Self Determination Theory to Develop Strategies for the Retention of Women in Engineering and Engineering Technology Programs

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Abstract

Women are drastically underrepresented in engineering fields. Although efforts have been successful at recruiting women into engineering and engineering technology (ET) programs, retention remains an issue due to several factors such as stereotype threat and a lack of established women role models. This paper reports on a five year National Science Foundation Scholarships in Science, Technology, Engineering, and Math (S-STEM) funded project: Critical Mass of Engineering Technology Scholars (COMETS), and how the utilization of self-determination theory (SDT) fostered a supportive professional community to retain women undergraduates in ET programs at the Rochester Institute of Technology (RIT). SDT posits that learning, motivation, and persistence are facilitated when the psychological needs of autonomy, relatedness, and competence are met. Interview and focus group findings show that although students continued to face amotivating factors from within their programs, they received, through their personal and professional communities, support for their psychological needs. This paper provides suggestions and evidence on how an SDT framework may guide programs and improve departmental cultures to support the retention of women in engineering.

Keywords

Women in Engineering, retention, self-determination theory

Introduction

The lack of diversity in U.S. engineering programs has been a persistent and troubling problem that has resulted in a primarily homogeneous engineering workforce. This underrepresentation of women in engineering is a pressing national issue for several reasons: (1) the United States is losing its advantage as the world's leader in research and development[1]; (2) the lack of potential contributions from women to the creativity and diversity of the engineering workforce; and (3) the principle of social equity stipulating that careers should be open to all people, unconstrained by factors such as gender.[2, 3] With predictions that by 2018 the growth rate of many science and engineering occupations will be faster than average,[4] failure to strengthen the Science, Technology, Engineering, and Math (STEM) pipeline may erode the U.S. ability to remain competitive in a global economy. Increasing underrepresented populations in engineering will allow the US to fully tap the potential of its citizens, while enhancing and diversifying the STEM workforce. In response, there have been numerous calls to action to increase the number of graduates from STEM university programs. In 2004 alone, "Thirteen federal civilian agencies spent approximately $2.8 billion to increase the numbers of students in STEM Fields and employees in STEM occupations and to improve related educational programs." [5] Despite efforts to increase STEM education recruitment and interest, the graduation rates for women in

engineering still remains very low; the percentage of engineering bachelor's degrees awarded to women has remained fairly stagnant through the 1990's and 2000's.

Thus, this article begins with brief overview on the barriers that women frequently encounter in their engineering programs, and how these may affect retention. Afterward, the use of a self-determination theory (SDT) framework to mitigate some of these barriers and support women in their programs is described. Lastly, findings from the COMETS program are discussed and provide suggestions for ways that SDT can guide programs and improve departmental culture to support the retention of women in engineering.

Self-Detemination Theory

Previous research shows that women in STEM programs often encounter situations that undermine their self-efficacy. Self-efficacy pertains to one's perceptions of whether or not they are able to accomplish certain goals or tasks, and it has been a fairly accurate indicator of student persistence and academic performance. [6, 7] These perceptions affect decisions about one's: (a) perceived self-confidence, (b) choices and courses of action, and (c) persistence and perseverance when meeting the demands of their program. Negative perceptions of self-efficacy may be exacerbated by: [8-11]

- A lack of prior knowledge related to engineering courses
- A lack of established women and minority engineers and faculty role models
- A sense of not belonging and of isolation
- A non-supportive network of friends and family
- Stereotype threat[*]
- Low grades leading to perceptions of self-doubt
- Poor time management because of both jobs and academic commitments

A supportive engineering community may counter these factors [12] through the use of an SDT framework. [13] SDT explicates that three basic psychological needs: autonomy, relatedness, and competence, determine motivation within an individual. [13] When these needs are not met, individuals may become demotivated, which may affect the success and retention rates of underrepresented engineering students. On the other hand, the development of knowledge-sharing professional communities may enable women to establish their own personal network of resources, which can, in turn, support their basic psychological needs; hence, intrinsically motivating students to sustain their own personal growth and well-being.

Within the SDT framework, self-efficacy is an essential part of the autonomy component. Additionally, the autonomy construct examines human agency, which refers to the degree to which an individual feels that they are acting of their own volition and choice. In autonomy supportive environments, students find support when they use their own voices; they feel empowered in making their own choices and decisions with regard to their personal and professional development. On the other hand, environments that are controlling (i.e., classroom environments where students feel they have little to no voice or say) or offer few choices for a

[*] Stereotype threat refers to the application of negative stereotypes to women, which results in lowered confidence, self-efficacy, and self esteem (Marra, Rodgers, Shen, & Bogue (2009); Steele & Aronson

students' personal, academic, and professional development may be perceived as amotivating. [14, 15]

SDT defines relatedness as a student's sense of belonging as a member of their personal, academic, and professional communities. With relatedness support, students feel connected to their school and their programs; they develop strong personal and professional networks that they can go to for help and support. Environments that develop and foster interpersonal relationships nurture this psychological need for emotional connections. However, in amotivating environments, students may feel like outsiders - isolated, different, and lonely. [14, 15]

The last psychological need within the SDT framework refers to a student's sense of competence, which pertains to their feeling of knowing what they are doing, or that they can and are able to accomplish a task. Competence is also related to self-efficacy and autonomy, in that if a student feels that they are incapable, or do not know enough, it will discourage their motivation to persist. [14, 15] Conversely, motivating environments provide a variety of resources from which students may draw upon for academic help and support – thus compensating for any feelings of inadequacy by providing strategies for academic and professional success.

NSF S-STEM COMETS project

The goal of the COMETS program was to build a critical mass at RIT of female scholars in Engineering Technology (ET) by recruiting, retaining, and graduating *additional* female students into the ET BS programs. A "critical mass" is defined by Etzkowitz, et al. (1994, p.51) as "the discrete point at which the presences of a sufficient number brings about qualitative improvement in the conditions and accelerates the dynamics of change….and has been defined as a strong minority of at least 15%." [16] At the beginning of this project, the percentage of women in the ET programs was just under 9%. After five years, this has increased to 12 % (an increase in the percentage of women in ET of 33%). This was accomplished through the development of a professional network that could provide support to the basic psychological needs of autonomy, relatedness, and competency within the SDT framework.

The COMETS project strategies to achieve critical mass included:

- Mentoring from faculty on topics related to academic success skills, career and graduate school preparation, and work-life balance.
- Ongoing academic and social support and professional skills development through the Women in Technology (WIT) program.
- Connecting the scholars with the existing RIT support network: a well-established, substantial network of support services encompassing areas that included: academic support centers, a Women's Center for health and wellness programming, and various diverse personal and professional interest groups, organizations, and clubs.

Programmatic implementation was data-driven, and supported through program evaluation, which periodically collected student focus group and interview data from 45 scholars during the fall and spring semesters. All participants were women enrolled in ET programs at RIT. The students ranged in age from 18-22. Thirty-seven were in the first or second year at RIT and started at RIT as freshmen. Eight students were third and fourth year students who started at RIT as transfer students from other colleges.

These data were qualitatively analyzed using initial, and later, thematic coding schemes. [17, 18] In the following section, findings compiled from five years of data are presented.

Results

Our results show that COMETS scholars continue to face amotivating factors from within their programs which align with the literature regarding women's' retention in STEM fields. However, scholars also talked about the motivating factors that they received from the program, which seemed to provide support for their psychological needs of autonomy, relatedness, and competence. [13]

Autonomy: The interview and focus group data showed that autonomy was compromised when students felt that they had no choices or voice in their environments. For example, a common complaint among women included being put into all male collaborative groups in their classes, where at least one lab partner exhibited microaggression and negative stereotyping because of the scholar's gender. In some cases, groups would automatically delegate scholars to a "secretarial" role in the group work, or not acknowledge any of her contributions. This was especially prevalent during the first year of their studies, where scholars frequently encountered the negative stereotype that women were incompetent or less capable than their male classmates. Furthermore, because scholars did not want to appear less knowledgeable than their peers, and thus perpetuate these stereotypes, a few shared their reluctance to ask questions in class; even during occasions when they felt that they needed help.

However, our data also show that women learned from WIT workshops, faculty mentors, and female peers on how to speak up for themselves to address the different forms of amotivating situations that they encountered. The WIT workshops also seemed to provide women with professional skills, and gave scholars the confidence to communicate clearly and assertively in both academic and professional settings. Because WIT offered events throughout the year on a variety of topics and activities, scholars were able to pick and choose what they wanted to attend. When possible, WIT events were also flexible, which enabled scholars to fit certain events into their very busy schedules. Mentors also helped scholars become more aware of the organizations and resources that were available at RIT; they provided advice for managing personal and professional development, as well as advocated for their scholars when it was necessary. Lastly, female peers often shared advice amongst themselves on how to deal with microaggression and particular challenges that they faced within the classroom. Hence, these resources provided autonomy support in different ways for COMETS scholars.

Relatedness: From both interview and focus group data, scholars reported several barriers that potentially affected their feelings of belonging to the communities at RIT. For example, many scholars expressed their initial shock at the extreme ratio of men to women in their classes. Oftentimes, scholars reported being in classes where they were the only female, or, at most, one of four or five females in their predominantly male classes. Furthermore, scholars shared experiences of being treated differently in positive and negative ways by both their classmates and faculty, which sometimes led to feelings of isolation. These feelings were sometimes compounded by being away from family and friends while they attended college. Some scholars also reported feeling culturally isolated from their classmates – especially if they came from ethnically diverse populations into the predominately white population at RIT. Furthermore, new scholars in particular reported feeling overwhelmed by their work schedules and the amount of

classwork that they had to complete in the semester. This left little time for socialization, or for reaching out to other sources for support and emotional connection.

Nevertheless, nearly all scholars conveyed strong social needs to connect with others at RIT. These needs were satisfied through meetings with their: (a) mentors and professors; (b) interactions with classmates, hall mates, roommates, and lab assistants; (c) professional organizations outside of ET; and finally, (d) participating in COMETS and WIT events. Several scholars reported the importance of their mentors as a person with whom they could go to for advice and support. In particular, scholars mentioned how they deeply related to their female mentors and female WIT guest speakers because they were not only successful role models, but they also shared similar stories of being female in a predominantly male field. Other scholars mentioned the importance of making connections with upper classmen, fellow classmates, roommates, and peers from which they drew upon for both academic and emotional support. Hence, most scholars were able to create, through initial contact with mentors and WIT, personal networks from which they could turn to for getting the motivating support that they needed.

Competence: Scholars frequently encountered stereotype threat from both their classmates and certain clubs and organizations. One scholar mentioned encountering negative stereotyping from the people in her internship. In her interview, she said, "Probably the hardest part about the [internship] is constantly trying to prove to people that I can do my job." These stereotype threats reiterated the assumption that women were less capable and knowledgeable than the men in their field. Indeed, some scholars reported that stereotype threat was further exacerbated by feeling that they were not adequately prepared for their courses at RIT, and lacked the preliminary knowledge and experiences to be successful. As previously mentioned in the autonomy section, some scholars also expressed a reluctance to get the help that they needed in class, because they did not want to appear incompetent to their classmates.

In response, COMETS provided students with extra tutoring sessions outside of class. Mentors also connected students to various academic resources on campus, as well as encouraged students to go to office hours to get one-on-one help from their instructors. Mentors were instructed to keep track of their scholars' grades and performance, and to proactively counsel them if they felt that their student needed extra support. One scholar mentioned that WIT helped her get better grades because she had people to talk to who understood her situation. Other scholars turned to upperclassmen and peers for support; they formed study groups, which not only helped them complete their assignments, but it also built up their own self-esteem when they were able to help others. As one scholar shared, "I guess I'm more than just a student. I can help be a mentor as well."

Quantitative Evidence: In the first two years of the COMETS program, 15 students were recruited into the program. Six left the COMETS program (40%). However, of the six that left, three continued and graduated from other STEM programs at RIT. Therefore, 60% were retained in STEM programs. In the last three years of the project, thirty additional students were recruited into the COMETS program. Of the 30, 22 have completed or are on track to complete the COMETS program (72%). Four of the eight who have left COMETS are continuing in other STEM majors at RIT (87% have been retained in STEM programs). Faculty mentoring has played a critical role in keeping the women students who left the ET program in STEM majors. Program evaluation also played a role in improving programming for the COMETS program to increase retention.

Since the implementation of the COMETS project, retention rates of women in the Engineering Technology programs at RIT have steadily improved. In 2010, the year the COMETS program started, one year retention rates for women students averaged 80 % across the six ET programs. In 2014, this had increased to 89%. Two year persistence over the same time period has increased from 72% to 85%. This data is for all women in the ET programs. COMETS played a role in improving retention of women in the ET programs at RIT by identifying strategies for retention and working with faculty and the Women in Technology program office to broadly implement these strategies.

Suggestions for WiE programs and Engineering Faculty

Focus group and interview findings from the COMETS project indicate that SDT can inform programmatic implementation as well as provide a useful analytic framework for highlighting areas of improvement to aid in the retention of women in the ET programs at RIT. By reinforcing support and qualities related to competence, relatedness, and autonomy, the three basic psychological needs in SDT may enhance internal student motivation and emotional wellbeing. Based on our findings, we suggest psychological needs support in the following ways:

Relatedness: Connect women with faculty mentors, peer support, and other support systems offered at the institution. Community building activities are important for underrepresented groups, particularly women, to help build interpersonal relationships and personal supportive networks. Provide opportunities for women students to interact with each other and with role models. Connect the students with professional societies and/or groups related to their academic major and personal interests. Convey to faculty in your programs about the disconnect women may feel between the engineering course content and their lived experiences. Promote the use of inclusive and equitable teaching strategies, and address negative stereotyping and microaggression that may be exhibited in the classroom.

Autonomy: Equip women students with the skills to assertively communicate with majority groups in their major, their professors, and potential employers. Provide faculty with the tools necessary to communicate ET curriculum content to best engage underrepresented students. Effectively employ available resources and technology to ensure students are aware of and are utilizing their support network. Communicate to women about how a career in engineering and technology can make an impact on the world. Provide spaces for student input on ways to improve their experiences within their programs.

Competence: Ensure women are aware of the multiple forms academic support offered at the department, college, and university levels. Assist the development of a stronger understanding of their academic discipline through company tours, connection with faculty mentors, guest speakers, and activities to support the faculty utilization of course materials that engage diverse groups and deepen their understanding. Promote their involvement in faculty research projects. Provide guidance to student groups on effective team work strategies. For example, rotating tasks will prevent women from potentially always playing the role of note taker.

Conclusions

From our five-year study of the COMETS program, it was found that although women in ET may encounter the same amotivating factors that affect retention rates as reported in the literature, mentoring and community connections can help mitigate these factors and provide

support for students by way of the SDT framework. In this paper, the specific qualities of SDT that inform programmatic implementation, and provided examples on how they may affect student motivation have been outlined. However, not all programs have the luxury of evaluation through focus group and interview data, which may be time consuming and require additional training for comprehensive analyses. Yet, periodic formative assessment has been instrumental in informing us of the needs of our student population. These needs may be site-specific, and require that programmatic support be flexible and adaptive. The development of an evaluative instrument that can be given to larger populations of students, or is tied to course evaluations that is simple to collect and analyze may provide useful data for programmatic implementation. Furthermore, having an SDT-based framework from which other programs may take and adapt to their sites may also be useful in supporting female students at other institutions.

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