Travel Grants Which Facilitate Engineering Leadership Identity in Female Engineering Students

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***Abstract*—In this pilot mixed methods study, we examine the impact of travel grants for female undergraduate and graduate engineering students at a large Midwestern university to attend non-technical conferences whose focus is on the development and empowerment of female leaders in science, technology, engineering and mathematics (STEM). Using a leader identity development framework, we analyzed applications, post- conference attendance surveys, required dissemination projects (i.e., sharing what was learned at the conference with the wider engineering audience at the university) and interview transcripts to examine the impact of this conference experience approach on participants' attitudes towards their anticipated degree and career paths. With an initial sample of 27 participants, preliminary results show a positive impact on professional and personal development, an increased commitment to completing current degree programs, an increase in/reinforcement of confidence in abilities, and inspiration to emulate the women leaders with whom the participants networked at the conference.**

I. Introduction and Related Work

CUTTING edge research and technology development are key to maintaining the United States international competitiveness; to this end, public and private resources must be invested to develop a society which is better educated in science, technology, engineering and mathematics (STEM) fields[1]. Although the total number of bachelor's degrees granted in the United States (1,869,818) increased for the 2013-2014 period, with 57.12% (1,068,122) awarded to women [2], in STEM disciplines women hold only a small percentage of undergraduate degrees, a phenomenon that is more prominent in engineering [3]. In spite of numerous initiatives focused on the recruitment and retention of female engineering students, the number of female engineering students, faculty and professionals remains low. For the period 2013-2014, just 18.38% (20,031) of bachelor's degrees in engineering and engineering technologies were held by women [2].

The gender gap also affects women who are already in STEM majors and careers. Murphy et al. [4] demonstrates that women in math, science and engineering (MSE) are negatively affected by gender imbalanced environments. Situational cues in such environments generate a lower sense of belonging for female students and decrease their desire to participate in MSE fields.

Numerous factors are possibly associated with the women to men disparity in STEM, including: self-confidence, gender stereotyping, lack of female role models, and self-efficacy [3]. Women's self-confidence is built and/or reinforced by supportive academic and familiar environments [5], [6]. Gender stereotyping contributes negatively to beliefs surrounding career appropriateness, goals, and expectations of women in careers held predominantly by men [7]. Lack of role models is also related to retention of women in STEM careers [8]. In engineering women's self-efficacy, perceived beliefs in one's capabilities, is related to persistence as well [9].

In addition, Mau [10] used social cognitive career theory (SCCT) to explore factors affecting career aspirations in middle school students. Results showed that the most important factors in career persistence for science and engineering, besides sex and race, were academic proficiency and math self-efficacy. Additionally, Lent et al. [11] stated that academic interest, performance outcomes and career choices related to engineering majors can be explained by SCCT for women and students at historically black universities. This theory is based on the interplay between environmental variables, behavioral variables and personal variables. On the other hand, GPA and SAT-math scores were found to be associated with persistence in engineering courses [5]. Marx and Roman [12] showed that perceived competence of a female role model can shield math performance from stereotype threat and even increase self-appraised math ability of female students. The research conducted by Rosenthal et al. [13] indicated that single-sex programs can increase women's sense of belonging in STEM majors. Additionally, female professors in STEM help to reduce stereotypes held by both men and women and serve as positive role models for women [14].

Drury et al. [15] states that in order to reduce the gender gap it is necessary to increase recruitment and retention of women in STEM fields. Since 1969, Purdue University throughout the Women in Engineering Program (WIEP) provides encouragement, personal and professional development, career information, and networking opportunities for K-12, undergraduate, and graduate students[16]. Fewer programs and studies appear to specifically address how to prepare female engineering students for the transition beyond bachelor and graduate degrees with regard to the same psychological and systemic barriers they will face. The authors of this study propose that research studies related to the preparation to enter either engineering-related industries or academic positions comprise a relatively untapped retention strategy with the potential to increase the number of women remaining in the engineering profession.

II. Methods

A. Theoretical Framework

This research study uses leadership theory coupled with self-efficacy theory as a framework. Creating a leader identity is key in the process of becoming a leader [17]. Of direct relation to this study, availability of relatable role models is necessary in order to construct leader identity [17].

Self-efficacy theory proposes that changes in expectations of success can lead to a behavioral change in the individual [18]. This research also explores student's self-beliefs by incorporating self-efficacy theory and a self-esteem assessment. Self-esteem is described by Heatherton & Polivy research as "a barometer that raises and falls as a function of one's aspirations and success experiences" [19, p.895]

B. Research Question

This research is guided by the following research question:

- How does participation in non-technical conferences influence female engineering students' attitudes towards their major?

C. Assessment Instrument and Data Collection

This research time frame is ongoing (at least a span of 2 years), and includes Fall 2015, Spring and Fall 2016, and Spring 2017.

For the term Fall 2015, participants first completed a survey containing demographic questions, such as gender, race-ethnicity, major and academic term. After attending the non-technical conference, students completed a post-conference survey which contained 14 multiple choice and 2 open-ended questions. The content covered feedback on overall conference experience and its usefulness, logistics, and conference impact.

The questions used for the quantitative data analysis asked students to indicate the level of agreement with the following statements - Attending this conference:

1) Increased my commitment to completing my current degree program.
2) Helped build/reinforce confidence in my abilities to be a successful engineering professional.
3) Positively impacted my personal development.
4) Positively impacted my professional development.
5) Inspired me to emulate the successful women I saw at the conference.

Students used a 6 point Likert scale to indicate their level of agreement or disagreement (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree and not applicable). Each question was assigned to a specific variable for further study (Table I). These variables are intrinsically related with leadership milestones such as personal and professional growth, and self-efficacy.

Additional qualitative data will be obtained through focus groups and interviews; however, the responses to the question "Please feel free to provide any additional comments here, including quotes that we may share with the sponsors of these travel awards about the impact of this award for you." was examined by the researchers.

TABLE I
VARIABLE ASSIGNATION

Question	Variable
1	Commitment
2	Confidence
3	Personal Impact
4	Professional Impact
5	Inspiration

D. Participants

Students were provided with full financial aid to attend these domestic non-technical conferences and were required to attended a pre-conference workshop organized by the authors of this paper. The workshop provided helpful tips to maximize their experience. When possible, more than one student attended the same conference to help build camaraderie in a shared experience.

In Fall 2015 the participants of this study were 27 female engineering students (Table II) who were awarded financial resources to attend a non-technical conference of their preference from a pre-approved list. These conferences were selected for focusing on elements related to the development and empowerment of female leaders in STEM and included conferences such as the Grace Hopper Celebration of Women in Computing Conference (GHC), Society of Women Engineers (SWE) national and regional meetings, Women of Color STEM Conference, and the Women in Engineering ProActive Network (WEPAN) national forum.

TABLE II
PARTICIPANTS' ACADEMIC LEVEL

Undergraduate	Graduate	No answer
9	15	3

The sample was predominantly White/Caucasian (51.85%), with an overall average GPA of 3.63. Undergraduate participants in this study encompassed first year, junior and senior students. Participants' majors included Agricultural and Biological Engineering, Electrical and Computer Engineering, Engineering Education and Industrial Engineering, among others.

III. Results

Results shown in this section correspond to the data set obtained for the term Fall 2015.

Twenty-four (88.88%) participants indicated that attending the non-technical conference increased their commitment to complete their degree. Twenty-five (92.59%) participants expressed that their confidence in their engineering abilities was built/reinforced by the non-technical conference. All the participants (100%) stated that the non-technical conference positively impacted their personal and professional development. Finally, 100% of the participants felt inspired to emulate successful women with whom they interacted during the conference. Table III presents the data obtained.

By analyzing the responses to the question "Please feel free to provide any additional comments here, including quotes that we may share with the sponsors of these travel awards about

TABLE III
RESPONSES SUMMARY AND STATISTICS

Question	SD	D	NAD	A	SA	NA	Mean	Variance	sd	Total
Commitment	0	0	3	12	12	0	4.33	0.46	0.68	27
Confidence	0	0	2	13	12	0	4.37	0.40	0.63	27
Personal Impact	0	0	0	11	16	0	4.59	0.25	0.50	27
Professional Impact	0	0	0	11	16	0	4.59	0.25	0.50	27
Inspiration	0	0	0	8	19	0	4.70	0.22	0.57	27

[SD=Strongly disagree, D=Disagree, NAD=Neither agree nor disagree, A=Agree, SA=Strongly agree, NA=Not applicable, sd=Standard Deviation].

the impact of this award for you" the researchers found that students considered the non-technical conferences as:

1) Learning opportunities
2) Source of inspiration
3) Networking opportunities
4) Source of personal development
5) Source of professional development

The following are examples of the responses obtained:

"This conference really came at a crucial point in my life. If I had not been given the funding to attend I would not have put forth the effort to go on my own. I was aware of the tools that the **X** conference promotes but by attending the conference I was able to clearly see how to implement them daily and given examples and people to refer to."

"This conference has really opened my eyes to the opportunities for and amazing things done by women engineers out there. Sometimes we are so overwhelmed by the tedious daily tasks of an engineering student that we forgot how awesome and privileged we are. The conference re-ignited my passion for engineering and provided me with an abundant amount of resources to pursue my goals."

These responses also showed that 11.11% of the participants were having doubts about their field of study:

"The **Y** Conference was amazing and came at just the right time for me. I had been feeling a little bit down about engineering...questioning why I wanted to continue, but then I went to the conference and all of my worries became irrelevant. I met so many powerful women who inspired me to create the next generation of change. They showed me that yes, college is difficult, but the difference you can make as a practicing engineer is what really matters."

IV. DISCUSSION

This study focused on how the experience of attending a non-technical conference impacted female engineering students' overall attitude towards their major or proposed career field. The analysis of quantitative and qualitative data suggest that the experience has a positive impact on students and that interacting with other female engineering students and professionals boosted participants' enthusiasm toward their major. This is consistent with research by Nauta et al. [20] on the positive relationship between role models and career aspirations of female students in engineering.

Female students' attendance at non-technical conferences which focus on women in STEM seems to have increased their commitment to engineering, which is in accordance with Rosenthal et al. [13] research concerning the increased sense of belonging which can occur in same-sex environments. Persistence in engineering is also related to learning to overcome academic and professional difficulties [21], and non-technical conferences represent one way to offer leadership learning and professional development to female engineering students in an encouraging and inspirational environment.

V. CONCLUSIONS

Non-technical conferences focused on mentoring and leadership can be used as a source of relatable role models and peer networking for female engineering students. Results also suggest that doubts about engineering fields of study in female undergraduate and graduate students can be dissipated by a timely intervention.

Finally, financial help to facilitate students' attendance at non-technical conferences is key. Most institutional awards tend to focus on academic/technical conferences.

VI. FUTURE WORK

The qualitative and quantitative data collection will continue for the terms Spring 2016, Fall 2016 and Spring 2017. New instruments will be implemented to better assess the impact which conference attendance has on changes in the variables listed in Table I.

For future data collection, we will employ the self-efficacy assessment from Mamaril et al. [22] and include questions related to general and experimental engineering skills. Additionally, a set of self-esteem questions from Heatherton & Polivy [19], will be added to assess this variable in a social and academic setting.

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