Women in Engineering: Promoting Identity Exploration and Professional Development

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Abstract

Engineering colleges are concerned about retention of women, especially women of color, in their programs. One possible solution is to promote undergraduate women's engineering identity. This paper describes an evaluation of a one-day technical and professional development conference for undergraduate women in engineering and computer science, which focused on understanding and facilitating engineering identity.

Data on the impact of the conference and engineering identity, were collected in pre- and post-conference surveys. The pre-conference survey assessed demographic information (e.g., first generation status, ethnicity), engineering student identity (i.e., commitment to engineering major; engineering competence, and engineering agency), social support, and reasons for attending. The post-conference survey assessed engineering student identity, ratings of self- and "engineer" creativity, professional identity, and evaluations of the conference.

193 participants returned pre-conference surveys and 103 returned post-conference surveys. Most were engineering (54%) and computer science (38%) majors; 46% were Asian, 28% LatinX; and 65% received financial aid. Correlations, MANOVA, regression, and content analyses were used to analyze the data.

Participants reported the conference was highly valuable. Both pre- and post-conference surveys revealed positive associations between commitment, competence, and agency, suggesting that undergraduate women view their engineering identities as a coherent set. Results indicated that the strength of a participant' professional identity is shaped by first-generation status and knowing an engineer. They also indicated that women undergraduates do not rate themselves as being as creative as a "typical engineer", and there is a strong association between self-ratings of creativity and professional identity. Engineering identity is discussed in the context of participants' reported goals for the conference and its benefits. Suggestions for promoting engineering identity are described.

Introduction and Background

As universities aim to address the gender gap problem of their engineering and computer science student population [1], recruiting and retaining women has become ever more critical. To this end, a one-day annual Women in Engineering conference [2] was organized and hosted by a large public university in the west. One overarching goal of the conference is to foster the development of participants' engineering identity which is related to their educational and professional persistence [3] [4]. A review of the literature summarizing approaches to recruitment and retention of women and the role of engineering identity can be found in a prior publication [2].

Our current project studied the impact of the 2019 conference on various aspects of engineering identity in the participants through pre- and post-conference surveys. Our work draws heavily from the following prior work, which indicates that identity in general, and engineering identity more specifically, is a multi-dimensional construct that is influenced by many factors and frequently dependent on context. Before describing influences in engineering identity, it is important to note that engineering identity is likely distinct from identity in other similar professions, given the large variance in skills, knowledge, and abilities required in these different professions. One growing area of research is the study of creativity in different fields in order to help understand how members of a profession define themselves in their field. An example of this kind of variance can be found in the research by Portillo who surveyed 313 professors from four related fields: interior design, architecture, landscape architecture, and engineering [5]. Respondents were asked to describe a highly creative practitioner in their respective field, using the Gough Adjective Check List scored with the Domino creativity scale. Out of a list of 59 traits, highly creative engineers were most frequently described as imaginative, adventurous, intelligent, inventive, and adaptable. In comparison, highly creative interior designers were described as imaginative, artistic, adventurous, energetic, and capable. No differences in responses were detected as resulting from gender of the respondent.

These findings suggest that it is important to understand how identity, broadly defined, develops and what shapes that development. Factors that influence engineering identity may include academic proclivities, beliefs about one's competence and abilities, and social experiences. Moreover, factors that influence traditional engineering students' identity (e.g., males and/or students of Euro-Anglo backgrounds) may not be the same as those influencing the engineering identities that women or students of color develop over time. To illustrate, Fleming et al. studied the engineering identity of underrepresented minority students at Minority Serving Institutions, contrary to much of the cited work at predominantly White Institutions [6]. For Black and Hispanic engineering undergraduate students, interactions with faculty and peers were strongly associated with intellectual development. Additionally, as interactions with faculty and peers increased, engineering identity increased. Furthermore, the majority of students (51/76) articulated the importance of being an engineer, reported the importance of math and science skills to being an engineer, and described the challenges in being an engineering student shaping their identities. Fleming and colleagues' results are consistent with those reported by Prybutok et al. who surveyed 563 engineering students to study the development of engineering identity as students progressed from lower-division to upper-division students [7]. Lower- division students scored higher on three aspects of engineering identity: math interest, engineering personal agency related to authority, and engineering global identity. They expressed a life-long interest in science and/or excitement in beginning their college engineering careers. Upper-division students scored higher on the physics recognition by others aspect of engineering identity in comparison to lower-division students. They felt that the programs were demanding but worth it, and they had more concerns about the content of their programs. Similarly, Godwin et al. found that math and physics identities as well as agency identities became more established with each additional STEM subject in a survey of 6,772 engineering from 50 colleges and universities [8][9]. Recognition was the strongest predictor of physics and math identities, which in turn heavily influenced the choice to study engineering in men; in women, agency played a stronger role in their choice to study engineering. This association between engineering identity and math/science courses develops even before college [10].

The above findings show differences between men and women, as well as differences between underrepresented minority (URM) and non-URM students with respect to engineering identity. Understanding these differences is important in developing programs that target a particular group. For example, one key programming component for URM students may be providing them with opportunities to join organizations that reflect their cultural and ethnic identities. To illustrate, Revelo interviewed 20 LatinX engineering students who attended the Society for Hispanic Professional Engineers (SHPE) conference [11]. The interviews indicated that students felt they developed professional and leadership skills through their membership in SHPE, with workshops and the conference itself playing a significant role in that development. Additionally, a key component for these LatinX students' engineering identity development was finding role models, as well as an engineering familia (home away from home), through their membership in SHPE.

In summary, programs that provide engineering students with opportunities to develop professional and leadership skills, find role models, and develop strong social connections with other engineering students similar to themselves may be able to facilitate the development of engineering identity in the student participants. The current study examines the impact of a one-day conference on the predominantly female engineering and computing science majors and their sense of engineering identity. The conference featured nearly 70 women engineering leaders as keynote speakers, technical presenters, and career panelists, along with parallel tracks in professional development and networking. There were about 400 student attendees from 28 campuses in the state.

Methods

Procedures and Participants

Research participants were recruited from an annual Women in Engineering (WiE) conference on campus. One week prior to the conference, registered attendees were sent an orientation packet that included a request to participate in the pre-conference survey. One week after the conference, attendees were sent another request to complete the associated post-conference survey (see measures below). With their consent, responses on the pre- and post-surveys were linked via the respondents' email addresses so that changes from pre-conference to post-conference could be measured. All scales (e.g., three measures of identity, sense of professional identity, and self/ideal ratings of creativity) were checked for internal consistency (i.e., how closely related items in a scale are to each other) using Cronbach's Alpha as the measure of scale reliability. Cronbach's Alpha has been shown to be an appropriate method for Likert scales, such as those used in the measures described below, and is not dependent on sample size [12].

There are 193 participants who returned pre-conference surveys, and 103 participants who returned post-conference surveys. Sixty-six of the participants returned both pre-conference and post-conference surveys. Figures 1 and 2 show, respectively, the majors and ethnic backgrounds of the193 participants.

Figure 1
<u>WiE Conference Participants' Majors</u>

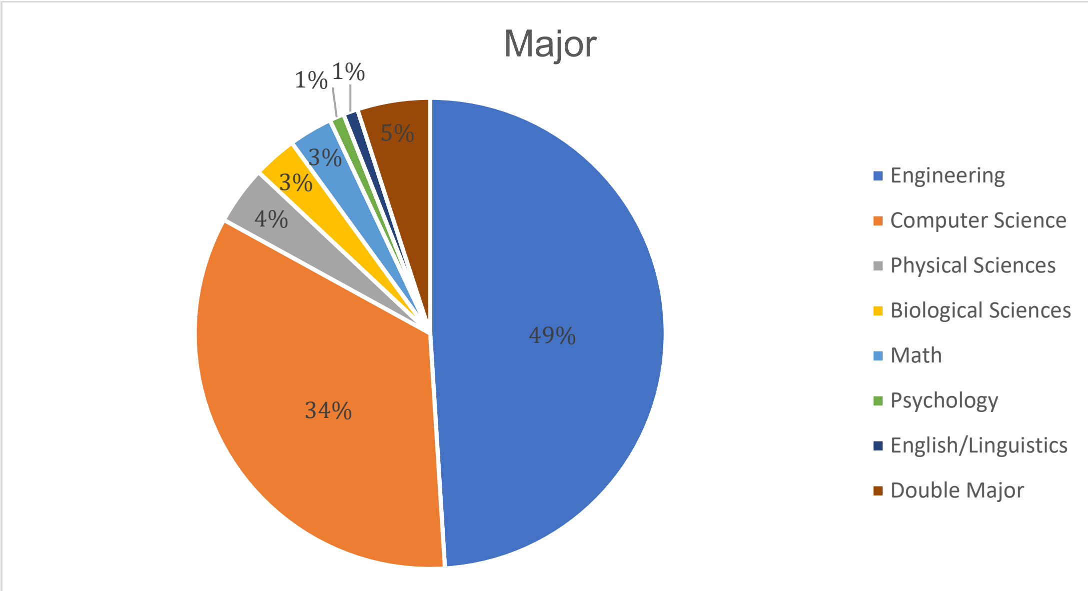
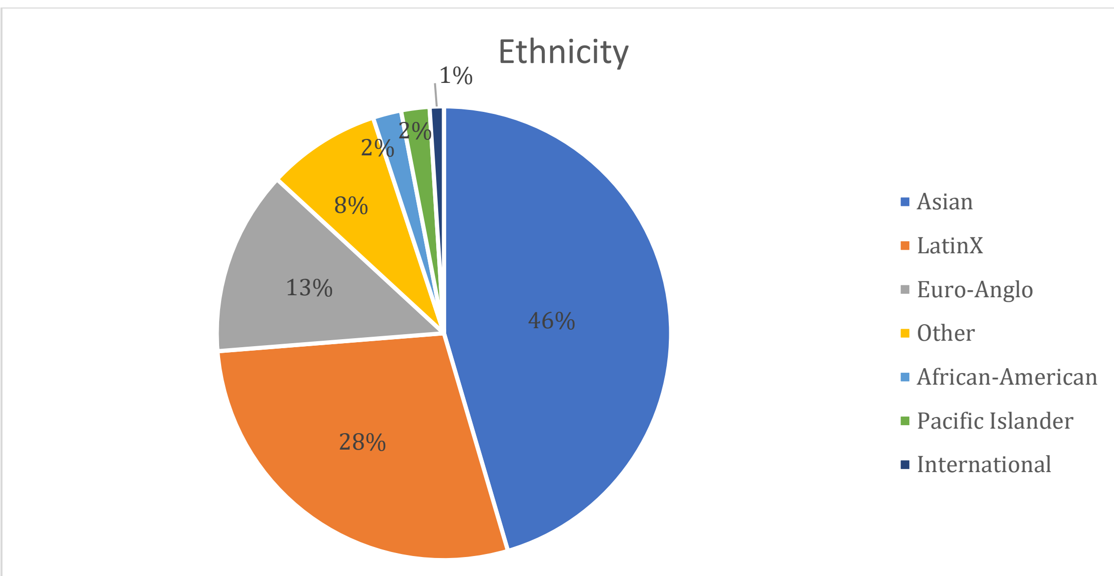


Figure 2
<u>WiE Conference Participants' Ethnicity</u>



A little over half (53.8%) of the 193 participants attended 4-year universities and an additional 37.7% attended 2-year community colleges. Participants were fairly evenly distributed between Frosh (12.1%), Sophomores (30.2%), Juniors (18.6%), Seniors (20.6%), and Graduate/Post-Bac (18.6%). Additionally, 41% reported being first-generation college students and the majority of participants (65.3%) received financial aid. Most of the participants (70.1%) reported personally knowing an engineer, and 75% reported having support for their engineering/computer science career goals.

Pre-Conference Survey

The pre-conference survey asked participants to provide information on their demographics, conference goals, and engineering student identity.

Demographics: Participants were asked to provide information on eight demographic variables: (a) major, (b) first-generation status; (c) financial aid status; (d) personally knowing an engineer; (e) having support for their engineering career; (f) ethnicity; (g) attending a 2-year vs. 4-year college; and (h) year in college.

Goals for the Conference: Participants were asked four open-ended questions regarding their (a) reasons for wanting to be an engineer; (b) reasons for attending the WiE conference; (c) beliefs about connections between the conference and their education goals; and (d) beliefs about connections between the conference and their career goals. These open-ended questions were coded, using a thematic approach. Reliability for coding all four sets of open-ended responses was acceptable, ranging from 91%-98%. See Table 1 for a list of codes for each question and sample responses for each code.

Table 1
Pre-Conference Survey's Questions on Goals for the Conference and Sample Responses

Question	Code	Sample Responses	Percent (N)
Reason to be an Engineer [a]	Personal Preferences	Love math/science Problem-solver; Curious how things work	35.7% (60)
	Making an Impact	Help the environment; Improve the health industry	31.5% (53)
	Creativity	Innovate; Design; Build	14.9% (25)
	Career Prospects	Job security; Family encouragement; Create diversity	12.5% (21)
Reason to Attend	Networking	Learn how to expand my professional network; Network with women professionals	27.2% (47)
	Women in Engineering	Gain motivation; Learn about women's experiences;	22.4% (39)
	Industry Knowledge/Learning	Learn about new technology; Learn about new trends	20.7% (36)
	Career	Advice; Work opportunities; Practice professionalism	7.7% (17)
	Organization Membership	STEM Core; MESA; Recommended by advisor	7.7% (17)

Question	Code	Sample Responses	Percent (N)
	Curiosity	Explore options; Looked interesting; Attend to see what it is like	8.1% (18)
Connection to Education [b]	Direct Connection	Woman in STEM; My field of study; Influence course selection or university	41.8% (71)
	Career Insights	How different fields connect; Industry insights; Connect major/study to industry	15.9% (27)
	Relevant Information	New technologies; Learn more about my field; Learn about new fields	19.4% (33)
	Support	Find a mentor; Support other women in STEM; Gain inspiration	13.5% (23)
	Develop Communication Skills	Network; Improve soft skills	7.6% (13)
Connection to Career Goals [c]	Direct Connection	Network with professionals; work opportunities, learn to market myself	43.8% (71)
	Industry Insights	Overview of the workplace; Learn from women's experiences;	17.9% (29)
	Advice	Career assistance; Help decide my field of study; Find a mentor	14.8% (24)
	Self-Improvement	Prepare for presentations; Professional development; Motivation/Inspiration	9.3% (15)
	General Knowledge	Interesting sessions; Learn new things	9.3% (15)

[a] 5.4% (N=9) of respondents reported they do not want to or plan to be an engineer
[b] 1.8% (N=3) of respondents reported they do not know how the conference connects to their education
[c] 4.9% (N=8) of respondents reported they were unsure how the conference related to their career goals

Engineering Student Identity: Participants were asked to respond to survey items related to three factors: Commitment to engineering/computer science majors, engineering competence, and engineering agency.

Commitment to Engineering/CS Majors: Three survey items were taken from a study by Fleming et al. [6] to assess the extent to which participants reported identifying with their engineering or CS major. (i.e., "*I am fully committed to getting my Engineering degree*"). Items were rated on a 5-point scale, with (5) Strongly Agree and (1) Strongly Disagree. The items achieved good reliability, with a Cronbach Alpha of .82.

Engineering Competence: Eight items are from a study by Prybutok et al. [7] to assess participants' confidence in their competence/performance in their engineering major (e.g., "*I can understand concepts I have learned in Engineering*"). The items were rated on a 5-point scale with (5) Strongly Agree and (1) Strongly Disagree, achieving high reliability with a Cronbach Alpha of .93.

Engineering Agency: Four survey items, such as "*Learning Engineering has helped me think more critically in general*", are from Godwin et al. [8] to assess participants' agency beliefs related to engineering. These items were rated on a 5-point scale with (5) Strongly Agree and (1) Strongly Disagree. They achieved high reliability with a Cronbach Alpha of .95.

Post-Conference Survey

The post-conference survey asked participants to provide information on their perceived benefits of the conference, professional (engineering) identity, and engineering student identity that consists of commitment to engineering/CS major, engineering competence, as well as engineering agency. Additionally, they were asked to rate their own creativity traits as well as those of an ideal engineer. The two additional measures, professional (engineering) identity and self/ideal creativity ratings) were assessed in the post-conference survey only for two pragmatic reasons. Specifically, participants were asked to take the pre-conference survey in addition to preparing for the conference (e.g., reading about the speakers, reading about the break-out sessions, preparing their resumes) and it was decided to limit the time requirements on pre-conference survey to ensure that participants completed and returned it prior to the conference. The second reason was that these two measures were more exploratory in nature with respect to being used with students rather than alumni and professionals. As noted in the results sections, both measures provided insight to participants' development of a professional identity and will be added to a revised pre-conference survey in 2022.

Benefits of the Conference: Participants were asked six open-ended questions regarding (a) whether the conference met their goals for attending and why/how it met those goals; (b) the impact the conference had on their knowledge of technology-related careers; (c) the impact the conference had on their interest in technology-related careers; (d) whether the conference influenced any courses they may be take in the future; (e) whether the conference helped them identify skills they wanted to improve; and (f) insights they may have gained from the conference. These open-ended questions were coded, using a thematic approach. Reliability for coding all six sets of open-ended responses was acceptable, ranging from 90%-97%. See Table 2 for a list of codes for each question and sample responses for each code.

Table 2
Post-Conference Survey's Questions on Benefits of the Conference and Sample Responses [a]

Question	Code	Sample Responses	Percent (N)
Conference Met Goals	Somewhat	Needs more opportunities to connect; More focus on areas of engineering other than CS	20.6% (14)
	Interesting Conference	Great speakers; Variety of activities; Interesting topics/panels; Learned a lot	19.1% (13)

Question	Code	Sample Responses	Percent (N)
	Industry Knowledge	How my major is utilized; Industry insight; Hear from professionals	19.1% (13)
	Networking	Network with Industry Professionals; Connections with other women in my field	16.2% (11)
	Motivation/Inspiration	More diversity than I thought; Inspired to find energetic women engineers	13.2% (9)
	Career Relevance	Explore options; Advice; Exposure to the field	11.8% (8)
Knowledge of Technology-Related Careers[a]	Technology	Learned about technology impacts; Learned about new forms of technology or software	44.9% (31)
	Career Options	Learned about more options to explore; Learned how to navigate career paths; Learned about the interconnection of fields	33.3% (23)
	Industry Knowledge	More diversity than expected; Understand what companies are looking for; Learned how my major fits in	18.8% (13)
	Other	Interaction with peers and industry leaders; Slightly	2.9% (2)
Interest in Technology-Related Careers[b]	Career Prospects	More options to explore; Related study to industry; New questions for technology careers	45.8% (27)
	Positive Feelings	More confidence in major; Inspired/Motivated; Better idea of what I enjoy	39% (23)
	Other	Interesting information; Networking; Philanthropy with tech; New technology	15.3% (9)
Influence Future Coursework	Will consider taking more classes in this field	New electives; More technology focused classes	30.8% (20)
	New interest in a different field/Expand Knowledge	Add a minor; Learn new area and get practical knowledge in it; Take business classes.	30.8% (20)
	No	Graduating; Already know the classes I need; Schedule is too tight	23.1% (15)

Question	Code	Sample Responses	Percent (N)
	Reconfirmed Interest	More certain of the job and major I want; I now know I am taking the right classes	15.4% (10)
Identify Skills to Improve [c]	Soft Skills	Communication; Confidence; Critical thinking; Networking	44.8% (26)
	Technical Skills	Programming; Coding; Software	25.9% (15)
	Expand Options	Exploring more fields; Continuing to higher education; Staying motivated	15.5% (9)
	Industry	Learn industry jargon; Learn business; gain work experience	8.6% (5)
	Career	Revise resume; Polish interviewing skills	5.2% (3)
Insights [f]	Women in Engineering	Experiences in industry; Support for women; Opportunities	25.7% (18)
	Advice on Success	Be more confident; Effort pays off; Out yourself forward;	24.3% (17)
	Industry	What the industry is looking for; Learned about companies	21.4% (15)
	Technology	New software; How technology can be used to help the environment	20.0% (14)
	Other	Networking; Expanding knowledge; Learned about myself; inspired to keep moving forward	8.6% (6)

[a] Not all respondents completed the open-ended questions; these percentages represent the responses of only those who provided qualitative feedback.
[b] 3% (N=3) of respondents reported that the conference increased or somewhat increased their knowledge but did not elaborate
[c] 1% (N=1) of respondents reported their interest decreased and explained they felt a bit intimidated/overwhelmed. 17% (N=16) reported no change in their interest

Commitment to Engineering/CS Major: The three items are the same as those of the pre-conference survey. The scale achieved high reliability, with a Cronbach Alpha of .92.

Engineering Competence: The eight items are the same as those of the pre-conference survey. The scale achieved high reliability, with a Cronbach Alpha of .92.

Engineering Agency: The four items are the same from as those of the pre-conference survey. The scale achieved very high reliability, with a Cronbach Alpha of .96.

Professional (Engineering) Identity: Six items were adapted from Mael and Ashforth's measure of organizational identification [13] to assess the extent to which participants identified themselves as members of the engineering profession. Participants rated items such as "*Engineers' successes are my successes*" and "*When I talk about Engineers, I usually say we rather than they"* on a 5-point scale, with (5) Strongly Agree and (1) Strongly Disagree. The items achieved good reliability, with a Cronbach Alpha score of .83.

Creativity Traits: A set of 25 adjectives that reflect creativity in the engineering field, developed by Portillo [5], separately assessed self-ratings and ratings for participants' beliefs about an "ideal" engineering professional. Adjectives included items such as "*Imaginative*", "*Clever*", and "*Logical*". Participants rated themselves on the set of creativity traits first, completed six items related to professional identity, then rated a hypothetical "ideal" engineering professional on that set of traits. Reliability was high for both self-ratings (Cronbach Alpha = .89) and ratings for the an "ideal" engineering professional (Cronbach Alpha = .93).

See Table 5 of the appendix for survey items of both pre-conference and post-conference surveys.

Results

Data Analysis

Analysis of the data was divided into three sets of analyses. In the first set, relations between the qualitative and quantitative measures was analyzed to establish a baseline for students' engineering identity and to explore potential connections between students' engineering identity and students' motivation for being an engineer and attending the conference. The second set of analyses examined potential changes in students' engineering identity from the pre-conference survey to the post-conference survey. Additionally, the second set of analyses explored potential explanations for, or predictors of, changes in engineering identity over time. The third set of analyses examined: (a) the interrelations among the identity and creativity measures that were unique to the post-conference survey, and (b) pre-conference predictors of the two measures unique to the post-conference survey.

Preliminary analyses, using Chi-Square tests (for nominal variables) and t-tests and one-way ANOVAs, (to compare the means of variables in two groups: t-tests; and multiple groups: ANOVAs) examined differences by the eight demographic variables, such as major, ethnicity, year in college, university type, financial aid, and first-generation status. Associations between variables of interest were examined in bi-variate correlation analyses. Regression models, partial correlations, and MANCOVA were used to test the models and study questions.

Pre-Conference Survey Results

Engineering student identity (commitment to major, engineering competence, and engineering agency) did not differ by participants' demographic variables except major. MANCOVA showed that commitment to major differed by major ($F_{(6,352)} = 5.73$, $p < .0001$). Follow-up Univariate analyses ($F_{(2,181)} = 13.36$, $p < .0001$) indicated that Computer Science majors had significantly higher scores ($M = 14.25$, $SD = 1.85$) on commitment to major than engineering majors ($M = 13.41$, $SD = 2.55$) or "other" majors ($M = 11.32$, $SD = 3.48$). As expected, “other” had significantly lower scores on commitment to major than both Computer Science and engineering majors.

MANCOVA, controlling for major, was used to examine differences in the three factors that measure engineering student identity by participants’ goals for the conference (see Table 3). The data indicated that participants’ reasons for wanting to be an engineer, reasons for attending the conference, and perceptions of how the conference is related to their education did not differentiate scores on the three factors of engineering student identity (commitment, competence, or agency). However, the MANCOVA testing the effects of participants’ perceptions of how the conference is related to their career goals on participants’ engineering student identity was significant ($F_{(5,146)} = 3.19, p < .01$). Follow-up univariate analyses revealed there were significant differences on commitment to major scores ($F_{(5,153)} = 2.53, p < .05$), but not on competence or agency scores, by perceptions of the conference’s connection to their career goals. In this case, participants who perceived a direct connection or had specific goals (i.e. to gain industry insights, advice, or general knowledge) had higher scores than those who had less specific goals (i.e. self-improvement).

Table 3
Pre-Conference Differences in Engineering Student Identity (Commitment, Competence, Agency) By Participants’ Goals for the Conference [a, b]

	Commitment [d]	**Competence** [d]	**Agency** [d]	***F*** **(df)** [c]
Why Engineering	F=1.17 (4, 157)	F=0.62 (4, 157)	F=1.20 (4, 157)	4.49** (4, 152) [e]
Preferences	13.65 (0.352)	17.91 (0.417)	33.47 (0.869)	
Impact	12.93 (0.383)	17.71 (0.453)	33.41 (0.945)	
Creativity	13.45 (0.552)	18.72 (0.652)	36.82 (1.36)	
Career	14.14 (0.615)	18.68 (0.727)	34.50 (1.52)	
Not a goal	12.36 (0.950)	17.86 (1.12)	34.71 (2.34)	
Reason to Attend	F=1.02 (5, 164)	F=1.83 (5, 164)	F=0.94 (5, 164)	2.21* (5, 158)
Networking	13.18 (0.425)	17.89 (0.487)	34.31 (1.02)	
Women in Engineering	13.42 (0.441)	18.05 (0.505)	33.50 (1.06)	
Industry Knowledge	13.91 (0.467)	18.83 (0.535)	35.86 (1.12)	
Career	12.78 (0.668)	18.03 (0.766)	33.55 (1.61)	
Organization	12.24 (0.659)	16.13 (0.756)	32.06 (1.59)	
Curiosity	13.37 (0.659)	18.53 (0.755)	34.73 (1.60)	
Relate to Education	F=1.06 (5, 160)	F=1.36 (5, 160)	F=0.39 (5, 160)	2.24* (5, 154)
Direct Connection	13.74 (0.337)	18.54 (0.366)	34.77 (0.780)	
Career Insights	12.90 (0.536)	17.43 (0.582)	33.98 (1.24)	
Industry Knowledge	13.25 (0.490)	18.26 (0.533)	34.64 (1.14)	
Support	12.47 (0.569)	17.05 (0.619)	33.21 (1.32)	
Communication Skills	13.36 (0.792)	18.86 (0.861)	34.28 (1.84)	
Don’t Know	11.85 (1.59)	17.28 (1.73)	31.18 (3.68)	

	Commitment [d]	Competence [d]	Agency [d]	F (df) [c]
Connection to Career	F=2.65** (5, 152)	F=0.98 (5, 152)	F=1.80 (5, 152)	3.19*** (5, 146)
Direct Connection	13.78 (0.328)	18.55 (0.368)	35.59 (0.752)	
Industry Insights	13.83 (0.523)	18.07 (0.857)	33.86 (1.20)	
Advice	12.18 (0.576)	17.22 (0.646)	33.18 (1.32)	
Self-Improvement	11.62 (0.752)	17.18 (0.843)	30.62 (1.72)	
General Knowledge	12.50 (0.698)	17.72 (0.743)	33.04 (1.60)	
Don't Know	13.25 (0.956)	18.48 (2.19)	33.63 (2.19)	

* $p = .06$; ** $p < .05$; *** $p < .01$; ***$p < .001$
a MANCOVAs controlled for participants' major
b Estimated Marginal Means (Standard Errors) are reported
c Multivariate Analyses F (df)
d Follow-up Univariate Analyses F (df)
e The MANCOVA was significant for major but not for reasons for being an engineer as was indicated by the follow-up univariate analyses.

Among students' demographic variables, it is noted that participants who were first-generation students were significantly less likely to personally know an engineer than those who were not first-generation (χ^2 (1) = 20.50, $p < .0001$), with 45% of first-generation participants reporting not personally knowing an engineer versus 16% of non-first-generation participants. However, there were no significant differences between first-generation and non-first-generation participants with respect to having support for their pursuit of an engineering education and career (χ^2 (1) = 0.11, p = NS).

Regarding the three factors of engineering student identity, bi-variate correlational analyses indicated that they are correlated, but do not appear to measure the same aspects of identity. Specifically, commitment to major was positively correlated with engineering competence beliefs ($r = .55$, $p < .0001$) and with engineering agency beliefs ($r = .54$, $p < .0001$). Engineering competence beliefs were more strongly correlated with engineering agency beliefs ($r = .82$, $p < .0001$). Thus, each factor appears to measure a different aspect of how one defines one's self as an engineering student, but in ways that fit together as a cohesive package.

Joint Analysis of Pre- and Post-Conference Survey Results

There were 103 post-conference surveys returned, with 66 of these having both pre- and post-survey responses. Of the 103 respondents, 84.7% reported that the conference met their needs and an additional 15.3% reported that the conference somewhat met their needs.

MANOVA, using the 66 cases with both pre- and post-conference surveys, tested for differences in the post-survey's three factors of engineering student identity (commitment, competence, and agency) by major, college type, year in college, and financial aid. The MANOVA was significant for both year in college ($F_{(12,72)} = 3.60$, $p < .0001$) and major ($F_{(6,46)} = 3.93$, $p < .003$). Financial aid and college type were not significant. However, follow-up univariate analyses indicated that year in college was significant for commitment to major ($F_{(4,58)} = 4.03$, $p < .01$) and sophomores had significantly lower scores than students of all other levels. Follow-up univariate analyses further revealed that year in college also was significant for engineering competence beliefs ($F_{(4,58)} = 7.67$, $p < .0001$) and indicated that sophomores had significantly lower scores than students of all other levels. Finally, follow-up univariate analyses showed that major was significant for commitment to major ($F_{(2,58)} = 4.18$, $p < .005$), with "other" majors (e.g., non-engineering specific majors) having significantly lower scores than both Engineering and Computer Sciences majors. In summary, year in college and major are significant with respect to post-survey's commitment to major and engineering competence. These two variables were therefore entered as controls in subsequent MANCOVAs.

The next set of analyses examined changes between pre- and post-conference ratings on the three factors of engineering student identity (i.e. commitment to major, engineering competence, and engineering agency). Paired t-tests indicated that scores on these three factors did not differ significantly between the pre- and post-conference surveys. Nevertheless, bi-variate correlation analyses revealed stronger associations between the post-conference factors relative to that between the pre-conference factors. Specifically, commitment to major was significantly correlated with engineering competence ($r = .77$, $p < .0001$) and engineering agency ($r = .75$, $p < .0001$). Additionally, engineering competence was significantly correlated with engineering agency ($r = .83$, $p < .0001$). These correlations suggest that these three aspects of engineering student identity, which tap into one's sense of self as a student, became more cohesive after the conference.

Four MANCOVAs were used to examine differences in the three factors of post-conference engineering student identity (commitment, competence, and agency) by participants' pre-conference goals for the conference: reason for being an engineer, reason for attending the conference, as well as expectations for the conference with respect to their education and career trajectory. Participants' major and year in college were controlled for in the analyses. Results indicated that reasons participants provided for wanting to be an engineer were not related to any of the three post-conference factors of engineering student identity. Reasons for attending the conference did impact post-conference ratings of identity (MANCOVA: $F_{(5,48)} = 3.04$, $p < .05$). Follow-up univariate analyses demonstrated that competence ($F_{(5,55)} = 2.95$, $p < .05$) differed by reason given by participants for attending. In particular, participants who listed Women in Engineering as their reason having lower scores than those who listed more focused goals (i.e., networking, industry knowledge, career, organization membership), or who were curious about the current state of the field. See Table 4.

Table 4
Post-Conference Differences in Engineering Student Identity (Commitment, Competence, Agency) By Participants' Pre-Conference Goals for the Conference [a, b]

	Commitment[d]	**Competence**[d]	**Agency**[d]	***F* (df)**[c]
Why Engineering	F=0.40 (4, 54)	F=1.00 (4, 54)	F=0.67 (4, 157)	2.67** (4, 48)[e]
Preferences	12.89 (0.713)	16.66 (0.780)	31.93 (1.63)	
Impact	12.87 (0.814)	18.61 (0.891)	33.47 (1.87)	
Creativity	14.36 (1.33)	18.81 (1.46)	36.96 (3.05)	
Career	13.23 (1.10)	18.89 (1.19)	33.71 (2.50)	
Not a goal	11.69 (1.89)	16.48 (2.06)	31.96 (4.30)	

	Commitment[d]	Competence [d]	Agency [d]	*F* (df)[c]
Reason to Attend	*F*=2.11 (5, 55)	*F*=2.95** (5, 55)	*F*=1.77 (5, 55)	3.04** (5, 48)
Networking	13.80 (0.869)	18.43 (0.929)	34.68 (2.03)	
Women in Engineering	10.93 (0.776)	15.03 (0.829)	28.97 (1.81)	
Industry Knowledge	13.91 (0.776)	18.81 (1.08)	34.88 (2.36)	
Career	13.49 (1.01)	19.11 (1.63)	36.60 (3.56)	
Organization	14.64 (1.53)	17.48 (1.23)	33.02 (2.68)	
Curiosity	14.14 (1.14)	19.41 (1.22)	36.46 (2.66)	
Relate to Education	*F*=3.11** (5, 54)	*F*=1.65 (5, 54)	*F*=2.49**(5, 54)	3.38*** (5, 47)
Direct Connection	13.36 (0.679)	17.78 (0.820)	34.52 (1.61)	
Career Insights	15.08 (0.903)	19.59 (1.09)	37.38 (2.15)	
Industry Knowledge	13.09 (0.984)	17.43 (1.90)	32.22 (2.34)	
Support	10.91 (0.988)	16.10 (1.19)	28.93 (2.35)	
Communication Skills	9.85 (1.32)	14.65 (1.59)	26.43 (3.31)	
Don't Know	13.47 (2.13)	17.82 (2.58)	33.69 (5.08)	
Connection to Career	*F*=3.35*** (5, 52)	*F*=1.11 (5, 52)	*F*=1.00 (5, 52)	5.38**** (5, 45)
Direct Connection	13.52 (0.568)	17.75 (0.717)	33.72 (1.48)	
Industry Insights	14.48 (1.05)	17.57 (1.32)	33.44 (2.73)	
Advice	12.71 (1.21)	17.22 (1.52)	35.75 (3.14)	
Self-Improvement	9.75 (1.12)	16.14 (1.41)	29.19 (2.91)	
General Knowledge	14.73 (2.07)	19.40 (2.62)	35.62 (5.40)	
Don't Know	9.06 (1.72)	13.50 (2.17)	26.35 (4.48)	

* $p = .06$; ** $p < .05$; *** $p < .01$; ***$p < .001$

a MANCOVAs controlled for participants' major and year in college

b Estimated Marginal Means (Standard Errors) are reported

c Multivariate Analyses F (df)

d Follow-up univariate analyses F (df)

e The MANCOVA was significant for major but not for reasons for being an engineer as was indicated by the follow-up univariate analyses.

The MANCOVA, testing the impact of participants' perceptions of how the conference is related to their education, was significant ($F_{(5,47)} = 3.38$, $p < .01$). Follow-up univariate analyses demonstrated that commitment to major ($F_{(5,54)} = 3.11$, $p < .05$) and engineering agency ($F_{(5,54)} = 2.49$, $p < .05$) differed by participants' perceptions of how the conference is related to their education. Specifically, for both commitment to major and engineering agency, those who perceived the connection to their education to be through developing communication skills (e.g., networking) and receiving support (e.g., gain inspiration) had lower scores than those who perceived the connection to be direct (e.g., this is my field of study) or through career insights, industry knowledge, or even a “I will know better after the conference” stance. A similar, but not significant, trend was found for engineering competence beliefs.

The last MANCOVA, for perceived connection to participants’ career, was significant ($F_{(5,45)} = 5.38$, $p < .001$). Follow-up univariate analyses demonstrated that commitment to major scores ($F_{(5,524)} = 3.35$, $p < .01$) were significantly lower for those who reported the connection was through self-improvement or who “did not know” compared to those who perceived the connection to be direct or through industry insights, getting advice or general knowledge. As with the other analyses, there was a similar but not significant trend for engineering competence and agency beliefs. See Table 4.

Post-Conference Survey Results

Two new factors of identity were added to the post-conference survey: Professional identity and ratings of creativity. Professional (engineering) identity measures identity as a function of defining one’s self as a member of the engineering profession. It significantly differed by whether or not participants personally knew an engineer ($F_{(1,57)} = 4.10$, $p < .05$). Those who personally knew an engineer (*M*=22.31, *SD*=4.00) had higher scores than those who did not (*M*=19.84, *SD*=5.03). There was a trend toward significant difference between first-generation and non-first-generation participants ($F_{(1,56)} = 3.71$, $p = .06$). First-generation participants report marginally lower scores (*M*=20.09, *SD*=4.63) than non-first-generation participants (*M*=22.38, *SD*=4.22). Except for first-generation status and personally knowing an engineer, professional (engineering) identity did not differ by other six demographic variables: ethnicity, financial aid, support for major/career, major, type of college, or year in college.

Ratings of creativity assessed participants’ self-ratings and ratings of a hypothetical ideal engineer on traits that capture creativity in engineering. Self-ratings and ratings of an ideal engineer on creativity did not differ by any of the eight demographic variables. However, paired t-tests ($t_{(76)} = -4.27$ $p<.0001$) indicated that participants rated a hypothetical ideal engineer as significantly more creative (*M*=91.12, *SD*=9.13) than they rated themselves (*M*=83.92, *SD*=14.98). This difference between self- and ideal-ratings is supported by bi-variate correlational analyses that indicated only a moderate association between these two sets of ratings ($r = .36$, $p < .005$), suggesting that participants may see themselves as developing their skills but they are not yet where they want to be.

Professional engineering identity and ratings of self- and ideal engineer creativity are moderately associated with one another, suggesting that there is some coherence to participants’ development of a sense of professional identity. Specifically, professional identity was moderately correlated with both self-ratings of creativity ($r = .44$, $p < .0001$) and ratings of an ideal engineer ($r = .32$, $p < .003$). These correlations indicate that participants who rated themselves as having a stronger professional identity also rated themselves and, to a lesser extent, ideal engineers as being more creative. A regression analysis, controlling for personally knowing an engineer, was used to test this association. The regression model was significant ($F_{(4,24)} = 6.41$, $p < .001$), and accounted for 25% of the variance in professional identity. The results suggested that self-ratings of creativity ($\beta = 0.37$, $t = 2.81$, $p < .007$), but not ratings of an ideal engineer ($\beta = 0.18$, $t = 1.39$, p = NS), are associated with participants' sense of professional identity.[1]

Because the following analyses were more exploratory in nature, partial correlation analyses were used to test the strength of the linear association between professional engineering identity and the pre- and post-conference measures of engineering student identity, while removing the effects of potentially confounding variables. The relation between professional engineering identity and the three pre-conference measures of engineering student identity were not significant (commitment: $r = .16$; competence: $r = .20$; and agency: $r = .24$). Partial correlation analyses, controlling for personally knowing an engineer, major, and year in college, did not reveal a significant association between professional engineering identity and the three post-conference measures of engineering student identity (commitment: $r = .24$; competence: $r = .19$; and agency: $r = .20$). The lack of significance between the measures of student engineering identity and the measures of professional engineering identity suggests that student and professional identity may be separate, but equally important, constructs.

The same analytic strategy described above was used to test for the strength of the linear associations between self- and ideal-ratings of creativity and pre- and post-conference measures of student engineering identity. Partial correlations, controlling for major, indicated that self-rated creativity was significantly associated with pre-conference ratings of competence ($r = .30$, $p < .05$) and agency ($r = .32$, $p < .05$), but not commitment ($r = .08$). These correlations suggest that one's sense of engineering relevant creativity is related to one's sense of engineering competence and agency, once the impact of students' major is removed. Results for the partial correlation analysis, controlling for major, of the association between ideal engineer creativity ratings and the three measures of pre-conference student engineering identity were significant for competence ($r = .37$, $p < .01$), but not for commitment ($r = .16$) or agency ($r = .13$). While the association between ideal engineer creativity ratings and participants beliefs about their own competence may be chance, future research should examine the possibility that students' perceptions of what traits are necessary for professional success are shaped by their beliefs about their own competence. The partial correlation analyses, controlling for major and year in college, did not show a significant association between self-ratings of creativity and post-conference measures of commitment ($r = .12$), competence ($r = .18$), or agency ($r = .22$). Similarly, the partial correlation analysis did not reveal any significant associations between ratings of an ideal engineer's creativity and post-conference measures of commitment ($r = .09$), competence ($r = .07$), or agency ($r = .05$).

With respect to benefits of the conference to participants, a qualitative analysis of the post-conference survey showed meaningful impact. (See Table 2.) However, the MANCOVAs were not significant when testing for differences in post-conference engineering student identity' factors by students' evaluations of what they gained from the conference. It is important to note that: (a) the sample size was significantly smaller for the post-conference survey, thus reducing statistical power to detect differences; and (b) evaluations of the conference were measured simultaneously with the three factors of engineering student identity, and the impact of the

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[1] Regression analyses with professional identity as the predictor for (1) self-ratings, and (2) ratings of an ideal engineer, were both significant and positive, suggesting that these constructs may influence one another.

conference may not yet have had time to influence participants' identity as engineering/computer science students.

Summary and Conclusions

The Women in Engineering conference brings together engineering students, many of whom are under-represented minorities, first generation, and women with successful female engineers from industry and academia. During the conference, participants have an opportunity to learn about advances in engineering, technology, and the industry. They also have opportunities to network with peers and industry leaders, develop career-relevant skills, find mentors, and develop a sense of belonging with like-minded students, faculty, and professionals in the industry. Our qualitative data from this and prior conferences [2] consistently show that the conference is successful in meeting these goals. To better understand how to support women in engineering, we also explored the impact of the conference of the development of an engineering identity, which has been shown to predict retention in engineering [3], [4].

The analyses of the Women in Engineering conference surveys have generated insights on the relationships among engineering student identities, professional identity, and demographics. These insights suggest ways for us to better prepare women engineering/computer science students from campus to career. First, our analyses showed that professional identity was stronger in participants who personally knew an engineer and first-generation students were less likely to personally know an engineer. Thus, pairing first-generation students with engineer mentors will strengthen their professional identity, and likely lead to a higher persistence rate in college and the workplace.

Second, there was a group of participants with low engineering student identity scores. Their responses to reasons for attending the conference, and to seeing connections between the conference and their education or career, reflected a desire to find support and advice. It appears that there is a subset of participants who are unsure of their pathway and identity in engineering. Providing these kinds of students with opportunities for professional development and leadership skills training [11] early in their academic career may facilitate their development of both an engineering student identity and a professional engineering identity. Those seeking support and attending the conference to meet and talk to women in the engineering profession may also benefit from opportunities to develop strong social connections with other students, faculty, and professionals in the field [11]. There was another group of participants with higher engineering student identity scores. These participants were prepared and eager to gain industry knowledge and career insights at the conference, which they generally do not get from classroom instructions. For students who have a stronger sense of identity as an engineering/computer science major, it appears to be important to provide them with opportunities to strengthen their sense of engineering identity, develop a professional identity, and to explore engineering as a profession.

Third, our data suggests that student and professional identities in engineering are not the same construct. These results suggest that programs should not only help facilitate students' identity as undergraduate/graduate engineering majors but should also create opportunities for students to develop professional identities early in their educational pathway. One potential mechanism may be to help students develop their creativity in engineering and to discover that they too share traits and abilities with creative engineers already working in the profession.

Understanding identity in the context of creativity may be valuable. This is because our results showed that self- and ideal engineer ratings of creativity were strongly associated with participants' scores on professional identity, suggesting that the more they understood what traits are important to engineers, the more they felt like they identified with being a professional engineer.

In conclusion, our results, combined with the extant literature, suggest that programs should address not only academic competence and skills, but also student and professional identity if they want to increase retention and graduation as well as career persistence. These efforts should address the specific needs of women and under-represented minorities enrolled in engineering programs.

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Appendix

Table 5: Survey Factors and Items

Factor	**Survey Items**	**Response Scale**
Commitment to Engineering Major [6]	To what extent do you disagree or agree to the following statements? (a) I plan to enroll/remain enrolled as an engineering or computer science major next semester. (b) I think that earning a bachelor's degree in engineering or computer science is a realistic goal for me. (c) I am fully committed to getting my college degree in engineering or computer science.	"1" for Strongly Disagree to "5" for Strongly Agree
Engineering Competence [7]	To what extent do you disagree or agree to the following statements? (a) I am interested in learning more about engineering or computer science. (b) I enjoy learning about engineering or computer science. (c) I am confident I can understand engineering or computer science outside of class. (d) I can overcome setbacks in engineering or computer science. (e) I am confident I can understand engineering or computer science in class. (f) I can do well on exams in engineering or computer science. (g) I can understand concepts I have studied in engineering or computer science. (h) Others ask me for help in engineering or computer science.	"1" for Strongly Disagree to "5" for Strongly Agree
Engineering Agency [8]	To what extent do you disagree or agree to the following statements? (a) Learning engineering or computer science will improve my career prospects. (b) Engineering or computer science is helpful in my everyday life (c) Engineering or computer science has helped me to see opportunities for positive change. (d) Learning engineering or computer science has helped me think more critically in general.	"1" for Strongly Disagree to "5" for Strongly Agree
Professional Identity [12]	To what extent do you disagree or agree to the following statements? (a) When someone criticizes engineers or computer scientists, it feels like a personal insult. (b) I am very interested in what others think about engineers or computer scientists. (c) When I talk about engineers or computer scientists, I usually say "we" rather than "they". (d) Engineers' and computer scientists' successes are my successes. (e) When someone praises engineers or computer scientists, it feels like a personal compliment. (f) If a story in the media criticized engineers or computer scientists, I would feel embarrassed.	"1" for Strongly Disagree to "5" for Strongly Agree

Creativity Traits (Rating Self) [5]	We are interested in how you define yourself with respect to personality, traits, and abilities. (a) Adaptable; (b) Adventurous; (c) Ambitions; (d) Artistic; (e) Assertive; (f) Capable; (g) Clear-thinking; (h) Clever; (i) Confident; (j) Curious; (k) Enthusiastic; (l) Idealistic; (m) Imaginative; (n) Impulsive; (o) Independent; (p) Individualistic; (q) Industrious; (r) Insightful; (s) Intelligent; (t) Inventive; (u) Logical; (v) Original; (w) Rational; (x) Reflective; (y) Resourceful	"1" for Not at All to "4" for A Lot
Creativity Traits (Rating an Ideal Engineer) [5]	We are interested in how you define a typical engineer with respect to personality, traits, and abilities. The same list of 25 adjectives as listed above.	"1" for Not at All to "4" for A Lot