International Journal of Engineering Education Vol. 28, No. 1, pp. 103–112, 2012
Printed in Great Britain

0949-149X/91 $3.00+0.00

How Self-Identification and Views of Engineering Change with Time: A Study of Students and Professionals*

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Engineering identity has been linked to both educational and professional persistence, but little has been reported on the views of professionals. The purpose of this study was to understand the relationship between engineering identity for students and professionals and how self-identification as an engineer changes over time and with certain key experiences. We surveyed a cross-section of undergraduate engineering students and alumni, within 10 years of receiving their undergraduate engineering degree, from the same institution during the spring of 2009. The survey yielded over 700 student responses and over 500 responses from alumni, and the differences in terms of who self-identifies as an engineer and what factors are viewed as most critical to engineering are reported. It was found that for both students and alumni work experiences are critical to self-identification but that gender was significant only for students. Finally, alumni were almost universally more selective in defining what factors (behaviors, experiences, etc.) are necessary to be considered an engineer. The one notable difference was in establishing relationships with fellow engineers in which a much higher percentage of alumni than students recognized it as necessary to be considered an engineer.

Keywords: engineering identity, professional persistence, educational persistence, gender

1. Introduction

Several reports indicate growing awareness of the important relationships among higher education, the STEM fields, and global competitiveness of the United States. Specifically, concerns over a disparity between supply and demand of qualified scientists and engineers [3, 7] have prompted engineering education researchers to study persistence in engineering. Persistence is two-fold: there is persistence as an undergraduate student in completing a STEM degree and persistence as a professional in continuation of the degree into the working world in an engineering related role. Student persistence has been considered in terms of high school preparation levels, standardized tests, and classroom performance [12, 19, 20]. Professional persistence is more difficult to study because once students leave an educational institution they are much more difficult to track, but there have been studies that consider students' intention to continue in engineering professionally [37]. Specifically, a multi-institutional, mixed-method study by the Center for the Advancement of Engineering Education (CAEE) through the Persistence in Engineering (PIE) Survey found that students who persist in undergraduate engineering studies but not professionally were more likely to have been motivated by family influences, and further, only 42% of engineering students in their senior year reported definitive intentions to continue in an engineering related career post-graduation [14, 36, 37].

Engineering identity has also been linked to persistence through a sense of belonging to the engineering community [30, 32]. Specifically, Tonso has done extensive qualitative assessment of teamwork and gender issues as they relate to engineering identity. Tonso [31] also recognized a clear difference in engineering identity between first-year students and seniors as evidenced in their ability to describe the engineering terrain. Others have also studied engineering identity and found an evolution of thought among engineering students through an increased sense of differentiation between engineers and non-engineers, as evidenced by the language "us vs. them" and "we vs. they" [29], boundary language for an understanding of membership, identity, and belonging [16]. The study by Stevens et al. considers how disciplinary knowledge, identification, and navigation of pathways through the engineering curriculum can be applied as an analytic framework. Institutional identification in terms of how the university and curricular structures of labeling a student as an engineer were found to be significant both in terms of students' self-perceptions and commitment to engineering. Additionally, it was reported that the institutional differences in terms of selection into an engineering

* Accepted 5 August 2011.

program were significant (i.e. whether students self-select to enter the program or there was an application / acceptance process) [29]. Engineering identity has also been the focus of several qualitative studies of under-represented groups including women [8, 11, 26, 33, 38], but there is limited large-scale quantitative research in the area of engineering identity.

Prior research has found that, for engineering students, experiences such as internships are formative towards engineering identity and professional persistence [14]. Further, experiences such as engineering-related internships and research experiences may be either affirming or dissuading towards professional continuation and self-identification as an engineer [18].

Building on the prior research, the present study seeks to understand how people's views of themselves (in terms of self-identification as an engineer) changes throughout undergraduate studies and into the work place. This study is approached by quantitatively assessing the experiences and perceptions of current engineering students and alumni from the same institution to understand the evolution of this thought process. The primary research questions for the current study included the following:

1. Who considers themselves to be an engineer among the engineering student and professional populations?
2. What experiences / plans may contribute to engineering self-identification?
3. What factors do engineering students and alumni deem critical to defining engineering?

2. Methods

The primary method for data collection was survey assessment. Survey administration offers advantages of larger sample sizes and statistical analysis to potentially identify trends within the data; the drawback is the lack of depth afforded by standardized questions [21]. The survey instrument used in the current study was adapted from an instrument originally developed by Arnett [2] that posed the question: "Are College Students Adults?" Arnett's original instrument was modified and parallels were developed for engineering identity. In light of the changes to the questions in this instrument, construct validity was strengthened by multiple reviews and revisions by experts. Expert reviewers included four engineering education researchers of diverse backgrounds and a sociologist. The survey was piloted on paper to a focus group of upper-division students in January of 2009. Revisions were incorporated for a second pilot conducted with lower-division students a few days later. Feedback from both of the focus groups was incorporated into the final version of the survey.

2.1 Setting

The survey had two administration processes, one for students (on campus) and one for alumni, both of which took place during the spring of 2009. The students surveyed were current engineering students at a medium sized, Midwestern, private institution while the alumni were graduates of the engineering program from the same institution living in multiple locations around the world (predominately the United States). At the institution studied, nearly all students complete their undergraduate studies in four years and are of traditional college ages (18–22 years old). The institution is considered selective and is religiously affiliated. The overall student body is 53% male and 47% female, while the College of Engineering is approximately 75% male and 25% female. All first-year students are admitted to a separate First-Year of Studies program, and select their major (engineering or otherwise) near the end of their first year, when they register for classes for the sophomore year. With few exceptions, engineering students complete a standard first-year curriculum, including the two-semester course sequence "Introduction to Engineering," before declaring which field of engineering they plan to pursue. Engineering disciplines at the institution studied include: Aerospace and Mechanical Engineering, Chemical and Biomolecular Engineering, Civil Engineering, Computer Science and Engineering, and Electrical Engineering. Beyond admission to the university, there are no admissions criteria for entering any of the disciplines of engineering; it is based on student interest alone.

2.2 Population

There are two distinct populations that were involved with this study: the current engineering students and engineering alumni within 10 years of graduation (1999–2008). This yielded a total of 1224 respondents with 701 being students and 523 alumni.

For the student population, the entire engineering student body, including all first-year students enrolled in the Introduction to Engineering course, was invited to complete the web-based survey. The overall response rate was 64%, which is higher than the 25–50% expected for a web survey [5, 6, 13]. This high response rate is attributed to the multiple e-mail contacts that came from a source the students were familiar with, the College of Engineering, as well as a pre-incentive of tic-tac® candies sent to each student's residence asking them to consider participating.

Table 1. Comparison of potential to actual survey responses for students

Student	Potential engineering student respondents			Actual engineering student respondents			Response
classification	Male	Female	Total	Male	Female	Total	Rates
Senior	207	54	261	101	39	140	53.6%
Junior	181	56	237	104	39	143	60.3%
Sophomore	188	76	264	136	60	196	74.2%
First-year	252	83	335	162	60	222	66.3%
Totals			*1097*			*701*	*63.9%*

As a percentage, the lower-grade divisions (first-year and sophomore) had slightly higher response rates than the upper-grade division (junior and senior) students. Each grade division had a response rate over 50% and the data collected from the sample population are relatively representative of the overall engineering student population. Based on a chi-squared test of independence, upper-division men were slightly under-represented while lower-division women were slightly over-represented. A higher response rate for women (74% vs. 61% for men) was observed, but is not uncommon [27] and is recognized as a limitation of the current study. Studies of survey response rates show gender is the single greatest predictor of survey completion [25]. Potential and actual student respondents by grade level and gender are shown in Table 1.

2.3 Administration

The alumni were invited to participate in this study through a single e-mail contact (no incentive for participation) with a link to the web based survey. The survey response rate for the alumni population was much lower that the student response rate, but it was more similar to the expected response rate for surveys conducted in this manner [5]. Overall, 1826 alumni from 1999 to 2008 were invited to participate with complete responses from 523 alumni collected. The distribution of self-reported graduation year of the participants is shown in Table 2. Of the 523 respondents, 387 self-reported as male (74%) and 136 as female (26%). There is a range in the number of responses by year (33–75 per year). There was less control / interaction with alumni, as the Alumni Association directly invited participation in the survey through e-mail contact, so less is known about the gender distribution of the alumni population—this is a limitation of the current study. Nevertheless the distribution of alumni participants by gender was proportional to the gender distribution of enrolled students (and was similar to the student response rates in which women are slightly over-represented for the populations during their time as students).

Table 2. Alumni responses by graduation year

Graduation year	Number of alumni respondents
2008	73
2007	63
2006	62
2005	75
2004	52
2003	40
2002	51
2001	33
2000	38
1999	36
Total	*523*

2.4 Incomplete data

Fifty-two incomplete survey responses from students and 106 from Alumni were dropped from the analysis (and are not included in the response rates reported). This was a condition set by the Institutional Review Board, which required a notice to participants on the opening screen of the survey that early termination of the survey indicated an individual was no longer willing to participate in the study. While respondents could terminate the survey at any point, to advance in the on-line survey instrument, it was necessary to answer all the questions on a page.

2.5 Survey instrument

In order to answer the three previously mentioned research questions, respondents were asked a series of questions, the first of which is an identity question. This was followed by a series of their perception of the importance of certain factors for an engineer.

Question 1: Do you consider yourself to be an engineer?

Response choices (3): Yes, In some ways*, or* No

Questions 2–41: *Indicate whether you feel each of the following is necessary to be considered an engineer.*

Response choices (2): Yes *or* No

Table 3 outlines these survey questions, note that Questions 32–41 correspond to the ABET criteria a–k, although they were not identified as such on the survey.

Finally, respondents were asked a series of background questions (demographics, experiences, and

Table 3. Survey items Questions 2–41. Which factors define engineering?

	Please read the following statements and indicate whether you feel each is necessary to be considered an engineer.
2	Being able to make competent design decisions
3	Being able to teach engineering content to another person
4	Speaking/communicating using accurate technical terminology
5	Feeling confident in engineering work without confirmation from others that the approach is technically sound
6	Making moral / ethical decisions considering all factors
7	Accepting responsibility for the consequences of actions
8	Making a long term commitment to a company
9	Making a long term commitment to a career
10	Being able to support a family financially
11	Establishing relationships with other engineers
12	Being able to work with others by sharing ideas
13	Committing to engineering as a major
14	Committing to the completion of an engineering degree
15	Avoiding procrastination on work responsibilities
16	Doing your best work beyond the minimum requirements
17	Showing up for class and meetings prepared
18	Participating actively in meetings
19	Being able to lead a design team / initiative
20	Possessing natural engineering ability
21	Excelling in subjects relating to mathematics and science
22	Completing the first year of engineering
23	Gaining practical engineering experience while still an undergraduate
24	Serving as a mentor to another engineering student
25	Obtaining full-time employment
26	Completing an undergraduate engineering degree
27	Completing a graduate engineering degree
28	Completing the 1st stage of professional licensure (FE: Fundamentals of Engineering Exam)
29	Completing the 2nd stage of professional licensure (PE: Professional Engineer Exam)
30	Reaching the age of 22
31	An ability to apply knowledge of mathematics, science, and engineering
32	An ability to design and conduct experiments, as well as to analyze and interpret data
33	An ability to design a system, component, or process to meet desired needs
34	An ability to function on multi-disciplinary teams
35	An ability to identify, formulate, and solve engineering problems
36	An understanding of professional and ethical responsibility
37	An ability to communicate effectively
38	The broad education necessary to understand the impact of engineering solutions in a global and societal context
39	A recognition of the need for, and an ability to engage in life-long learning
40	A knowledge of contemporary issues
41	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

future plans) to better understand contributory factors to self-identification as an engineer, which served as critical explanatory variables for analysis. The quantitative data were analyzed statistically using the statistical software package STATA [28] and involved frequency counts / tabulations, tests of statistical significance (t-tests), and ordinal logistic regression modeling. Logistic regression techniques were employed given the binary nature of survey responses [1]. The independent variable was the response to the opening survey question, “Do you consider yourself to be an engineer?” Response choices included three options: Yes; In some ways yes, and some ways no; and No. As such, an ordinal regression technique was selected over a more traditional regression analysis approach (which would only consider two response choices). The explanatory variables included several background questions relating to factors such as age, gender, educational grade classification, engineering discipline, and other experiential factors.

3. Results

To begin the analysis, a comparison of Alumni versus undergraduate student response frequency distributions was considered for Question 1 and then for Questions 2–41 collectively.

3.1 Analysis of Question 1: Self-identification

Table 4 shows the response distributions for both students and alumni to the self-identification question, “Do you consider yourself to be an engineer?” These data are further broken down by respondent gender.

As a percentage, more male students self-identified as engineers than female students, and that trend was also present in the alumni data in which male alumni more frequently self-identified as engineers than their female counterparts. Interestingly, male students were more likely to self-identify than male alumni, although that was not true of female

Table 4. Student vs. Alumni engineering self-identification response

	Student				Alumni			
Self-identification	**Male (#)**	**Male (%)**	**Female (#)**	**Female (%)**	**Male (#)**	**Male (%)**	**Female (#)**	**Female (%)**
Yes	357	71.0%	113	57.1%	248	64.1%	80	58.8%
In some ways	138	27.4%	75	37.9%	117	30.2%	45	33.1%
No	8	1.6%	10	5.1%	22	5.7%	11	8.1%
Total	*503*		*198*		*387*		*136*	

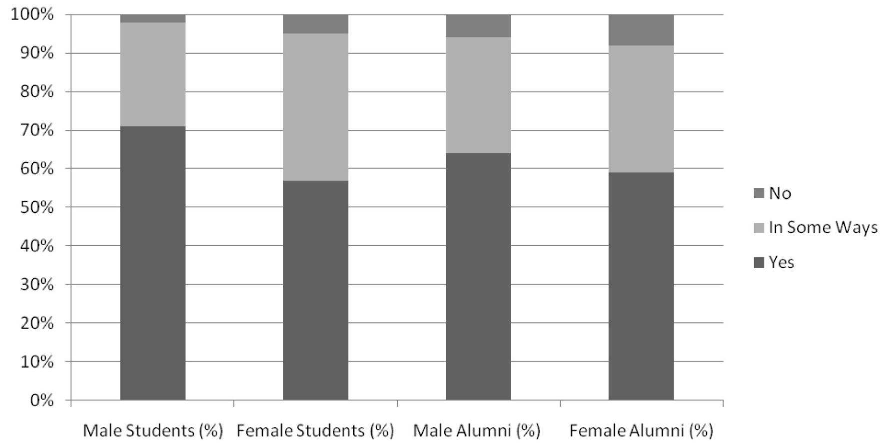

Fig. 1. The percentage of respondents in each self-identification classification.

students and alumni. Graphically, the data from Table 4 are shown in Fig. 1.

For the student and alumni respondents, these data are broken down by graduation year shown in Table 5 and graphically in Fig. 2. Overall these data suggest that perceptions of engineering identity may shift with time. The group of students from sophomore year through the alumni during their first year post-graduation (2008–2011) were all in the 70–75% range for definitively self-identifying as engineers. Next, alumni who graduated two years previously (2006–2007) were less likely to self-identify as engineers (65%) and alumni 4–5 years post graduation (2004–2005) show a further drop in percentage to 55% of individuals self-identifying as engineers. The trend then changes and an increase is seen in the alumni 5–6 years post graduation (2002–2003) being more likely to self-identify as engineers, which was followed by another decline as the 10-year mark post graduation approached (2001). The relative peaks and valleys of affirmative self-identification as an engineer over years since graduation indicates there may be more variation in those that responded than in actual differences in the level of self-identification by graduation year. This was explored by developing a regression model that

Table 5. Self-identification summary by graduation year

			Raw			Percent		
Student or alumni	**Graduation year**	**Qty**	**Yes**	**In some ways**	**No**	**Yes**	**In some ways**	**No**
Student	2012	222	126	90	6	57%	41%	3%
Student	2011	196	138	56	2	70%	29%	1%
Student	2010	143	102	37	4	71%	26%	3%
Student	2009	140	104	30	6	74%	21%	4%
Alumni	2008	73	55	14	4	75%	19%	6%
Alumni	2007	63	41	20	2	65%	32%	3%
Alumni	2006	62	42	15	5	68%	24%	8%
Alumni	2005	75	39	31	5	52%	41%	7%
Alumni	2004	52	29	19	4	56%	37%	8%
Alumni	2003	40	28	11	1	70%	28%	3%
Alumni	2002	51	35	16	0	69%	31%	0%
Alumni	2001	33	15	12	6	45%	36%	18%
Alumni	2000	38	22	13	3	58%	34%	8%
Alumni	1999	36	22	11	3	61%	31%	8%

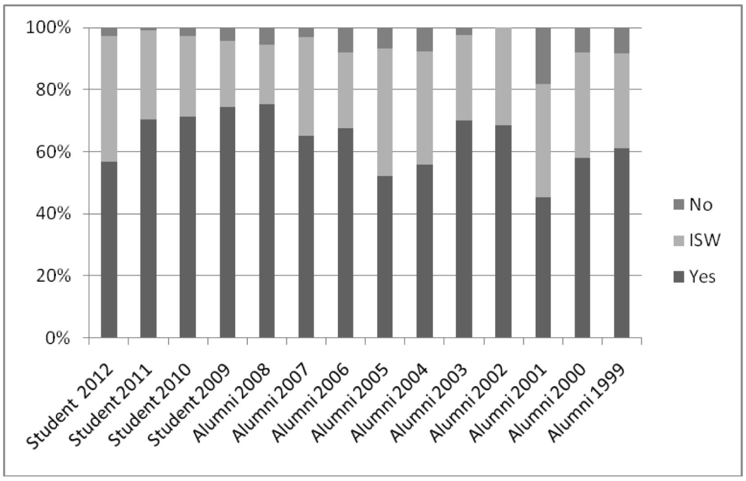

Fig. 2. Self-identification summary by graduation year.

controls for key demographic and experiential factors that may influence respondents.

3.1.1 Regression modeling

To understand more fully what factors may relate to self-identification as an engineer, an ordinal logistic regression model was considered. Table 6 shows the model for students in which class level (first-year student vs. sophomores, juniors, and seniors), gender, and future engineering work plans were all statistically significant factors in engineering self-identification. Based on the original study, which began by looking only at student responses [17], the background factors were found to be individually important to understanding who self-identifies as an engineer, those factors were considered simultaneously using ordinal logistic regression to control for the other factors. Table 6 summarizes the results that show that women are less likely than men to self-identify as engineers. The odds ratio of 0.485 indicates that women are less than half as likely as men to self-identify as an engineer. Further, the model shows that sophomores, juniors, and seniors are collectively 1.5 times as likely to self-identify as an engineer than first-year students. This is supported by the odds ratio of 1.561. Finally, students with future professional or educational work plans for 3 years post-graduation were 1.4 times more likely to self-identify as engineers as students who did not have future plans. Note that the reference category is "Yes" to the self-identification question, so the comparison is to those that did not self-identify as an engineer (In some ways or No).

A similar ordinal logistic regression model was developed for alumni respondents and is shown in Table 7. Interestingly, the only factors that related to engineering self-identification for alumni (post-graduates) were experiential in nature. If a respondent reported plans to work in an engineering related field in the future they were much more likely to self-identify as an engineer. Among alumni, the single greatest factor relating to engineering self-identification was if an individual had ever worked in an engineering related job (even if they did not at the time of the survey). And, while other studies have found that women are much less likely to persist in engineering related fields post-graduation [34], our research suggests that if a

Table 6. Logistic regression model for students—factors related to self-identification

Background question	p	Standard error	Odds ratio	95% Confidence interval
Class level (First-Year vs. Soph, Ju, Sr)	0.019*	0.296	1.561	1.07–2.26
Engineering discipline	0.154	0.230	1.289	0.91–1.83
Female	< 0.001***	0.092	0.485	0.33–0.71
Engineering related future career plans	< 0.001***	0.105	1.441	1.25–1.66
Engineering related work experience	0.138	0.249	1.322	0.91–1.91
Engineering research experience	0.161	0.286	1.347	0.89–2.04
Engineering organizational involvement	0.779	0.200	1.055	0.73–1.53
Core group of individuals for support	0.815	0.200	1.046	0.72–1.52

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Table 7. Logistic regression model for alumni—factors related to self-identification

Background question	***p***	**Standard error**	**Odds ratio**	**95% Confidence interval**
Years since graduation (1=2008, 10=1999)	0.114	0.033	0.947	0.885–1.013
Engineering Discipline (Reference category Aerospace & Mech. Eng.)	0.530	0.173	0.883	0.602–1.299
Female	0.621	0.192	0.900	0.593–1.367
Engineering related future career plans	< 0.009**	0.334	1.681	1.139–2.481
Engineering related work experience	< 0.001***	1.307	5.567	3.514–8.818
Core group of individuals for support (peer support)	0.614	0.227	1.109	0.742–1.657

*$p < 0.05$, **$p < 0.01$, *** $p < 0.001$.

woman has ever worked in an engineering-related job or plans to in the future, she is just as likely to self-identify as an engineer as a male counterpart.

No other interesting findings emerge when the alumni and student data are pooled, and the obvious differences between the two populations make it unreasonable to combine the two datasets.

3.2 Analysis of Questions 2–41

Table 8 shows the percentage of respondents, both students and alumni, who agreed that a factor was necessary in order to be considered an engineer. The table is sorted according to the frequency of responses by alumni. Interestingly, students and alumni generally agreed as to the most important and least important factors. In fact, the top 11 factors were the same for both students and alumni, although there was slight variation in the order (this was indicated by the relative percentages in each group that placed importance on a factor). There was a similar trend for the least frequently recognized factors but it was not as clearly distinguishable. In the case of the factors least frequently cited, the percentages vary much more widely between students and alumni; and in virtually all of the 40 factors, alumni were more selective than students as evidenced by the lower percentage of agreement in each category; this was especially apparent at the bottom of the spectrum. Specific examples of this disparity included: gaining practical work experience while still an undergraduate, avoiding procrastination in work responsibilities, and licensure (both phases). There was one notable difference in which the disparity went the other way, alumni indicated that establishing relationships with fellow engineers at a rate of 65% versus 20% for students, indicating that once in a professional environment there is a greater realization that relationships with others is more important than they originally thought. A study by CAEE asked seniors to rank the most important skills for practicing engineers (this included ABET a–k criteria) through which the students identified: problem solving, communication, and team work as most important [35]. These were also among the most recognized items by the cross-section of students in the current study (based on percentage).

4. Discussion and limitations

Our study found that men were more likely to self-identify as engineers than women, both in students and alumni populations (although it was only statistically significant for students). The finding that gender was significant for students in terms of engineering identity but not for alumni / professionals appears consistent with prior studies. For example, Rayman and Brett conducted a study to better understand professional persistence of women who graduated with a degree in a field of science (who stayed, changed, or left science). They found that most of those responding that they were no longer working in a field of science left immediately after graduation [23]. The current study appears to support this conclusion, specifically; there is a noted change in the regression results for the students versus the alumni in this realm. For students, both gender and future engineering work plans were significant in who self-identified as an engineer (women were less likely to self-identify and also less likely to persist in an engineering related field following graduation). In contrast, the alumni surveys indicated only experience factors as impacting self-identification. One possible explanation for this change, consistent with Rayman and Brett, is that women who did not self-identify as engineers at the point of graduation pursued careers not related to engineering. In fact, the most significant factor for an alumni self-identifying as an engineer was having work experience in an engineering-related job at some point since graduation. The attrition of women from engineering at the point of graduation who did not self-identify as engineers reveals that the remaining population is now on a level playing field—only experience matters. In other research, a woman's perception of compatibility between her career and family life has also been found to be a significant factor for professional persistence

Table 8. The factors considered necessary to be an engineer by students and alumni

Question	Student		Alumni	
	Yes (#)	**Yes (%)**	**Yes (#)**	**Yes (%)**
An ability to identify, formulate, and solve engineering problems	698	99.6%	520	99.3%
An ability to apply knowledge of mathematics, science, and engineering	697	99.4%	520	99.3%
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	689	98.3%	513	97.8%
An ability to design a system, component, or process to meet desired needs	688	98.1%	508	97.0%
Being able to make competent design decisions	691	98.6%	507	96.9%
Speaking /communicating using accurate technical terminology	652	93.0%	510	96.3%
An ability to design and conduct experiments, as well as to analyze and interpret data	673	96.0%	489	93.5%
Accepting responsibility for the consequences of actions	665	94.9%	486	92.3%
Being able to work with others by sharing ideas	676	96.4%	484	92.1%
An understanding of professional and ethical responsibility	646	92.2%	482	92.0%
An ability to function on multi-disciplinary teams	655	93.4%	470	89.1%
Making moral / ethical decisions considering all factors	605	86.3%	455	86.8%
An ability to communicate effectively	630	89.9%	446	84.8%
A recognition of the need for, and an ability to engage in life-long learning	621	88.6%	443	84.0%
Excelling in subjects relating to mathematics and science	572	81.6%	30	82.1%
Feeling confident in engineering work without confirmation from others that the approach is technically sound	539	76.9%	423	79.4%
Committing to the completion of an engineering degree	577	82.3%	409	77.6%
Completing an undergraduate engineering degree	606	86.4%	84	77.0%
Showing up for class / meetings prepared	597	85.2%	403	76.9%
Doing your best work—beyond the minimum requirements	560	79.9%	391	74.5%
The broad education necessary to understand the impact of engineering solutions in a global and societal context	561	80.0%	389	74.0%
Committing to engineering as a major	516	73.6%	383	71.8%
Being able to lead a design team / initiative	529	75.5%	371	71.0%
Being able to teach engineering content to another person	476	67.9%	376	70.7%
A knowledge of contemporary issues	522	74.5%	346	66.0%
Establishing relationships with fellow engineers	*145*	*20.7%*	*349*	*65.3%*
Participating actively in meetings	523	74.6%	333	63.6%
Completing the first-year of engineering	390	55.6%	236	61.2%
Gaining practical engineering experience while still an undergraduate	535	76.3%	429	58.1%
Obtaining full-time employment	398	56.8%	305	48.1%
Possessing a natural engineering ability	313	44.7%	404	45.7%
Avoiding procrastination on work responsibilities	412	58.8%	223	43.1%
Being able to support a family financially	388	55.3%	176	34.1%
Making a long term commitment to a career	277	39.5%	150	28.9%
Reaching the age of 22	176	25.1%	97	19.2%
Completing of the 1st stage of professional licensure (FE: Fundamentals of Engineering Exam)	329	46.9%	97	19.0%
Serving as a mentor to another engineering student	140	20.0%	322	16.5%
Completing of the 2nd stage of professional licensure (Professional Engineering Exam)	251	35.8%	72	14.1%
Making a long term commitment to a company	152	21.7%	53	11.2%
Completing a graduate engineering degree	68	9.7%	249	6.4%

[22–24] although factors such as the economy and the level of encouragement from parents, faculty, and advisors also made a difference [23].

Prior work experiences and future work plans are critical to self-identification as an engineer, both for students and alumni (statistically significant in both regression models). It has been recognized that experiences are formative and play an integral role in the decision making process, although there are concerns that a single experience may be weighted very heavily [14, 18]. In light of prior research that indicates that the climate in the engineering workplace influences professional persistence of women (that continued in an engineering related field for at least some amount of time post-graduation) [23, 24], an interesting future study would consider the points at which people leave engineering after graduation and for what reasons (and is there a difference for men and women).

Finally, alumni appear to be much more selective in what factors they indicate are necessary to be considered an engineer, as was evidenced by lower percentage rates for alumni. This was consistent for almost all of the 40 factors and is likely due to the greater understanding of engineering as a field that results naturally through experience. Educationally speaking others have reported an evolution that takes place over the course of an undergraduate experience [9, 10, 15, 32], so it seems plausible that increased understanding would result in a higher discrimination level among professionals post graduation. There was one notable exception—"establishing relationships with fellow engineers," in which a much larger percentage of alumni (65%)

as compared with students (21%) identified it as necessary to be considered an engineer. This result indicates that professional relationships are more important than students may initially realize, and after time in the work place there is a higher recognition for the need to interact with other engineers. Essentially, this represents the endorsement by alumni engineers of the importance of social capital and recognition of the value that social networks provide [4]. Students do not perceive the importance of these until after they have spent some time in the profession.

The primary limitations of the current study relate to the population of students and alumni that participated in the study. For the student sample population, women are slightly over represented relative to the engineering student body. For the alumni population, those invited to participate came through the Alumni Association at the institution studied such that alumni who did not have an e-mail address registered with the Alumni Association were not accessible as potential survey respondents. Although the respondents from the alumni group were proportionately representative of the gender and discipline graduation rates we cannot affirm the exact breakdown of respondents versus potential respondents. Finally it must be recognized that this study is cross-sectional in nature and, as such, comparisons between alumni and students can be considered collectively, but they are in fact different people (rather than measuring an evolution of individuals in terms of engineering identity over time, which would make for a very interesting future study).

5. Conclusions

This study provides useful evidence that while there may be a gender gap in professional persistence at the point of graduation (women graduating with engineering degrees are less likely to pursue engineering employment), gender differences are greatly reduced for women who actually engage in engineering employment. Our results regarding the student perception that social capital is not an important characteristic of the engineering profession suggest that engineering students should receive greater exposure to communities and networks of engineering professionals.

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