2018 ASEE Annual Conference & Exposition
June 24-27, 2018, Salt Palace Convention Center, Salt Lake City, UT

Paper ID #21780

Impact of Non-technical Conferences in Female Engineering Students' Self-esteem and Engineering Self-efficacy

Dr. Suzanne Zurn-Birkhimer, Purdue University, West Lafayette (College of Engineering)

Dr. Suzanne Zurn-Birkhimer is Associate Director of the Women in Engineering Program and Associate Professor (by courtesy) in the Department of Earth, Atmospheric, and Planetary Sciences at Purdue University. Dr. Zurn-Birkhimer conducts research and leads retention activities including administration of the undergraduate and graduate mentoring programs and the teaching of the Women in Engineering seminar courses. For the past decade, Dr. Zurn-Birkhimer's research has focused on broadening participation of women and underrepresented group in STEM fields. Recently, she has been investigating the intersection of education and career path with cultural identity and is developing strategies to inform programming and policies that facilitate recruitment and retention of underrepresented populations in academia. In 2012 Dr. Zurn-Birkhimer was presented with an Outstanding Alumni Award from the Department of Earth, Atmospheric, and Planetary Sciences at Purdue University. She also serves on their Alumni Advisory Board. Dr. Zurn-Birkhimer earned her B.S. in Mathematics from the University of Minnesota, and an M.S. and Ph.D. in Atmospheric Science from Purdue University.

Ing. Mayari Illarij Serrano Anazco, Purdue Polytechnic Institute

MAYARI SERRANO is currently a graduate research assistant in the College of Engineering at Purdue University. She earned her B.S. degree in Biotechnology Engineering from the Army Polytechnic School, Quito, Ecuador. She completed her M.S. in Computer and Information Technology at Purdue University. Mayari is currently a PhD student at Purdue University and is working in for the Women in Engineering Program. Her interests include foster STEM enthusiasm, and technology innovation.

Rachel Ann Baker

Impact of Non-technical Conferences on Female Engineering Students' Self-esteem and Engineering Self-efficacy

Abstract

It has been long noted that there exists a gender imbalance across science, technology, engineering, and mathematics (STEM) fields in higher education. Engineering in particular saw only 20.9% of its bachelor degrees awarded to women in 2016 which is a slight 2.8% increase from 2007[1]. This disparity creates a gender imbalance in the academic environment that persists into the work place.

There are several factors that may contribute to the gender disparity in STEM, such as, but not restricted to, gender-stereotyping, lack of female role models, girl's image of engineering, self-efficacy, and self-esteem. In this paper, we address two of these factors: self-esteem, one's overall subjective emotional evaluation of their worth, and self-efficacy, a confidence in one's own ability to achieve intended results.

This study used the State Self-Esteem Scale to examine two self-esteem factors, academic performance and social confidence, and the Engineering Self-Efficacy Test to examine the facets of general engineering skills and experimental skills. The study collected data from 38 female engineering students, of all academic levels, before and after attending non-technical conferences.

Graduate and undergraduate students are rarely encouraged to attend non-technical conferences. However, these conferences present a non-threating environment in which students can meet female role models, develop leadership skills, and network. Results show a positive impact in the participant's self-esteem and self-efficacy after attending a non-technical conference.

Introduction and Related Work

The United States Census Bureau reported that 35.6% of the employed civilian population between 25 and 64 years of age has obtained a bachelor degree or higher in a science, technology, engineering, or mathematics (STEM) field[2]. However, only a small percentage (29%) of these 9.348M STEM degrees are held by women[2]. The National Student Clearinghouse Research Center reported that of all bachelor degrees earned in 2014, 26% went to men in STEM fields and 12% went to women in STEM fields[3]. Compared to the previous decade when 24% of the degrees earned were by men in STEM and 11% by women in STEM, it is clear that there is still not enough progress in encouraging more women to pursue STEM degrees[3]. Even more discouraging than this small change is that during the period from 2004 to 2014, the share of bachelor degrees earned by women decreased in Engineering (from 20% to 19%), Computer Science (from 23% to 18%), Earth, Atmospheric, and Ocean Sciences (from 40% to 38%), Physical Science (from 42% to 39%), and Mathematics (from 45% to 42%)[3].

Annually, the American Society for Engineering Education publishes the Engineering by the Numbers report, which examines national trends in engineering. The 2015-16 data show that over 50,000 degrees were awarded in the fields of Mechanical, Computer, and Electrical engineering[1]. Those same three fields, however, awarded the fewest percentage of bachelor degrees to women: Mechanical at 13.8%, Electrical at 12.7%, and Computer at 12.3%[1]. This disparity creates a gender imbalance in the academic environment that, unfortunately, persists into the work place.

For years academics have been asking themselves: Why are so few women pursuing engineering degrees? There are several well-established contributing factors, including gender-stereotyping, lack of female role models, a girl's image of engineering, self-efficacy, and self-esteem. Hill, Corbett, and St. Rose's 2010 book *Why So Few?* addresses many of these issues[4]. They note that the two persisting stereotypes that continue to effect girl's and women's desire to pursue careers in STEM are that (a) girls are not as good as boys in math and (b) scientific work is better suited to boys and men.

Recent work shows that these gendered stereotypes continue to persist. A 2016 study from Banchefsky, Westfall, Park, and Judd[5] included showing photos of tenured/tenure track faculty from elite research institutions to a group of participants who were to rate the likelihood of the person in the photo to be a scientist. Respondents, regardless of gender, used women's gendered appearance, but not men's, as indication that they were less likely to be scientists and more likely to be teachers and journalists[5].

Similarly, Carli, Alawa, Lee, Zhao, and Kim[6] asked participants, undergraduate students from a small single-sex college and a large private university, to rate traits of an adult man, an adult woman, and a successful scientist . They found that women are thought to possess fewer of the characteristics necessary to be successful scientists than men do. However, they also found that the higher the percentage of women in a scientific field, the more people perceive an association of women's traits with the traits of successful scientists[6].

These studies show that eliminating stereotyping, increasing female role models, and changing a girl's view of what an engineer looks like would increase the number of women pursuing engineering degrees. These are daunting goals but teams of dedicated researchers and practitioners continue to tackle these issues on a daily basis.

This study, instead, focuses specifically on the person: self-esteem, one's overall regard of the self as a person[7]; and self-efficacy, a confidence in one's own ability to achieve intended results[8]. Seron, Silbey, Cech, and Rubineau[9] followed cohorts of undergraduate students from four different types of institutions (elite private college; large, public land-grant institution; engineering-only college; and single-sex college) for four years. Through diaries and interviews, they were able to tease out how socialization, both during team-based projects in classes and in the workforce through internship opportunities, leads women to develop less confidence that they will 'fit' into the culture of engineering[9]. Results from comparing climate surveys conducted at a large Midwestern research institution showed that self-efficacy was rated significantly lower by both the men and women undergraduate engineering students in 2015 than their counterparts rated engineering self-efficacy in 2008 [10]. These research studies suggest that increasing self-esteem and/or self-efficacy could impact a student's desire to remain in a STEM field.

This study investigates impact in self-efficacy and self-esteem in participants, undergraduate and graduate female engineering students, who attend non-technical national conferences focused on women participants and/or topics of interest to women in STEM such as professional development, public policy, or leadership. There are several areas of self-esteem that can be examined for variation such as academic, performance, social, appearance, and general self-esteem [11]. This study specifically examines academic performance self-esteem, one's sense of general competence; and social confidence self-esteem, how people believe others perceive them [12]. Similarly, there are many facets of self-efficacy. This study focuses on engineering self-efficacy, or the students' beliefs about their capabilities to learn and perform a variety of engineering tasks [13].

Methods

Research Question

This research is guided by the following research question:

- How does participation in non-technical conferences influence female engineering students' self-esteem, general engineering skills self-efficacy, and experimental skills self-efficacy?

Data Collection and Assessment Instrument

The data were collected over a two year period in the academic sessions of Spring 2016, Fall 2016, Spring 2017, and Fall 2017 at a large Midwestern research university. Each period, graduate and undergraduate female engineering students were recruited through an open invitation to apply to a competitive travel award program. If selected, the award allowed them to attend the non-technical conference proposed in their application. Awarded participants completed two on-line assessments, a pre-survey prior to attending the non-technical conference and a post-survey after returning from the conference. Participants had a one week time frame to complete each survey.

The assessment instruments were implemented to measure the personal impact of the conference and included questions related to conference usefulnesses, self-esteem, self-efficacy, and program logistics, as well as feedback about the overall conference experience. The Heatherton and Polivy [11] State Self-Esteem Scale (SSES) was specifically designed to measure state self-esteem, which is defined as the temporary fluctuations in self-esteem. The SSES is generally considered to be a stable qualitative measure that is psychometrically sound and valid in laboratory, classroom, and clinical settings [11]. Table 1 lists the 14 questions from the SSES utilized by this study to measure the self-esteem subcategories of academic performance (seven questions) and social confidence (seven questions). A 5-point Likert scale was used to scored each item (1 - not at all, 2 - a little bit, 3 - somewhat, 4 - very much, and 5 - extremely).

A previously validated survey, Mamaril, Usher, Li, Economy, and Kennedy's[13] General Engineering Self-Efficacy and Experimental Self-Efficacy, was used to evaluate self-efficacy around general (six questions) and experimental (four questions) engineering skills (refer to Table 1). All questions were scored using a 5-point Likert scale (5 - Strongly Agree, 4 - Agree, 3 - Neither Agree Nor Disagree, 2 - Disagree, and 1 - Strongly Disagree). Only those participants currently enrolled in classes were required to answer the General Engineering Self-Efficacy questions. Similarly, only participants that were enrolled as graduate students were presented with the Experimental Skills Self-Efficacy questions.

Participants

Female undergraduate and graduate engineering students were invited to apply for an all-expenses-paid domestic non-technical conference of their choice. For Spring 2016 and Fall 2016, applicants were required to have a cumulative GPA of 3.0 or greater. In Spring 2017, this requirement was permanently lifted. Participants were selected based on answers to the following questions: "*Since this is a competitive application, please describe specific reasons why the selection committee should fund your registration and travel expenses to this conference*" and "*What ideas do you have for sharing what you learn at this conference*".

Over the course of the study period, 98 individuals applied for the award, 56 were awarded, and 42 accepted the award. Of the accepted individuals, 38 completed both the pre-survey and the post-survey.

The participants' pool was formed by 18 undergraduate and 20 graduate students. These participants attended 14 different non-technical conferences; 12 of these conferences took place out-of-state and two in-state. The conferences' focus was classified as follow: (i) professional community conferences defined as specific to major or professional community, (ii) leadership conferences that emphasized coaching, mentoring, and/or leadership topics, (iii) minority conferences focused on a specific minority group, and (iv) professional development conferences that offered professional development topics. Table 2 shows each conference category and the conferences the 38 participants attended.

Data Analysis

Paired t-test analyses were used to determine if there was a significant difference between pre- and post-survey self-esteem and self-efficacy data with an α equal to 0.05. Self-esteem questions one, four, and five had reverse scoring[11], thus for analysis purposes, the scoring system was change to: 5 - not at all, 4 - a little bit, 3 - somewhat, 2 - very much, and 1 - extremely.

The paired t-tests were applied to: the overall score for self-esteem (sum of questions 1 through 14), the general engineering skills score (sum of questions 15 through 20), and the experimental skills score (sum of questions 21 through 24). The tests were first run for the entire participant pool and then separately for the graduate participants and undergraduate participants. Finally, supplementary paired t-tests were conducted for the self-esteem subcategories of academic performance and social

Table 1: Assessment questions

Variable	Subcategory	#	Question	Scoring System
Self-Esteem	Academic Performance	1	I feel confident about my abilities. *	1 - not at all 2 - a little bit 3 - somewhat 4 - very much 5 - extremely
		2	I feel frustrated or rattled about my performance.	
		3	I feel that I am having trouble understanding things that I read.	
		4	I feel as smart as others. *	
		5	I feel confident that I understand things.*	
		6	I feel that I have less scholastic ability right now than others.	
		7	I feel like I'm not doing well.	
	Social Confidence	8	I am worried about whether I am regarded as a success or failure.	
		9	I feel self-conscious.	
		10	I feel displeased with myself.	
		11	I am worried about what other people think of me.	
		12	I feel inferior to others at this moment.	
		13	I feel concerned about the impression I am making.	
		14	I am worried about looking foolish.	
Self-Efficacy	General Engineering	15	I can master the content in the engineering-related courses I am taking this semester.	5 - Strongly Agree 4 - Agree 3 - Neither Agree Nor Disagree 2 - Disagree 1 - Strongly Disagree
		16	I can master the content in even the most challenging engineering course if I try.	
		17	I can do a good job on almost all my engineering coursework if I do not give up.	
		18	I can do an excellent job on engineering-related problems and tasks assigned this semester.	
		19	I can learn the content taught in my engineering-related courses.	
		20	I can earn a good grade in my engineering-related courses.	
	Experimental Skills	21	I can perform experiments independently.	
		22	I can analyze data resulting from experiments.	
		23	I can orally communicate results of experiments.	
		24	I can communicate results of experiments in written form.	

Questions 1 to 14 were obtained from the State Self-Esteem Scale[11] and 15 to 24 from the Engineering Self-Efficacy Test[13]. (*) Indicates reverse scoring.

Table 2: Conference classification

Classification	Conference
Professional Community	• Materials Research Society Spring Meeting and Exhibit • DMMM2: diversity in the minerals, metals, and materials profession • Robert H. Goddard Memorial Symposium
Leadership	• National Conference for College Women Student Leaders • IEEE Women in Engineering International Leadership Conference • Indiana Conference for Women • Women Leaders Conference • UNM Mentoring • USNA Leadership Conference
Minority	• Out to Innovate 2017 • Women of Color STEM
Professional Development	• Purdue Annual Conference for Pre-Tenure Women • Society of Women Engineers National Conference • Women in Engineering ProActive Network Annual Conference

confidence for each of the three groups: the entire pool, graduate participants, and undergraduate participants.

Results

Demographics

All of the 38 participants were female engineering students with 18 (47.37%) undergraduate students and 20 (52.63%) graduate students. Students came from the following College of Engineering departments: Aeronautical and Astronautical (3), Agricultural and Biological (4), Biomedical (2), Chemical (2), Civil (2), Electrical and Computer (4), Engineering Education (3), Environmental and Ecological (2), First-Year (2), Industrial (3), Mechanical (7), and Material Science (4). The self-reported ethnicity of the participants was 27% International, 59% White, 9% Asian, and 5% Underrepresented minorities. This division is similar to the self-reported ethnicity of the institution's pool of eligible students; 29% International, 51% White, 8% Asian, 6% Underrepresented minorities (which includes African American/Black, Hispanic/Latino, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander), 3% Two or more races, and 3% Unknown.

Statistical Analysis

- Self-Esteem:

  The paired t-test of the self-esteem questions of the entire pool of participants (n=38) resulted in p ≤ 0.05 ; the pool of undergraduate participants (n=18) resulted in p $\leq$ 0.05; and the graduate participants pool (n=20) had p $\leq$ 0.05. Thus, the difference between the pre- and post-survey scores are deemed significant. The sub-analysis (paired t-test) of academic performance self-esteem revealed that pre- and post-survey scores are significantly different for the total, undergraduate, and graduate pools. Also, a paired t-test showed significant difference for the total and graduate pools of social confidence self-esteem. The undergraduate pool, however, did not reveal a significant difference between pre- and post-survey data (refer to Table 3 for details).

Table 3: Self-esteem paired t-test data analysis results

		Pre-survey		Post-survey		Pre vs. Post
		Mean	SD	Mean	SD	p-value
Overall (Questions 1-14)	Total	32.47	8.962	28.79	8.332	0.0022*
	Undergraduate	30.5	8.17	26.72	5.655	0.0282*
	Graduate	34.25	9.464	30.65	9.943	0.0398*
Performance (Questions 1-7)	Total	15.66	5.174	13.92	4.009	0.002*
	Undergraduate	15.39	5.822	13.39	3.728	0.0306*
	Graduate	15.9	4.656	14.4	4.285	0.0327*
Social (Questions 8-14)	Total	16.816	4.787	14.868	7.096	0.0094*
	Undergraduate	15.11	3.462	13.33	3.430	0.1172
	Graduate	18.35	5.354	16.25	6.382	0.0423*

(SD) Standard Deviation, (*) indicates that the p-value ≤ 0.05.

- Self-Efficacy:

  The paired t-test analysis of the general engineering self-efficacy questions for the entire pool (n=38) resulted in $p \leq 0.05$, thus the difference in the scores before and after attending the non-technical conference are deemed statistically significant. The p-values found for both the graduate student pool and the undergraduate student pool indicate that the differences seen in the pools separately are not significant. Only the graduate student participants answered questions around experimental skills self-efficacy. A $p > 0.05$ was obtained (n=20) so the difference between pre- and post-survey data are not considered significant. Refer to Table 4 for the detailed results of the analysis around self-efficacy.

Table 4: Self-efficacy paired t-test data analysis results

		Pre-survey		Post-survey		Pre vs. Post
		Mean	SD	Mean	SD	p-value
General Engineering (Questions 15-20)	Total	25.16	2.693	26.41	2.872	0.0056*
	Undergraduate	24.72	2.539	26.22	2.962	0.4608
	Graduate	25.58	2.835	26.58	2.854	0.0920
Experimental (Questions 21-24)	Graduate	16.95	1.959	17.05	2.139	0.7481

(SD) Standard Deviation, (*) indicates that the p-value ≤ 0.05.

Discussion

Self-esteem is a relatively stable trait where individuals can have a high self-esteem or a low self-esteem or somewhere in between. However, self-esteem can increase or decrease based on the individual's success experiences and aspirations[11]. The results of this study show that participants' self-esteem was positively affected by their attendance at a non-technical conference. Hence, participation in non-technical conferences could then be categorized as a ‘success experience’.

Self-esteem impact is often used as a predictor of satisfaction for positive experiences[14]. The results of the self-esteem subcategory of academic performance show that both the graduate student pool and the undergraduate student pool saw positive affects. This was notable since the conferences were focused on professional development and not technical areas, suggesting that attendance at non-technical conferences represent a positive experience for female engineering undergraduate and graduate students, leading to an increased confidence in academic abilities. Interestingly, only the difference seen in the graduate student pool social confidence self-esteem subcategory was found to be significant.

Self-efficacy was also examined. One can think of self-efficacy as the level of competence an individual feels about certain tasks such as learning engineering or performing well on a test or homework. In this study, self-efficacy for general engineering skills was impacted positively by the participants’ experience at a non-technical conference. Given the non-technical nature of the conference, this result was unexpected but encouraging. Interestingly however, when the statistical test was performed separately for the graduate pool and the undergraduate pool, the difference, while positive, was not statistically significant.

Experimental self-efficacy, or the students’ belief in their ability to conduct experiments, was only measured in the graduate student pool since not all undergraduates conduct research. The difference in experimental self-efficacy in graduate students was not statistically significant. Therefore, no conclusion can be made about the impact of participation in non-technical conferences on experimental self-efficacy.

The increase on the participants’ self-esteem and the sustained scores in their self-efficacy, indicate the significant role that non-technical conference participation could have in a student’s academic career. Non-technical conferences generated a boost in one’s self-esteem dissociated from academic performance. This is important because, as stated by Crocker, Karpinski, Quinn, and Chase[15], students who use academic performance as building blocks of their self-esteem are more likely to have an unstable self-esteem which could lead to disidentification with their major.

Conclusions

This study focused on the impact that participation by female engineering students in non-technical conferences had on their self-esteem, as well as general engineering skills and experimental skills self-efficacy. It was found that attendance at non-technical conferences had a positive impact on both undergraduate and graduate students’ self-esteem and general engineering self-efficacy. Graduate students, however, did not experience statistically significant changes in their experimental self-efficacy.

Non-technical conferences may serve as a non-academic path towards building female engineering students’ self-esteem. Since self-esteem is one’s view of their self-worth, increasing self-esteem can lead to an individual feeling that they better belong, or ‘fit’, in their engineering major.

Non-technical conferences represent a non-threatening environment in which students meet successful role models, network with peers, and learn to cope with career anxieties. Additionally, non-technical conferences can be used as tools to detach self-esteem from academic achievement. Heavy weight on academic achievement can lead to fluctuations in self-esteem, which can have negative consequences on psychological well-being.

Even though the focus of the conference was non-academic, the experience led to a significant increase of the participants' general engineering self-efficacy. The motivation gained by an increase in general engineering self-efficacy makes participants' success in their engineering career more likely. This increase may be a result of the conferences' relevant resources, networking opportunities, and exposure to successful female role models.

Future work could further investigate the impact of technical versus non-technical conferences in participants' self-esteem, and general engineering and experimental self-efficacy. In addition, past participants could be re-tested to determine if the increases in self-esteem were sustained. Also, this research examined participants' reaction to one non-technical conference attendance, the effect of successive attendance at these types of conferences could be explored. Finally, the assessment instrument was comprised of portions of two previously validated instruments. It would be interesting to examine the validity of the instrument created for this project.

References

[1] Brian L. Yoder. *Engineering by the Numbers*. ASEE, Washington, DC, 2016.

[2] United States Census Bureau. Where do college graduates work? a special focus on science, technology, engineering and math, 2014. URL `https://www.census.gov/dataviz/visualizations/stem/stem-html`.

[3] Doug Shapiro, Afet Dundar, Faye Huie, Phoebe Khasiala Wakhungu, Xin Yuan, Angel Nathan, and Ayesha Bhimdiwala. Completing college: A national view of student completion rates–fall 2011 cohort.(signature report no. 14). *National Student Clearinghouse*, 2017.

[4] Catherine Hill, Christianne Corbett, and Andresse St. Rose. *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. AAUW, Washington, DC, 2010.

[5] Sarah J. Banchefsky, Jacob Westfall, Bernedatte Park, and Charles M. Judd. But you don't look like a scientist!: Women scientists with feminine appearance are deemed less likely to be scientists. *Sex Roles*, 75:95–109, 2016.

[6] Linda L. Carli, Laila Alawa, YoohAh Lee, Bei Zhao, and Elaine Kim. Stereotypes about gender and science: Women do not equal scientists. *Psychology of Women Quarterly*, 40(2): 244–260, 2016.

[7] Kristen C. Kling, Janet Shibley Hyde, Carolin J. Showers, and Brenda N. Buswell. Gender differences in self-esteem: a meta-analysis. *Psychological bulletin*, 125(4):470–500, 1999.

[8] Antony S.R. Manstead and Sander A.M. van Eekelen. Distinguishing between perceived

behavioral control and self-efficacy in the domain of academic achievement intentions and behaviors. *Journal of Applied Social Psychology*, 28(15):1375–1392, 1998.

[9] Carroll Seron, Susan S. Silbey, Erin Cech, and Brian Rubineau. Persistence is cultural: Professional socialization and the reproduction of sex segregation. *Work and Occupations*, 43 (2):178–214, 2016.

[10] Mary E. Fitzpatrick, Manuela Romero, and Jennifer Sheridan. Changes in undergraduate engineering college climate and predictors of major commitment: Results from climate studies in 2008 and 2015. In *123rd American Society for Engineering Education Annual Conference*, New Orleans, LA, 2016.

[11] Todd F. Heatherton and Janet Polivy. Development and validation of a scale for measuring state self-esteem. *Journal of Personality and Social psychology*, 60(6):895–910, 1991.

[12] Todd F. Heatherton and Carrie L. Wyland. Assessing self-esteem. *In Assessing Positive Psychology. S. Lopez and R. Snyder (Eds)*, pages 219–233, 2003.

[13] Natasha A. Mamaril, Ellen L. Usher, Caihong R. Li, D. Ross Economy, and Marian S. Kennedy. Measuring undergraduate students' engineering self-efficacy: A validation study. *Journal of Engineering Education*, 105(2):366–395, 2016.

[14] Jennifer Crocker and Lora E. Park. The costly pursuit of self-esteem. *American Psychological Association*, 130(3):392–414, 2004.

[15] Jennifer Crocker, Andrew Karpinski, Diane M. Quinn, and Sara K. Chase. When grades determine self-worth: consequences of contingent self-worth for male and female engineering and psychology majors. *Journal of personality and social psychology*, 85(3):507–516, 2003.