.0 (Muthén and Muthén 1998-2010) on the confirmatory sample of 240 participants. We used the maximum likelihood robust estimator in Mplus because our variables, with the exception of cultural adaptability, were negatively skewed. We relied on standard goodness of fit indices (Hu and Bentler 1999) to judge the quality of the confirmatory analyses: Comparative Fit Index (CFI; .90 or above is considered good), Root Mean Square Error of Approximation (RMSEA; .08 or less is considered good, confidence interval reported in brackets), and the Tucker Lewis Index (TLI; .90 or above is considered good). Our analyses indicated we could improve the fit if we correlated four of the reversed scored items from cultural adaptability with each other. For example, “I hate team projects where I am forced to work with students who do not speak English well” correlated with “The trouble with engineering education is there are too many foreign students.” After doing so, the results show a reasonable fit to the five-factor structure ($\chi^2 = 412.31(261)$, $p < .001$, CFI = .92, TLI = .91, RMSEA = .05 [.04, .06]). An examination of a one-factor solution (using the same estimator and with the same items correlated) in comparison did not fit the data as well ($\chi^2 = 755.41(271)$, $p < .001$, CFI = .76, TLI = .73, RMSEA = .09 [.08, .09]). Descriptive statistics, reliability estimates for the scale factors, and correlations, all obtained on the confirmatory sample, are shown in Table 4.

Discussion

Our study purpose was to create a scale that accurately and consistently measures engineering students’ attitudes towards learning professional skills. We created a 25-item measure of attitudes towards learning professional skills that according to the Theory of Planned Behavior can support engineering educators in predicting students’ intention to learn professional skills. The measure comprises five factors: communication, leadership, civic and public engagement, cultural adaptability, and innovation. Furthermore, although we aimed our scale at learning professional skills for engineering, the skills are relevant to all sciences and the scale items may be adapted to fit other science disciplines.

The scale was developed using methods to maximize construct validity, such as ensuring the construct domain was well defined and basing item development on an extensive review of the literature. The analyses were based on a large enough sample of engineering students across diverse engineering sub-disciplines and grade levels to provide confidence in the scale structure and retention of items (DeVellis 2012). The choice of which items to retain for the scales was made using the development sample only, providing assurance in the results obtained on the confirmatory sample. The resultant factors were correlated, as expected given

Table 2 Final attitudes towards learning professional skills scale

	Item	F1	F2	F3	F4	F5
F1	Cultural adaptability					
1	The trouble with engineering education is there are too many foreign students. (R)	.84				
2	I hate team projects where I am forced to work with students who do not speak English well. (R)	.73				
3	I realize it may not be politically correct to say this, but the best engineers are from Western cultures. (R)	.70				
4	As an engineer I value working with a global workforce.	.69				
5	I think learning how to work with many nationalities and cultures is essential for my development as an engineer.	.58				
6	We should not be pushing for more women in engineering; they do not fit in. (R)	.54				
F2	Communication					
1	Learning communication skills helps my team-working skills.		.85			
2	Developing good communication skills is just as important as mastering technical content in engineering.		.82			
3	Engineers have to be able to write well, therefore, I appreciate learning this skill.		.71			
4	I understand the value of developing my listening skills to be a better professional.		.68			
5	Good communication skills allow me to demonstrate respect for others, which is essential for success as an engineer.		.63			
6	Presenting to non-technical audiences is a necessary skill for an engineer.		.45			
F3	Civic and public engagement					
1	A good engineer has a responsibility to apply his or her knowledge to create positive global change.			.94		
2	Engineers have a responsibility to provide their knowledge and skills to improve the quality of life in local communities.			.93		
3	Learning how to connect the content of my courses with real-world community problems is critical towards becoming an engineer.			.60		
4	I appreciate that engineers must sometimes give away their knowledge for the benefit of society; it is not always about making money.			.59		
5	Engineers play a vital role in individual and collective action aimed at identifying and resolving issues of public concern.			.58		
F4	Leadership					
1	A good leader works well with his or her team members.				.84	
2	Trust and respect of fellow engineers are key characteristics of good leaders.				.82	
3	Being a good leader involves recognizing that sometimes the best contribution one can make is being a good follower.				.46	
4	Successful teams are inclusive of all members.				.42	
F5	Innovation					
1	As an engineer, I am expected to find new approaches to complete my daily tasks.					.74
2	Successful engineers look for opportunities to improve things.					.67
3	To be a good engineer, I need to know how to generate original and novel solutions to problems.					.62
4	Learning how to systematically introduce innovative approaches into existing work practices is just as valuable as creating novel products.					.49

R reverse scored. Loadings from principal axis factor analysis. Five factors cumulatively account for 52% of the variance

the measure assesses attitudes towards learning, yet correlations between factors were not high indicating sufficient differentiation (Brown 2006). In addition, internal reliability coefficients for each factor of the overall scale were respectable and remained relatively constant across the development and confirmatory samples.

Practical Implications

The scale developed in this study is an important step in identifying and planning efforts to engage students in learning professionalism skills. Science programs, and in particular engineering programs, are attempting to provide the professional skills, yet their efforts are likely

Table 3 Items removed from the original questionnaire

1	I find it difficult to learn communication skills from faculty/instructors who themselves seem to struggle with communication.
2	Learning communication skills should be left to liberal arts students and not required of engineering students. (R)
3	It is common knowledge that engineers' careers peak before they are 30 years old. (R)
4	It is my responsibility to call out fellow engineers who fail to adhere to the engineering code of conduct.
5	Being a good engineer includes knowing how to make decisions that balance safety vs. quality vs. cost.
6	Every engineer should be trained to handle work dilemmas, like protection of intellectual property, conflicts of interest, and whistle-blowing.
7	It is more important to get an A - even if that means being somewhat unethical - than it is to be honorable and get a D. (R)
8	Learning ethical principles of decision making is necessary for my skill development as an engineer.
9	I appreciate that I have a responsibility to prevent and report any workplace harassment that I observe.
10	Learning negotiation skills is valuable for my teamwork skills.
11	To be a good engineer, I must know how to make a group work successfully and not just "be" a good team member.
12	I find it difficult to learn teamwork skills from faculty/instructors who themselves seem unable to work well with others.
13	Learning how to be a good team member is something I can do after I graduate. (R)
14	I do not see why we have to learn about the makeup of teams or their development; engineers work in teams, do not create or develop them. (R)
15	As an engineer, work is primarily completely independently and not in a team setting. (R)
16	It is important for everyone's ideas to be heard by the group, even when the ideas are different from mine.
17	I realize that to be a successful team, we need to leverage each other's unique strengths.
18	Engineers get the work done – they are not leaders. (R)
19	Dealing with emotions at work should be left to workplace psychologists, not engineers.(R)
20	People skills are for managers and leaders, not engineers. (R)
21	Learning negotiation skills is valuable for my teamwork skills.
22	To be a good engineer, I need to have good leadership skills.
23	Developing leadership skills is nearly as important as mastering technical content in engineering.
24	To be a good engineer, I must know how to negotiate for win-win solutions.

R reverse scored

unsuccessful if the students themselves do not have the same positive outlook about mastering professional skills as they do towards mastering the technical ones. Furthermore, by assessing attitude levels using the attitudes towards learning professional skills scale, colleges can apply attitude change models like the ELM (Petty and Cacioppo 1981), as needed, to increase negative or weak attitudes towards learning professional skills. ELM proposes that attitudes can be changed when people are motivated and have time to consider the strengths and weaknesses of the arguments presented in favor of the attitude change. Thus, by presenting positive evidence about the value of learning professional skills when students have the motivation and capability to adequately consider this evidence, instructors can create long-lasting positive attitudes that are also resistant to future efforts by others to change that attitude. In this case, resistance could come in the form of student peers who do not yet see the value in professional skills and expend effort convincing their peers to join them in rebelling against new curriculum that emphasizes skill development. ELM further states that if people lack the motivation and time to think through the presented arguments for attitude change, they are inclined to focus on irrelevant information, such as the charisma of the communicator or the number of arguments presented, rather than the quality of the arguments. In such cases, any attitude change is temporary and susceptible to weak counterattacks. Hence, it is important to present compelling evidence for why learning professional skills is essential only when students' have the motivation and capacity to listen. ELM has been used extensively in

Table 4 Descriptive statistics, reliabilities, and correlations for scale factors

		$MeanS_1$	SD S_1	$S_1\alpha$	$MeanS_2$	SD S_2	$S_2\alpha$	1	2	3	4	5	6	7	8
1	Sex	1.32	–	–	1.29	–	–	–							
2	Grade level	–	–	–	–	–	–	−.07							
3	Ethnicity	–	–	–	–	–	–	−.03	.00						
4	Age	21.71	4.44	–	21.68	4.18	–	−.20	.49	.04					
5	Communication	4.86	0.80	.86	4.96	0.75	.86	.20	−.06	−.04	−.17				
6	Leadership in teams	5.17	0.62	.75	5.18	0.66	.79	.15	−.08	.02	−.13	.62			
7	Civic and public engagement	4.98	0.78	.85	4.91	0.87	.85	.27	−.15	.06	−.20	.60	.66		
8	Cultural adaptability	4.76	0.81	.83	4.76	0.71	.72	.25	−.10	.02	.00	.37	.37	.47	
9	Innovation	4.92	0.66	.71	4.91	0.72	.78	.02	−.13	.00	−.13	.42	.54	.46	.27

$S_1N = 294$, $S_2N = 240$. $S_1\alpha$ = alpha reliability obtained on the development sample. $S_2\alpha$ = alpha reliability obtained on the confirmatory sample. Correlations are on S_2. Correlations under |.11| are not significant, whereas all those equal to or above |.11| are significant to .01. Males were coded as 1 and females as 2 consumer marketing and social awareness programs (e.g., Areni and Lutz 1988; Bhattacherjee and Sanford 2006; Kar and Ho 2005; Li 2013; Schumann et al. 2012). Other models of attitude change should be considered as well (Kitchen et al. 2014).

Colleges can use our scale in combination with previous efforts in assessing students' importance ratings (i.e., subjective norms) and competency levels (i.e., behavioral control) to apply the Theory of Planned Behavior (Ajzen 1991) to predict actual professional skill development, or identify which component of the model should be addressed in the curriculum. For example, students with low levels of confidence in their ability to enact professional skills may require additional help in developing that confidence through opportunities to practice the skills in various contexts.

Limitations, Strengths, and Future Directions for Research

The limitations of our study include that we sampled engineering students from one university only, which limits the generalizability of the results to other engineering colleges that may be vastly different in student demographics and training norms, and to other science programs. Even though we can argue that students' attitudes are most effectively collected using self-report (Chan 2009; Judge et al. 2000), researchers may find alternative methods for collecting responses on attitudes, such as corroborating reports from peers (Conway 2002). We did not obtain validity evidence using a separately collected sample before reporting our findings, nor before developing a subscale for ethics and teamwork skills. For scale construction, splitting a single sample in half may be considered insufficient, because respondents represent the same population and provided responses at the same time. We did not obtain validity evidence for the relationships between our scale and other variables, sometimes referred to as criterion-related evidence. We recommend a longitudinal study whereby researchers collect responses on the attitudes towards learning professional skills attitudes scale, conduct an intervention, and reassess responses on the scale along with other variables, such as scores on number of voluntary team projects. Lastly, we did not employ a scale to control for socially desirable responding, although one can assert that by offering the survey online, students could take it in a private location where others would not see their responses, which helps reduce feelings of pressure to respond in socially desirable ways (Podsakoff et al. 2003).

Despite the limitations, our findings advance the literature and remain valuable for several reasons. Our study was situated within an ongoing conversation within the education literature focused on professional skill development (e.g., Smith 2015). We used well-established theories to explain the mechanisms by which the scale can contribute to knowledge on students' learning of professional skills. We assessed a large diverse sample of students across a variety of engineering sub-disciplines. By collecting data from one university only, we controlled for variability due to university culture and curriculum. We obtained content validity evidence by engaging subject matter experts and obtaining empirical support for the internal structure of the measure. Lastly, our study was conducted using rigorous methods of survey design and scale development, which together lend confidence to the findings, and to the quality and usability of the final measure.

To extend our findings, researchers should collect additional validity evidence for the use of the attitudes towards learning professional skills scale, as the accumulation of validity evidence is a never-ending process (Douglas and Purzer 2015). Researchers have called for investigations into developing adequate measurement instruments, including those directed at professional skills (Shuman et al. 2005), and our study contributes to this growing conversation.

Whether the factors of the scale replicate in other samples is an empirical question, as is evaluating the quality of the scale using methods that minimize socially desirable responding. Researchers should also develop items for ethics and teamwork skills. Furthermore, one objective for understanding students' attitudes towards professional skills is to predict their intention to master those skills during college and enact them after graduation. Thus, future studies should include a longitudinal examination of the causal path from attitudes to behaviors during training, as well as to behaviors after graduation.

Lastly, we noted that the Theory of Planned Behavior (Ajzen 1991) comprises three components that lead to individuals' intent to engage in a specific behavior. Our study focused on one of those components—attitudes, and the behavior we focused on was learning professional skills. Other researchers have made initial progress on understanding students "conception" of what engineering is as a profession (Forman and Freeman 2013; Winters et al. 2013), which might influence their expectations for technical versus professional skill development in their curriculum. It may be that students who expect such training have a positive attitude towards learning the skills. Future research can examine this supposition empirically.

Conclusion

We developed a 25-item scale for consistently measuring students' attitudes towards learning professional skills. The continued development and use of such a measure has the potential to advance research in engineering education and be used in science colleges to enhance the success of their curriculum. Without understanding students' attitudes, departments may struggle in their professional skill curriculum efforts, not because of the pedagogy, but because students lack a positive attitude towards learning the skills.

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References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: a theoretical analysis and review of empirical research. *Psychological Bulletin, 84*(5), 888–918. https://doi.org/10.1037/0033-2909.84.5.888.

American Educational Research Association, American Psychological Association, and National Council on Measurement in Education (US) (2014). Standards for educational & psychological testing.

American Society for Engineering Education (2013). *Transforming undergraduate education in engineering: Phase I: Synthesizing and integrating industry perspectives.* Retrieved from https://www.asee.org/TUEE_PhaseI_WorkshopReport.pdf.

Anseel, F., Lievens, F., Schollaert, E., & Choragwicka, B. (2010). Response rates in organizational science, 1995–2008: a meta-analytic review and guidelines for survey researchers. *Journal of Business and Psychology, 25*(3), 335–349. https://doi.org/10.1007/s10869-010-9157-6.

Areni, C. S., & Lutz, R. J. (1988). The role of argument quality in the Elaboration Likelihood Model. *Advances in Consumer Research, 15*(1), 197–203.

Armstrong, R. L. (1987). The midpoint on a five-point Likert-type scale. *Perceptual and Motor Skills, 64*(2), 359–362. https://doi.org/10.2466/pms.1987.64.2.359.

Baytiyeh, H., & Naja, M. K. (2010). *Impact of college learning on engineering career practice.* ASEE/IEEE Frontiers in Education Conference in Washington, D.C. https://doi.org/10.1109/FIE.2010.5673241
Besterfield-Sacre, M., Atman, C. J., & Shuman, L. J. (1998). Engineering student attitudes assessment. *Journal of Engineering Education, 87*(2), 133–141. https://doi.org/10.1002/j.2168-9830.1998.tb00333.x.
Bhattacherjee, A., & Sanford, C. (2006). Influence processes for information technology acceptance: an elaboration likelihood model. *MIS Quarterly, 30*, 805–825.
Blue, A. V., Crandall, S., Nowacek, G., Luecht, R., Chauvin, S., & Swick, H. (2009). Assessment of matriculating medical students' knowledge and attitudes towards professionalism. *Medical Teacher, 31*(10), 928–932. https://doi.org/10.3109/01421590802574565.
Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York: Guilford Press.
Chan, J. C. (2009). When does retrieval induce forgetting and when does it induce facilitation? Implications for retrieval inhibition, testing effect, and text processing. *Journal of Memory and Language, 61*(2), 153–170. https://doi.org/10.1016/j.jml.2009.04.004.
Chan, C. Y., Zhao, Y., & Luk, L. Y. (2017). A validated and reliable instrument investigating engineering students' perceptions of competency in generic skills. *Journal of Engineering Education, 106*(2), 299–325. https://doi.org/10.1002/jee.20165.
Chiang, F.-K., Wuttke, H., Knauf, R., Sun, C.-S., & Tso, T.-C. (2009). Students' attitudes toward using innovative information technology for learning based on theory of planned behavior. *International Journal of Advanced Corporate Learning, 2*(4), 9–14. https://doi.org/10.3991/ijac.v2i4.969.
Cialdini, R. B., Petty, R. E., & Cacioppo, J. T. (1981). Attitude and attitude change. *Annual Review of Psychology, 32*, 357–404. https://doi.org/10.1146/annurev.ps.32.020181.002041.
Conway, J. M. (2002). Method variance and method bias in industrial and organizational psychology. In S. G. Rogelberg (Ed.), *Handbook of research methods in industrial and organizational psychology* (pp. 344–365). Malden: Blackwell Publishing.
Conway, J. M., & Huffcutt, A. I. (2003). A review and evaluation of exploratory factor analysis practices in organizational research. *Organizational Research Methods, 6*(2), 147–168. https://doi.org/10.1177/1094428103251541.
Crawford, A. V., Green, S. B., Levy, R., Lo, W., Scott, L., Svetina, D., & Thompson, M. S. (2010). Evaluation of parallel analysis methods for determining the number of factors. *Educational and Psychological Measurement, 70*(6), 885–901. https://doi.org/10.1177/0013164410379332.
Davidson, R. J., Gray, J. A., Lazarus, R., Rothbart, M. K., & Ekman, P. (1994). How do individuals differ in emotion-related activity? In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: fundamental questions* (pp. 319–343). New York: Oxford University Press.
de Jong, J., & den Hartog, D. (2010). Measuring innovative work behaviour. *Creativity and Innovation Management, 19*(1), 23–36. https://doi.org/10.1111/j.1467-8691.2010.00547.x.
DeVellis, R. F. (2012). *Scale development*. United States: SAGE Publications, Inc.
Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method*, 4th Edition. John Wiley & Sons, Inc.
Douglas, K. A., & Purzer, S. (2015). Validity: meaning and relevancy in assessment for engineering education research. *Journal of Engineering Education, 104*(2), 108–118. https://doi.org/10.1002/jee.20070.
Farr, J. V., & Brazil, D. M. (2010). Leadership skills development for engineers. *IEEE Engineering Management Review, 38*(4), 110–118.
Fishbein, M. (1963). An investigation of the relationship between beliefs about an object and an attitude toward that object. *Human Relations, 16*, 233–239.
Fisher, D. (2014). *Fostering 21st century skills in engineering undergraduates through co-curricular involvement.* Presented at the annual conference for the American Society of Engineering Education in Indianapolis.
Ford, J. K., MacCallum, R. C., & Tait, M. (1986). The application of exploratory factor analysis in applied psychology: a critical review and analysis. *Personnel Psychology, 39*(2), 291–314. https://doi.org/10.1111/j.1744-6570.1986.tb00583.x.
Forman, S. M., & Freeman, S. F. (2013). *The unwritten syllabus: It's not just equations—student thoughts on professional skills*. Presented at the 120th ASEE Annual Conference & Exposition in Atlanta, Georgia.
Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: the broaden-and-build theory of positive emotions. *American Psychologist, 56*(3), 218–226. https://doi.org/10.1037/0003-066X.56.3.218.
Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology, 95*(5), 1045–1062. https://doi.org/10.1037/a0013262.
Furnham, A. (1992). Relationship between knowledge of and attitudes towards AIDS. *Psychological Reports, 71*(3, Pt 2), 1149–1150. https://doi.org/10.2466/PR0.71.8.1149-1150.
Gardner, P. L. (1995). Measuring attitudes to science: unidimensionality and internal consistency revisited. *Research in Science Education, 25*(3), 267–281.

Garland, R. (1991). The mid-point on a rating scale: is it desirable? *Marketing Bulletin, 2*, 66–71.
Green, S. B., Levy, R., Thompson, M. S., Lu, M., & Lo, W. (2012). A proposed solution to the problem with using completely random data to assess the number of factors with parallel analysis. *Educational and Psychological Measurement, 72*(3), 357–374. https://doi.org/10.1177/0013164411422252.
Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55. https://doi.org/10.1080/10705519909540118.
Humphreys, L. G., & Montanelli, R. G. (1975). An investigation of the parallel analysis criterion for determining the number of common factors. *Multivariate Behavioral Research, 10*, 193–205.
Jaschik, S. (2015). *Well-prepared in their own eyes.* Retrieved from https://www.insidehighered.com/news/2015/01/20/study-finds-big-gaps-between-student-and-employer-perceptions.
Judge, T. A., Bono, J. E., & Locke, E. A. (2000). Personality and job satisfaction: the mediating role of job characteristics. *Journal of Applied Psychology, 85*(2), 237–249. https://doi.org/10.1037/0021-9010.85.2.237.
Kar, Y. T., & Ho, S. Y. (2005). Web personalization as a persuasion strategy: an Elaboration Likelihood Model perspective. *Information Systems Research, 16*(3), 271–291. https://doi.org/10.1287/isre.1050.0058.
Katz, S. M. (1993). The entry-level engineer: problems in transition from student to professional. *Journal of Engineering Education, 82*(3), 171–174.
Kitchen, P. J., Kerr, G., Schultz, D. E., McColl, R., & Pals, H. (2014). The elaboration likelihood model: review, critique and research agenda. *European Journal of Marketing, 48*(11/12), 2033–2050. https://doi.org/10.1108/EJM-12-2011-0776.
Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., Brantley, M., & Fredrickson, B. L. (2013). How positive emotions build physical health: perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological Science, 24*(7), 1123–1132. https://doi.org/10.1177/0956797612470827.
Krosnick, J. A., Boninger, D. S., Chuang, Y. C., Berent, M. K., & Carnot, C. G. (1993). Attitude strength: one construct or many related constructs? *Journal of Personality and Social Psychology, 65*(6), 1132–1151. https://doi.org/10.1037/0022-3514.65.6.1132.
Li, C. (2013). Persuasive messages on information system acceptance: a theoretical extension of elaboration likelihood model and social influence theory. *Computers in Human Behavior, 29*(1), 264–275. https://doi.org/10.1016/j.chb.2012.09.003.
Loraas, T. M., & Diaz, M. C. (2011). Learning new technologies: the effect of ease of learning. *Journal of Information Systems, 25*(2), 171–194. https://doi.org/10.2308/isys-10109.
Morreale, M. K., Balon, R., & Arfken, C. L. (2011). Survey of the importance of professional behaviors among medical students, residents, and attending physicians. *Academic Psychiatry, 35*(3), 191–195. https://doi.org/10.1176/appi.ap.35.3.191.
Muthén, L. K., & Muthén, B. O. (1998-2010). *Mplus user's guide* (Sixth ed.). Los Angeles: Muthén & Muthén.
National Academy of Engineering. (2004). *The engineer of 2020: Visions of engineering in the new century.* Washington, DC: The National Academies Press. https://doi.org/10.17226/10999.
National Academy of Engineering. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century.* Washington, DC: The National Academies Press. https://doi.org/10.17226/11338.
Nguyen, D. Q. (1998). The essential skills and attributes of an engineer: a comparative study of academics, industry personnel, and engineering students. *Global Journal of Engineering Education, 2*(1), 65–74.
O'Flynn, S., Power, S., Horgan, M., & O'Tuathaigh, C. P. (2014). Attitudes towards professionalism in graduate and non-graduate entrants to medical school. *Education for Health, 27*(2), 200–204. https://doi.org/10.4103/1357-6283.143770.
Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: classic and contemporary approaches*. Dubuque: Brown.
Podsakoff, P. M., MacKenzie, S. B., Lee, J., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879.
Rees, C., Sheard, C., & Davies, S. (2002). The development of a scale to measure medical students' attitudes towards communication skills learning: the Communication Skills Attitude Scale (CSAS). *Medical Education, 36*(2), 141–147. https://doi.org/10.1046/j.1365-2923.2002.01072.x.
Royal Academy of Engineering (2015). *Engineering for a successful nation.* Retrieved from http://www.raeng.org.uk/publications/reports/engineering-for-a-successful-nation.
Salancik, G. R., & Pfeffer, J. (1978). A social information processing approach to job attitudes and task design. *Administrative Science Quarterly, 23*(2), 224–253. https://doi.org/10.2307/2392563.
Sauermann, H., & Roach, M. (2013). Increasing web survey response rates in innovation research: an experimental study of static and dynamic contact design features. *Research Policy, 42*(1), 273–286. https://doi.org/10.1016/j.respol.2012.05.003.

Schumann, D. W., Kotowski, M. R., Ahn, H.-Y., & Haugtvedt, C. (2012). The elaboration likelihood model: a 30-year review. In S. Rodgers & E. Thorson (Eds.), *Advertising theory* (pp. 51–68). NY: Routledge.

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "professional skills"—can they be taught? Can they be assessed? *Journal of Engineering Education, 94*(1), 41–55. https://doi.org/10.1002/j.2168-9830.2005.tb00828.x.

Smith, G. (2015). The impact of a professional development programme on primary teachers' classroom practice and pupils' attitudes to science. *Research in Science Education, 45*(2), 215–239.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences* (3rd ed.). Mahwah: Lawrence Erlbaum.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: understanding concepts and applications*. Washington, DC: American Psychological Association.

Winters, K. E., Matushovich, H. M, Brunhaver, S., Chen, H. L., Yasuhara, K., & Sheppard, S. (2013). *From freshman engineering students to practicing professionals: Changes in beliefs about important skills over time*. Presented at the 120th ASEE Annual Conference & Exposition in Atlanta, Georgia.