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Determining Strategies for the Embry- Riddle Aeronautical University College of Engineering Faculty to Use to Increase the Retention Rate of Women in their Undergraduate Engineering Programs

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Introduction

This report analyzes and evaluates strategies that could be used to increase the retention rate of undergraduate women engineering students for Embry-Riddle Aeronautical University's (Embry-Riddle) College of Engineering. It recommends strategies that could be easily integrated into the existing engineering programs. Additionally, this report addresses all women and does not specify different strategies for women of color. Much of the reason that women leave the engineering discipline is due to their decreased confidence in a male-dominated culture. This decreased confidence sets in during their very first year and persists while they are a minority in their field. To remedy the gender gap, it is recommended that women be allowed and encouraged to work with each other in the Introduction to Engineering (EGR101) course, and that women are more present in the Engineering Sciences faculty.

Background

Throughout America, only 28% of science, technology, engineering, and mathematics (STEM) students are women.[1] This gender disparity is even more pronounced in Embry-Riddle's undergraduate population, where only 20% of the enrolled students in fall of 2016 were women, which means that only about 1,000 students of the 4,300 under graduate student population are women.[2] According to Dasgupta et al., having a significant gap between the number of female and male students leaves women as the "untapped human capital that, if leveraged, could increase the STEM workforce substantially".[3] Therefore, Embry-Riddle's College of Engineering would benefit from an increase in the number of women who are enrolled in their undergraduate engineering programs.

Unfortunately, Embry-Riddle does not have much control over the external factors that contribute to a woman's choice of major before she applies to and enrolls in college, .

[1] Nilanjana Dasgupta et al., "Female Peers in Small Work Groups," *Proceedings of the National Academy of Sciences* 112, no. 16 (2015): 1.
[2] "Fall Enrollment, All Students: Gender," Embry-Riddle Aeronautical University Office of Institutional Research, 2016.
[3] Ibid., 1.

such as institutional stereotypes, family pressure, and quality of previous STEM education. The $5,000 "Woman of Excellence" scholarship is helpful, and it makes sense that by providing financial assistance to women, they will be more compelled to attend Embry-Riddle. Therefore, this report focuses on ways to increase the retention rate of women in Embry-Riddle's undergraduate engineering programs, instead of the enrollment rate. In addition to offsetting the disproportionately small number of women in these programs, increasing the retention rate would contribute to higher tuition revenues, as well as Embry-Riddle's national ranking.[4]

Resources

The research included in this report is a combination of scholarly articles, some of which include primary research, and data gathered by both Embry-Riddle's Office of Institutional Research and Smith College's Office of Institutional Research. The scholarly articles were published in the Proceedings of the National Academy of Sciences, Journal of Engineering Education, ILR Review, Sex Roles, and the International Journal of Applied Engineering Research. Of those, all except the article published in the ILR Review conducted their own research through experiments or surveys. The article published in the ILR Review analyzed information from the "2003 and 2010 National Survey of College Graduates."[5] The information from Embry-Riddle's Office of Institutional Research is in the form of raw data, which is synthesized with the other research so that the conclusion and recommendations are tailored specifically to Embry-Riddle.

Scope and Limitations

This report addresses methods that could potentially be used to increase the number of female undergraduate engineering students at Embry-Riddle. The report does not perform a cost analysis of these methods. While the report addresses women as a whole and does not specifically address women of color, it is implied that the recommendations can be applied to all women as well as to women of color. Much of the reason that women tend to leave engineering programs is due to their presence as a negatively-stereotyped solo, which is also the case of women of color, due to Embry-Riddle's undergraduate population being comprised of 54% white students.[6]

Additionally, Embry-Riddle's Office of Institutional Research does not specify whether students who leave their original engineering program switch to another engineering program, or leave the college of engineering altogether. However, according to Hunt, women are more likely [than men] to leave STEM fields altogether, as opposed to switching between, for example, mechanical and electrical engineering.[7] Therefore, it is assumed that the attrition rates consist mostly of women who are leaving the college of engineering.

Literature Review

The current research surrounding the topic of women in engineering and other underrepresented STEM fields acknowledges the gender gap and examines factors that could be causing this gap, as well as specific methods for how to increase the number of women in these fields. However, to increase the number of women working in engineering jobs, the first step is to increase the number of women who graduate with engineering degrees.

[4] Joseph Raelin et al., "The Gendered Effect of Cooperative Education," *Journal of Engineering Education* 103, no. 4 (2014): 3.
[5] Jennifer Hunt, "Why Do Women Leave Science and Engineering?" *ILR Review* 69, no. 1 (2016): 3.
[6] Nilanjana Dasgupta et al., "Female Peers in Small Work Groups," *Proceedings of the National Academy of Sciences 112, no. 16 (2015): 1*; "Fall Enrollment, All Students: Ethnicity," Embry-Riddle Aeronautical University Office of Institutional Research, 2016.
[7] Jennifer Hunt, "Why Do Women Leave Science and Engineering?" *ILR Review* 69, no. 1 (2016): 2

That is what most of this research is focused on; it gathers information mostly from undergraduate-level college students and tests methods that apply to them.

According to Jagacinski, much of the difficulty women face in engineering courses is not the subject matter itself; it is their own perception of their ability.[8] Women do not perceive themselves to be as capable as they truly are. Therefore, women are discouraged from pursuing engineering. The lack of mentorship tailored to women simply adds to the idea that women should not be engineers.[9] However, when mentorship and support is offered, "female undergraduate engineering students in their first and second years [take] significantly more advantage of the support provided to them through friends, professional clubs, and the university [than any other group of students]".[10] This shows that women are willing to work hard to become engineers if they know that they are supported and have a chance at success. However, their drive is undermined without the necessary support.

In addition, the study conducted by Jagacinski indicated that women do not lack interest in engineering; they actually find engineering courses more enjoyable than men.[11] Although it may be a reason that some women leave engineering fields, a lack of interest is not inherent to women as a whole. This is further supported by a study conducted by Youn, which cites "sociocultural factors" as being one of the main reasons women leave engineering. This includes, but is not limited to, a male-dominant culture, glass ceiling barriers, and society's prejudice against female engineers, all of which contribute to low self-confidence in women.[12] Unfortunately, combined with the high standards women set for themselves, their feelings of inadequacy persist throughout their career and may ultimately cause them to leave the field altogether.[13]

Male Dominant Culture

In addition to a lack of self-confidence, a significant reason that women leave engineering can be directly attributed to their presence as a minority. According to Hunt, the gender gap in engineering is significantly larger than most other fields, with the interesting exception of economics and finance.[14] The work done by people in these two fields shares very little similarities. This implies that many women choose to leave these fields because of the predominance of men, as opposed to the type of work that is required of them. Additionally, before women believe that they are equally as competent as men, they must continually outperform those men. Even though women had higher academic achievement levels than their male counterparts, they "rated their academic abilities lower than did male engineering students."[15] This is all due, in part, to the untrue cultural belief that men are more naturally gifted with regards to STEM fields. The effect of a male-dominant environment is further studied by Dasgupta et al.; when women are asked to do group work with a group which is made up of 50% men, they interpret the group environment as more "threatening" and are less willing to share their ideas. In groups that are made up mostly of other women, they feel challenged in a more positive way. These

[8] Carolyn Jagacinski, "Women Engineering Students," *Sex Roles* 69, no. 11 (2013).
[9] Jennifer Hunt, "Why Do Women Leave Science and Engineering?" *ILR Review* 69, no. 1 (2016): 17
[10] Joseph Raelin et al., "The Gendered Effect of Cooperative Education," *Journal of Engineering Education* 103, no. 4 (2014): 17.
[11] Carolyn Jagacinski, "Women Engineering Students," *Sex Roles* 69, no. 11 (2013): 8.
[12] Jong Tae Youn and Song Ah Choi, "Factor Analysis for Women in Engineering Education," *International Journal of Applied Engineering Research* 11, no. 8 (2016): 4.
[13] Carolyn Jagacinski, "Women Engineering Students," *Sex Roles* 69, no. 11 (2013): 11.
[14] Jennifer Hunt, "Why Do Women Leave Science and Engineering?" *ILR Review* 69, no. 1 (2016): 6.
[15] Carolyn M. Jagacinski, "Women Engineering Students," *Sex Roles* 69, no. 11 (2013): 2.

effects are significantly more pronounced during the first year of undergraduate education.

Embry-Riddle's Office of Institutional Research also provides some valuable data. For example, from Figure 1 (below), it is possible to see that the change in the attrition rates of men and women in the undergraduate engineering programs are not significantly different. However, because women are already so underrepresented, the difference in their attrition rates has a much larger impact. It is also worth noting that the change in the women's attrition rates after the second year is significantly less than between the first and second years, and continues to decrease afterwards, which suggests that once women have established themselves in the field, they are less likely to leave. Additionally, Hunt states that men are more likely to involve themselves in another STEM field, whereas women are more likely to leave STEM altogether, which supports the idea that while men may be switching between engineering fields, women are more likely to make a complete departure from engineering.[16] Although Smith College's Office of Institutional Research contains different information than that of Embry-Riddle, it is important to note the distinct change in retention rates. Smith College has an all-women engineering program, and the school as a whole has a retention rate of 94%.[17] Although the retention rate specific to their engineering program is not given, it can be assumed that the data for the college can be reasonably applied to the engineering program as well. This is a much higher retention rate than Embry-Riddle, and although there may be other factors, it is worthwhile to consider the gender difference as influencing the retention rate.

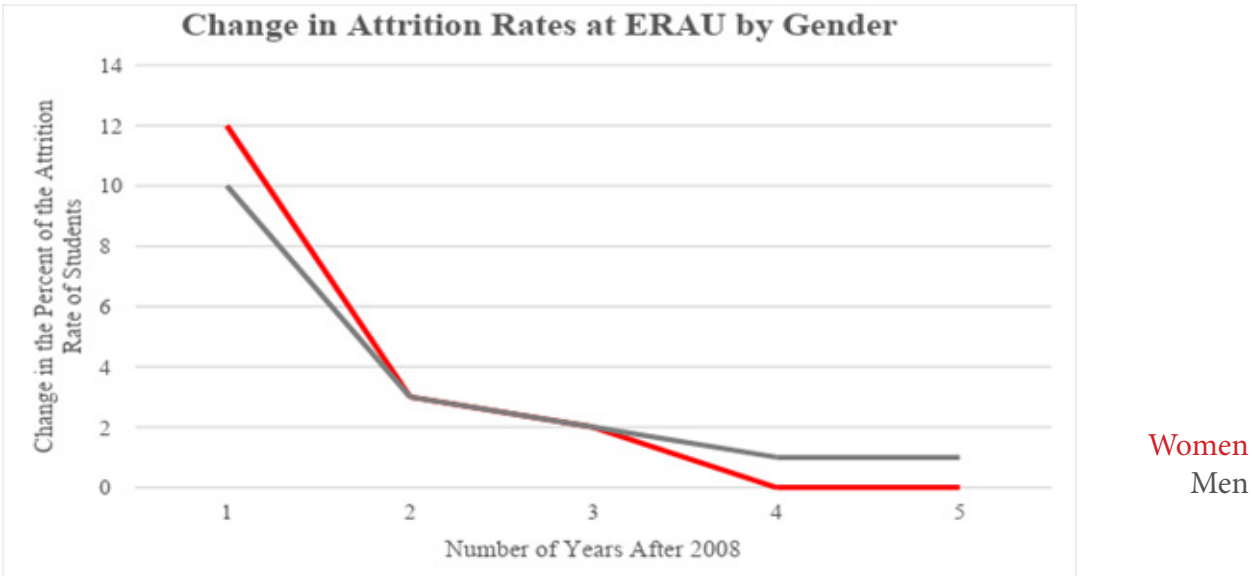

Figure 1: Change in the percent of an original group of students who either left their degree program or left ERAU after a certain number of years, by percent (ex. between their first and second years, 12% more women and 10% more men were not enrolled in their same degree program, or ERAU altogether). Adapted from Embry-Riddle Aeronautical University Office of Institutional Research.

[16] Jennifer Hunt, "Why Do Women Leave Science and Engineering?" *ILR Review* 69, no. 1 (2016): 2.
[17] "Common Data Set," Smith College Office of Institutional Research, 2014: 5.

Analysis

Using this information, it can be determined that in order to convince more women to stay involved in engineering, the effects of being a "token" in a male-dominated culture should be lessened as much as possible. As can be seen in the study done by Dasgupta et al., only women who are part of a female majority are able to "deflect stereotypes," accept the challenge of their work, and participate more actively.[18] Therefore, an environment which is made up of at least 50% males has a negative effect on women's self-confidence and willingness to participate. Embry-Riddle's environment, being made up of 80% males, clearly falls into a category where women do not have the benefit of being surrounded with other women.[19]

The negative effects this could have on women's desire to persist are clear. With a lowered amount of self-confidence due to the predominantly male atmosphere, women tend to rely on support from each other and from women faculty members.[20] If this contextual support is lacking, women will tend to drop out of school or change their major. Additionally, because "women are more likely to switch out of engineering during the first 2 years," much of this support must be able to reach women within their first semesters attending college, when they are at the highest risk of attrition from engineering programs.[21] The opposite effect can be seen in Smith College's all-women engineering program.[22]

The first two years of many Embry-Riddle engineering students' curriculum include introductory courses as well as courses which teach the basic science behind engineering. EGR101 is generally taken by freshman, and it is often their first real experience with engineering processes. The course also requires a great deal of group work, although the exact amount varies by instructor and engineering discipline. The Engineering Science (ES) courses are often taken during students' sophomore years and include Statics, Dynamics, Thermodynamics, and Solid Mechanics. Both of these are prime locations for women to be impacted.

Findings

Although on the surface there may seem to be many reasons that women do not continue with undergraduate engineering programs, they can all be combined into one series of events. Women who have chosen to study engineering enter college and are immediately singled out as being one of a few of their gender. Combined with the cultural stereotype that women are not traditionally involved in engineering, the male-dominant atmosphere causes women to interpret this new environment as threatening, and their self-confidence plummets, even if they thoroughly understand the material and are outperforming their male classmates on graded assignments. This lower self-confidence eventually causes women to leave engineering altogether, instead of trying to persist in a field which they believe is not right for them. However, this process can be avoided if the women's environment is made up of at least 50% women, or if they are receiving strong support from peers and faculty. Additionally, if women remain in the engineering discipline after their second year of college, they are far more likely to graduate with an engineering degree.

[18] Nilanjana Dasgupta et al., "Female Peers in Small Work Groups," *Proceedings of the National Academy of Sciences* 112, no. 16 (2015): 5.
[19] "Fall Enrollment, All Students: Gender," Embry-Riddle Aeronautical University Office of Institutional Research, 2016.
[20] Joseph Raelin et al., "The Gendered Effect of Cooperative Education," *Journal of Engineering Education* 103, no. 4 (2014): 17.
[21] Carolyn M. Jagacinski, "Women Engineering Students," *Sex Roles* 69, no. 11 (2013): 1.
[22] "Common Data Set," Smith College Office of Institutional Research, 2014.

Recommendations

Based on the research, it is recommended that Embry-Riddle's College of Engineering should:

- Target first- and second-year undergraduate students.

- Place female students into female-dominated groups in the EGR101 course. By doing so, the women will feel like they can contribute more to the project, and will feel more rewarded when the project is complete. This does not have to be the case for all projects, however, if a woman is assigned solely to male-dominated groups, she may feel less confident of her abilities and less likely to continue with engineering.

- Encourage the presence of women as faculty members and professors in the ES courses. Much of the faculty of the Engineering Fundamentals (EGR) courses are women. This is good because most students take EGR courses within their first year, and it gives the women in those courses support as well as role models within their disciplines. However, the presence of women in the faculty of ES courses would help significantly as well. By continuing to provide faculty support and role models into the second year of women's education, the women will be more likely to continue working towards an engineering degree.

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