AC 2012-3644: COLLABORATIVE RESEARCH: GENDER DIVERSITY, IDENTITY, AND EWB-USA

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Abstract

This recently initiated research[i], funded by the National Science Foundation's Division of Engineering Education and Centers, investigates the motivations driving members of the service organization Engineers Without Borders-USA (EWB-USA) in the theoretical context of identity and social cognitive theory. As a rare example of a professional engineering organization with a roughly balanced gender ratio among its membership, EWB-USA provides a strategic research site for unpacking gendered motivations and identity formations in engineering.

Females are underrepresented in STEM fields. This is true for student and professional cohorts. Past research suggests that recruitment, not retention, is the problem for females in university engineering programs. In contrast to this, female engineering professionals experience higher attrition rates than do their male counterparts. This dual problem of recruitment and retention means that capable female engineers leave or never enter the profession, disproportionately contributing to the shortage of engineers. As a result, this research will consider an extended STEM pipeline that includes both undergraduates and professionals, recognizing the importance of not only recruiting but also retaining diverse genders in STEM.

Social cognitive theory proposes that self-efficacy and expected outcomes form the basis for professional identity and motivation. This research will test social cognitive theory as a framework for attracting diverse groups to engineering. Specifically, it proposes that participation in EWB-USA changes the expected outcomes of engineering—from Dilbert to the engineer of 2020. In addition, it provides career scaffolding that helps members navigate careers. Both of these aspects are hypothesized to be particularly attractive and beneficial to females, which in turn is hypothesized to explain the gender ratios observed in the EWB-USA membership.

This project proposes a multi-method approach. The first research phase is primarily qualitative and consists of data collection through semi-structured focus groups, interviews, and written responses to open-ended questions. We will conduct 28 interviews of female and male students and professionals involved with EWB-USA. These interviews will contain open-ended questions aimed at understanding the motivations for joining EWB, what they gain from their membership in the organization, what they believe to be lacking in their education, and how their membership has changed them. 16 focus groups will be held with female, male, and mixed gender groups, students and professional groups, and EWB and non-EWB groups. The participants in these focus groups will be asked many of the same questions and will be asked to vote on the most important and least important aspects of what the group discussed. Participants in both the interviews and focus groups will be asked to write a description of an EWB member, engineer, and themselves to determine perceptions of engineering identity and motivation, and differences in these generalizations for the various cohorts. In addition, at a series of EWB-USA meetings, EWB-USA members will be asked to write responses to open-ended questions regarding identities and motivations. This data will be transcribed and coded in QSR NVivo to analyze emergent trends. In the second phase of the research, this qualitative data will be used as

the foundation for a quantitative survey that will be distributed to the memberships of EWB-USA, the Society of Women Engineers, the American Society of Civil Engineers, and the American Society of Mechanical Engineers.

This research hypothesizes that the expected outcomes of engineering will vary among the targeted research cohorts, and that EWB-USA members will report important career scaffolding experiences due to EWB-USA participation. This new knowledge will be of use in the design of evidence-based university curriculum and industry programs to increase the participation of females in engineering.

Introduction

The 12,000 member organization Engineers Without Borders-USA (EWB-USA) is one of the few engineering societies that reports roughly balanced membership ratios of males and females[1]. This appears to be true among both undergraduate students and industry professionals who are members. By providing a community of mentors for students and STEM professionals with similar numbers of males and females, EWB-USA may provide career scaffolding especially beneficial to females. Additionally, it may change perceptions of self-efficacy and the expected outcomes of being an engineer. For females, a particularly motivating expected outcome may be altruism and the ability to "make a difference". These combined forces may contribute greatly to the formation and retention of engineering identity, especially among females. Universities and industry have both begun to commit substantial resources to pursue these perceived advantages. This research will investigate these anecdotally reported trends leveraging a unique team of industry and university partners.

This research, led by EWB-USA and the University of Colorado at Boulder, home of the first EWB-USA chapter, will investigate motivations driving EWB-USA engineering volunteers nationwide in the theoretical context of engineering identity and social cognitive theory. This research considers an extended STEM pipeline that includes both undergraduates and professionals, recognizing the importance of not only recruiting but also retaining diverse genders in STEM.

Project Objectives

The research objective of this proposal is to uncover motivations for engagement in EWB-USA to understand why the organization enjoys balanced gender membership. Using a mixed method research approach, the research will focus on identity, altruism and changed outcomes through the lens of social cognitive theory to investigate the following questions:

- How does participation in EWB-USA support, sustain, or diminish motivation to enter and stay in engineering?
- Which demographic factors influence involvement and retention in EWB-USA?
- How does participation in EWB-USA impact the expected outcomes of participation in engineering?
- Why do students and professionals join and remain engaged with EWB-USA?
- How does involvement with EWB-USA effect sense of identity?

Points of Departure

The following sections provide context for the research. First, the paucity of females in engineering is discussed. Secondly, we discuss the need for additional research into pathways from university to industry for female engineers, and how this research will contribute to this gap. Next, we describe social cognitive theory's framework and how it applies to the EWB-USA experience, with an emphasis on altruism. Finally, we describe how these factors may impact the creation of engineering identity for females in engineering.

Underrepresented Minorities in STEM

It is widely recognized that the engineering profession is facing serious challenges[2]. There is a recognized shortfall in the number of young engineers in the US. Further, the National Academy of Engineers[3] finds that students have a limited sense of what it means to be an engineer. Students feel both men and women can be engineers, but tellingly are typically only able to name male engineers. There is some evidence that teachers share this bias; when asked to "draw an engineer,' a majority of 80 biology teachers drew a Caucasian man[4]. It is vital that the engineering profession resolves this identity crisis.

Females, minorities, and the disabled are underrepresented in the engineering profession[5]. They are less likely to choose STEM as a career and are less likely to advance in a STEM career even should they remain[6,7]. While many reasons for this have been suggested—including a lack of mentors, discrimination in the workplace or academia, and a lack of flexibility to support female's heavier household workload[6]—we cannot yet explain why in recent times females have made large advances in some fields, such as medicine[5], and not in others, such as engineering. In contrast, it is simple to describe why this is a problem for society. The National Academies of Engineering have recognized that in order to prepare the engineer of 2020, we must first recognize the changing socio-technological challenges they will need to address[8]. Handling these diverse challenges calls for people with diverse perspectives working together. In addition to the benefits of diverse perspectives, the reduced size of the pool of potential STEM practitioners reduces the ultimate number of those practitioners. This in turn reduces America's ability to compete in the global market and harms all of its citizens. Finally, social equity demands that we discover and demolish the barriers that are systemically preventing females, minorities, and disabled people from STEM professions.

By investigating student and industry members of an engineering organization with nearly balanced male to female ratios, this research aims to address one of the diversity challenges within the profession.

Pathways Through Engineering: Career Scaffolding from University of Industry

In recent years, NSF and the academic community have made a large investment in promoting engineering to K-12 students, including public television shows, websites, workshops, and high school curriculum targeted at attracting students to engineering[7]. These initiatives are particularly important as research suggests that the shortage of females in undergraduate

education is currently due to recruitment rather than retention[9,10]. Corroborating the need for early outreach is a recent study by Nosek et al.[11] that compared math and science performance of students with gendered perceptions of those fields in 34 countries. As national bias towards considering science as 'masculine' increased, so too did the gender gap on achievement scores. They also found that a significant number of students who do enter university in a STEM field drop out before gaining a degree. However, research has shown that the students who leave STEM are just as capable as those who persist. In addition, researchers have found gendered differences in reasons for persisting or leaving engineering between males and females [12,13]. While less research has been done regarding professionals in engineering, what we do know describes similar trends[14–18].

In contrast to undergraduate students, there is evidence that female engineering professionals experience higher attrition rates than males do. For example, a recent survey by SWE showed that only 61% of females with an undergraduate engineering degree were employed as engineers within 3 years of graduation. Among a cohort 18-20 years away from graduation, only 33% of females were employed as engineers, while 50% of males were. Like undergraduate students, males and females reported different reasons for leaving engineering. Significant to this research, females were most likely to report leaving engineering because they found "more interesting work in a different field"[13].

Another reason cited for this disproportionate attrition is that females who do remain in the STEM workforce are more likely to experience discrimination and generally be paid less than their male counterparts. Structural reasons are often blamed for this, especially among those females who are balancing a family with a career[19,20]. For example, a mother who cannot work late because she must pick up her children from school may appear less dedicated to her job and thereby be passed over for promotion. With the cycle building upon itself, the family member who earns less is the logical choice to care for the family, and this further hinders that person's professional development. It must be noted that the negative impacts of these issues extend to males as well as females, by building in structural constraints that may prevent personal choice. It is easy to imagine that addressing these factors would benefit all STEM workers. A supportive work environment, then, may be the key to retaining females in the workforce and generally improving recruitment and retention to the profession. However, this challenge is compounded by the existing dominant demographics of the aging workforce that is struggling to accommodate new pressures. Additionally, we have limited knowledge regarding the experiences of professional female engineers.

Social Cognitive Theory

Social cognitive theory is an established theory that has been extensively applied to education and career choice[21]. Concisely, it proposes that self-efficacy, or belief in one's own abilities and expected outcomes form the basis for professional identity and motivation[22,23].

Social cognitive theory continues to attract an increasingly large amount of empirical attention in education[6,21,24–34]. Generally, self-efficacy and outcome beliefs are found to be predictive of engineering vocational choices. However, although it was noted to have potential for attracting females to male-dominated careers as early as 30 years ago[24], a recent meta analysis of studies

testing this framework for vocation and career choice found only 3 published studies (prior to 1995) that examined predominately female sample sets[21]. Further, Sheu et al.[21] notes that studies tend to focus on self-efficacy rather than outcome expectation even though their analysis indicates that outcome expectation may have a stronger impact on choice than previously theorized.

This research contributes to this literature by testing social cognitive theory as a framework for improved engineering education. It proposes that involvement in EWB-USA or similar organizations impacts both self-efficacy and expected outcomes. By enabling students to participate in a real engineering project, it increases their sense of self-efficacy. Furthermore, by providing diverse mentors and providing an alternative to Dilbert©-style engineering, it changes the expected outcomes of becoming or remaining an engineer for both students and professionals. The changed expected outcomes that will be tested include improved self-perception, the excitement of travel and meeting interesting people, the excitement of helping society through engineering technology, power over the physical world, enhanced career advancement, the feasibility of motherhood and a career, etc. Research has shown that creating a better career fit enhances retention[33,35,36]. By supporting a more diverse set of expected outcomes of becoming an engineer, more diverse people may be attracted to and retained in engineering.

This research will not only make a theoretical contribution by testing social cognitive theory against career motivations for college students and professionals, but it will also test a basis—EWB-USA style experience—for the practical implementation of social cognitive theory in undergraduate curriculum and industry outreach should it prove warranted.

Altruism and Engineering Motivation

While it is expected that different people perceive different expected outcomes with involvement in EWB-USA, one motivation that may have particular relevance for this research and females in STEM is altruism.

In a survey of over 3,600 individuals, NAE found that "making a difference" was a significant motivator for students of engineering[3]. This finding agrees with the groundbreaking 1997 study, Talking About Leaving[12]. This research collected extensive gender and ethnicity segregated data for STEM students who both persisted or left engineering. One of the findings was that the students who identified altruism as a reason for choosing a STEM major were predominately (90.9%) female. More recent research by Schreuders et. al[37] also concludes that many females are drawn to engineering in order to improve conditions to people in socially conscious ways, and suggests that engineering faculty need to leverage this in curriculum.

This research will investigate altruism and contributing to society as motivators for the EWB-USA membership. It posits that EWB-USA helps students and professionals make the connection between altruism and engineering, and that this helps attract and retain them in the engineering profession. If proven true, this finding can have a significant impact on necessary changes to engineering curriculum to attract a more diverse student and practitioner population.

Engineering Identity

The construction of professional or personal identity is dynamic and multiple. In other words, identity reflects membership in many groups and changes over time. Socialization into a profession may be done via many avenues. However, it is commonly suggested that having examples of people like oneself may be a strong contributor. In STEM fields with low female membership, this may hinder the entry and retention of females into engineering[38–40].
STEM study and work is perceived by students as more difficult than many social sciences or humanities[12]. For students to undertake this more difficult work, they must perceive the outcome to be worth the more arduous effort. Similarly, many females leave engineering for 'more interesting' work elsewhere[13]. This research theorizes that participation in EWB-USA serves to make engineering worthwhile by demonstrating a different set of expected outcomes than that commonly implied by the standard engineering curriculum. Students describe engineering as largely sedentary, performed on computers, and involving little contact with other people[3]. None of these is true of volunteering with EWB-USA, which involves international travel, fieldwork and construction activities, and social involvement with designers, professional engineers, donors, and community members.

This research hypothesizes that participation with EWB-USA helps students and professionals build and maintain engineering identity into their sense of selves. It does this by providing mentors and a larger community who have different demographics than the existing engineering profession, and also by changing the expected outcomes of becoming an engineer.
This sense of identity, when paired with the career scaffolding described above, mean that females both desire to be an engineer and have a mentor to help them achieve this goal.

Methodology

A multi-method research approach will be employed, progressing from qualitative to quantitative data collection and analysis. The research trajectory will advance from exploratory, open-ended interviews with individuals and small, semi-structured focus groups to quantitative analysis employing surveys across the large organizations committed to the research. This will enable the research to explore uncharted territory by collecting open-ended responses, but also enable formal reporting and recommendations from responses validated across the EWB-USA, ASCE, ASME, and SWE membership. Figure 1 shows this research design.

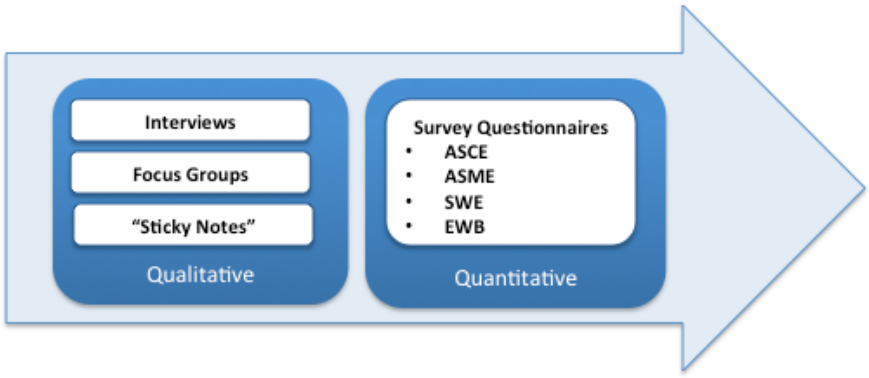
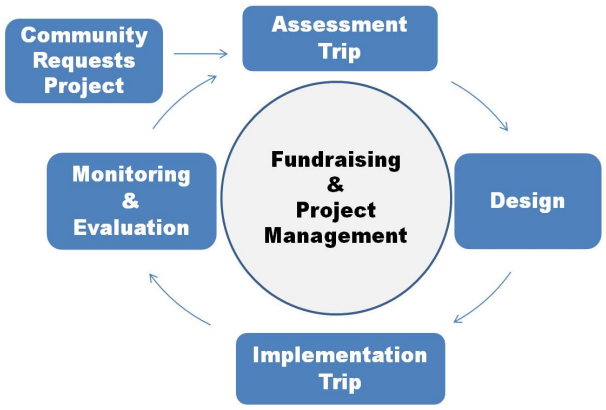


Figure 1: Multi-method research approach

Strategic Research Opportunity: Engineers Without Borders-USA

Figure 2—EWB-USA Simplified Project Model



Dr. Bernard Amadei, a Professor at the University of Colorado, founded EWB-USA in 2002. Today, EWB-USA boasts over 12,000 members in the United States[41]. These 12,000 members are a combination of students and professionals. All are volunteers; most are engineers. The EWB-USA model, in highly simplified form, can be seen in Figure 2. The proposed research will interview and conduct focus groups with EWB-USA (as well as student who do not belong to EWB-USA) to inform the development of a questionnaire sent to the entire membership of EWB-USA, as well as ASCE, ASME and SWE, to understand and compare and contrast reasons for participation.

Qualitative Data Collection and Analysis

The qualitative portion of the research will consist of coding and analyzing open-ended responses of individual interviews semi-structured focus group sessions, and written responses to open-ended questions.

Participant Recruitment

All selected participants will be enrolled in an accredited STEM degree program. We will recruit active members of EWB-USA and non-members. Non-members will be recruited from the ASCE, ASME, and SWE membership. Interview and focus group data are being collected at EWB-USA's annual conferences and at individual chapters affiliated with Universities and professional chapters. Initial data for pilot interviews and focus groups was collected at the March 2011 conference with funding support provided by CH2M HILL. Students who are not involved in EWB-USA will be recruited at Universities and companies whose students and employees participated in the EWB-USA focus group sessions. To encourage participation, we are providing $10 gift cards and light refreshments to focus group and interview participants as incentives. Participant enrollment for qualitative research will target even numbers of male and female participants and will target a minimum of four different EWB-USA chapters to be represented within each focus group. Survey phase data is expected to include more responses from males than females due to the gender composition of ASCE and ASME. Any further gender identification will be self-reported by the participants. Data in all research phases will be disaggregated by gender for analysis.

Individual Interviews

The research effort will identify and conduct exploratory, open-ended questions with students and practitioners involved with EWB-USA. A minimum of seven female and seven male students and seven female and seven male professionals will be selected for interviews. These

interviews are being conducted in-person or via telephone when required. This will provide insights into the main components of the research, enabling it to be exploratory by allowing new findings and discoveries through open-ended responses.

Ethnographic-style questions, using techniques proposed by Spradley[42], will be posed to the participants, including descriptive questions of how and why they chose to major/practice in engineering, how and why they became involved in EWB-USA, what EWB-USA has provided them, and why they remain involved in EWB-USA. Participants will also be asked a series of background questions, including gender and racial identification, academic or professional status, major, and socioeconomic identification.

Focus Groups

A variety of focus group sessions will be held. To explore motivations for joining EWB-USA, we will adopt between-group design to compare responses between student and professional focus groups. These groups will include: (1) EWB-Women [EWB-W]; (2) EWB-men [EWB-M]; (3) EWB- mixed-gender [EWB-M]; (4) Non-EWB Women [NEWB-W]; (5) Non-EWB Men [NEWB-M]; (6) Non-EWB mixed-gender [NEWB-M]. To minimize bias, this research phase will include focus groups held at chapters with gender ratios approaching national engineering demographics, though to date such chapters have been difficult to identify.

Questions for students involved with EWB-USA will focus on motivations for joining EWB-USA and what benefits EWB-USA is providing, while questions to students not involved in EWB-USA will focus on why they did not join. Similar questions regarding engineering identity such as descriptions of a typical engineer and what expected outcomes of an engineering career are will be asked of each group. Questions posed in the individual interviews are expanded to focus on identity, expected outcomes, mentors, and other important items that emerge. Optimally there will be between 5-10 participants for each group. This size is recommended to create a balance between depth and breadth of data collection[43,44]. In addition to gender and EWB-USA involvement selection for the between-group design, purposive sampling helps to inform within-group design in an attempt to include a combination of ethnic identification, socioeconomic status, and a mix of on-site EWB-USA field experience.

At the beginning of the focus group, the moderator describes the purpose of the study, the format and rules of the group session, the confidentiality of the discussion, and proceeds with self-introductions of the participants. Data will be collected by (i) audiotapes, (ii) board notes (iii) observer notes and (iv) written responses to open-ended questions by participants to ensure reliability of the data.

Sticky Notes

Within the focus groups, we will collect written responses to six open-ended questions by the participants (as indicated under (iv) above). These questions will address their motivations for becoming an engineer, being involved in EWB-USA, their expected outcomes of an engineering career and EWB-USA membership, and their descriptions of a typical engineer versus an EWB-USA member. These questions are answered on a colorful 8.5 x 11 sheet of paper that resembles colored “sticky notes” and includes self-identified descriptions of membership, gender, age, and

professional status at the bottom of the sheet. Within the focus groups, these "sticky notes" sheets help engage thinking on the subject matter and are used to record their beliefs prior to group discussion.

These "sticky notes" sheets are also being administered at seven EWB-USA regional workshops around the country. This has resulted in over 800 "sticky note" sheets of responses to approximately 10 open-ended, rotating questions.

Qualitative Analysis

The responses to the interviews, focus group discussions, and "sticky note" sheets will be transcribed. These transcriptions, along with observations and any documentation collected, will be imported as sources into a qualitative coding software, QSR NVivo. Using NVivo, this material will be coded into similar categories, including motivations for selecting engineering major, motivation for involvement in EWB-USA, benefits and barriers of involvement in EWB-USA, reasons for continued involvement in EWB-USA, definitions of what an engineer is and does, existence and involvement in mentorship roles, and expectations of what engineering and EWB-USA will mean to their lives. Non-EWB-USA participant's responses will also be coded into related categories; however, many questions instead focus on why they are not involved with EWB-USA and what groups they do identify with. The background information of participants will be coded as case attributes in QSR NVivo.

We will analyze the coded documentation for patterns using within-group and between-group analysis. Through iterative analytical coding and the use of queries and response analysis, we will build theory grounded in the evidence collected[45,46]. The results and propositions developed from this analysis will be used to develop the survey questions in the next phase.

Quantitative Data Collection and Analysis

The analysis of the interviews and focus group data will help inform the questionnaire to the entire EWB-USA membership. Questions will be developed based on data collected in interviews and focus groups. The qualitative results will allow theory building that will be tested through quantitative surveys.

The questionnaire will be administered to the entire EWB-USA membership via an online survey. This will result in a potential sample size of approximately 12,000. To improve research validity, this survey will be finalized using established best practices[47,48] and insights gleaned from the previously conducted interviews and focus groups. This questionnaire will also be administered to the memberships of ASCE, ASME, and SWE. Data collected by the questionnaires will include basic self-reported demographics such as gender, ethnicity, disability status, GPA, university, year of study, and major. Demographics will allow for both selection of numerically dominant categories for ease of entry (e.g., male or female) and, to avoid imposing heteronormative or ethnocentric categories, open text boxes for keyed entry. Collected data will be imported into the research database for analysis and cross-tabulation. Statistically significant relationships will be identified. Relationships that were expected to be statistically significant that are not will also be identified.

Expected Results

This research will work to proactively shape what appears to be the next major trend in engineering education and workforce retention—namely, EWB-USA type experiences. By creating knowledge regarding gendered engineering identity formation, this research will enable universities and industry to build diverse programs that are founded in science. This will enable them to capture the portions of this experience that contribute to recruitment and retention of balanced gender ratios. Just as importantly, it may also prevent them from wasting resources on unfounded interventions that will not have the desired impact.

The outputs of this research will be well-constructed theory that will be immediately and practically applicable to industry and educators. EWB-USA provides a strategic research site—an organization that reports balanced male to female ratios—that provides a unique opportunity to unpack some of the previously elusive reasons behind STEM inequality. Should it be justified, EWB-USA also provides a functional model on which to base interventions for both universities and industry.

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[i] Due to the early phase of research, this poster does not present results but rather describes the project methodology and expected results, drawing heavily from the recently funded NSF proposal text.