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Women's Leadership in Engineering: Defying Bias

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Abstract*– Globally, women are underrepresented in leadership positions in the workforce, and the gender gap is more prominent in male-dominated fields like engineering. We used a questionnaire to investigate the main barriers and assistance women and men in engineering have in their path to leadership. A total of 79 responses that met the inclusion criteria were analyzed. We found that balancing work and home life, devaluing their achievements, and discouragement from peers and superiors are the main barriers to leadership for both genders. Notably, women were about 5 times more likely to experience blatant gender bias and 4 times more likely to receive disparaging comments about their gender than men. 80% of women and 10% of men reported having experienced gender bias at work. This study shows that holding a leadership position in engineering can be more challenging for women than for men because of gender bias and highlights the importance of a positive working environment to promote leadership in women and contribute to gender equality.

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***Abstract*– Globally, women are underrepresented in leadership positions in the workforce, and the gender gap is more prominent in male-dominated fields like engineering. We used a questionnaire to investigate the main barriers and assistance women and men in engineering have in their path to leadership. A total of 79 responses that met the inclusion criteria were analyzed. We found that balancing work and home life, devaluing their achievements, and discouragement from peers and superiors are the main barriers to leadership for both genders. Notably, women were about 5 times more likely to experience blatant gender bias and 4 times more likely to receive disparaging comments about their gender than men. 80% of women and 10% of men reported having experienced gender bias at work. This study shows that holding a leadership position in engineering can be more challenging for women than for men because of gender bias and highlights the importance of a positive working environment to promote leadership in women and contribute to gender equality.**

I. Introduction

Worldwide across history, gender-based occupational segregation has persisted due to stereotypes, traditional gender roles, social and cultural expectations, as well as educational and training paths. According to data from LinkedIn, women are overrepresented in health care and care services (64.7%) and education (54%) and underrepresented in science, technology, engineering, and mathematics (STEM) (29.2%) [1]. STEM jobs are well-remunerated and growing in demand, so the gender gap puts women in a disadvantageous position with respect to future professional opportunities. In addition, a "glass ceiling" prevents women from advancing to higher levels of leadership within an organization. LinkedIn data from 2023 shows that women account for 41.9% of the workforce, but the share of women in senior leadership positions (director, vice president, and C-suite) is 32.2% [1]. With respect to STEM fields, women are 29.4% of employees at the entry level and 29.9% at senior positions. However, the share of women in leadership positions drops: manager (25.5%), director (26.7%), vice-president (17.8%), and C-suite (12.4%) [1]. A leaking pipeline is observed that reduces the presence of women in top leadership positions, which is more prominent in STEM fields.

Several studies in different countries have analyzed the factors affecting female engineering leadership. Some of the most recent works are described next. Using qualitative interviews, Schmitt analyzed the role of social support for women leaders in engineering fields in Germany [2]. The results show that a masculine culture and "engineering habitus" make it difficult for women to feel part of the working environment, and adapting while keeping their feminine identity can be challenging. In this process, social support from the partner, supervisors, role models, colleagues, and networks is essential to receive emotional assistance, motivation, and advice to avoid conflicts and defend against gender stereotypes [2].

A study with Brazilian engineering students found that female students perceive gender disparities in opportunities, income, and social mobility in engineering careers [3]. In addition, unlike men, women in leadership positions are expected to be kind because of the stereotypes, and at the same time, confident and assertive to fulfill the role requirements [3]. This imposes more pressure on women leaders. Students consider that the development of knowledge, know-how, and interpersonal skills contribute to women's preparation for leadership positions.

To identify the barriers and promoters of women's leadership, McCullough did a study in the US with women in STEM holding academic leadership positions [4]. The results show that the main barriers to women's leadership are balancing work/home life, undervaluing of their achievements, and imposter syndrome. On the other hand, the main assistance and encouragement for women comes from their partners and peers, not from their institutions [4]. Similarly, a study by Hickey and Cui found that factors that promote leadership in women are support from their partners, early mentoring, and motivation [5]. This study was developed in the US with 20 women holding senior leadership positions in architecture, engineering, and construction.

In Latin America, STEM fields are essential to promote technological and socio-economic development, but the persistent gender gap threatens progress advancements by excluding valuable perspectives and talents. A study developed in 2020 in nine Latin American universities found that women were only 27.8% of the total population of engineering students [6]. The participation of women in STEM is required to ensure diverse and inclusive environments that sustain innovation and fight bias in science and technology. To contribute to gender equality in engineering, in 2020, the Matilda Latin American Open Chair (CAL Matilda) was established as a joint initiative of the Colombian Association of Engineering Faculties (ACOFI), the

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Argentinean Federal Council of Deans of Engineering (CONFEDI), and the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI). The main purposes of CAL Matilda are to promote equal rights, opportunities, and spaces for women in engineering and to attract girls and young women to engineering fields. In CAL Matilda several studies and activities have been developed to measure gender gaps in engineering, investigate the factors that sustain inequality, highlight the achievements of women in engineering, and develop strategies to contribute to gender equality.

One of the objectives of the fifth sustainable development goal is to ensure women's equal opportunities to access to leadership roles across all levels of decision-making. The importance of women's leadership extends beyond individual success. Women leaders in STEM serve as role models for girls and young women, promoting their participation in these fields. In addition, a previous study developed in Australia reported a positive relationship between women's leadership and increased appointment and promotion of women in engineering and construction [7]. Therefore, breaking the "glass ceiling" can be a strategy to reduce gender gaps. Identifying and removing barriers to women's leadership is fundamental, especially in male-dominated fields. This paper describes a study developed by the research committee of CAL Matilda with the purpose of investigating the barriers that women in engineering experience on their path to leadership positions. We applied a questionnaire to leaders in the engineering field in Latin America to identify their main challenges and sources of support.

II. Materials and Methods

This study is proposed from a cross-sectional perspective. The data was collected using a self-reported questionnaire in October 2023.

A Participants

Professionals working in the fields of engineering with experience in leadership positions were invited to participate in this study through social media.

B. Data collection instrument

The instrument developed by McCullough [4] was translated into Spanish and adapted as described next. The word STEM was replaced by engineering, to be more specific. Some questions were removed to keep the questionnaire short. We added one question about years of professional experience. Neither the names nor contact information of the participants were collected. Two researchers read the questions to assess clarity, conciseness, and writing style. The suggested modifications were incorporated.

The final questionnaire had a total of 15 questions, including open-ended, single-choice, and multiple-choice questions on the following topics:

1) Demographic questions: country of residence, biological sex, academic background, years of professional experience, career field (academy, industry, etc.).

2) Leadership questions: past and current experience in leadership positions, the title of the role and functions, barriers, assistance, intention to leadership, and general comments.

C. Data collection and preparation

The questionnaire was activated to receive responses and distributed using social media. The participants gave their informed consent. At the time of analysis, a total of 92 responses were collected. The inclusion criteria were:

1) Having a career in engineering or a related STEM field.

2) Being in a leadership position or having had a leadership position.

3) Living in a Latin American country.

Thirteen responses were discarded because they did not meet the inclusion criteria. A total of 79 responses were analyzed.

III. Results and Analysis

A. Demographics

Figs. 1 and 2 show the shares of women and men in the sample and their country of residence.

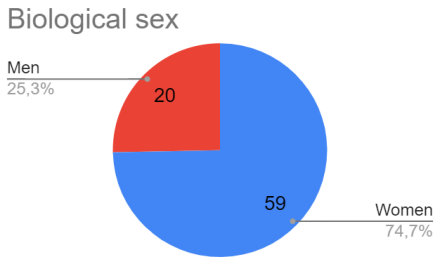

Fig. 1 Share of men and women in the sample.

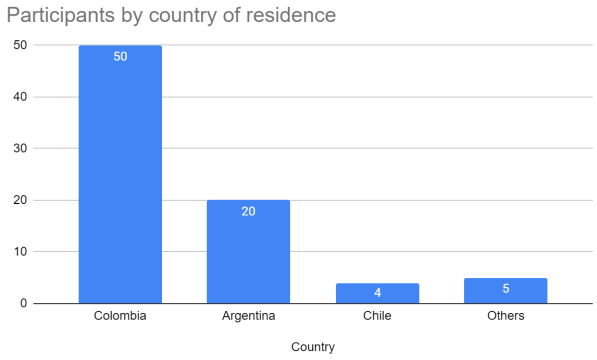

Fig. 2 Participants by country of residence.

The sample was composed of 59 women and 20 men. Most participants are from Colombia and Argentina, and we received some responses from Chile, Ecuador, Honduras, and Costa Rica.

Figs. 3 and 4 show the years of professional experience and career field. The sample includes people from entry-level to senior positions. 51% of the participants have more than 20 years of experience. With respect to the career field, 72% of the participants (57 responses) are in the academy (higher education or lifelong learning), 22% are in the industry (17 responses), one person is in a research lab/center, and four persons are in the government.

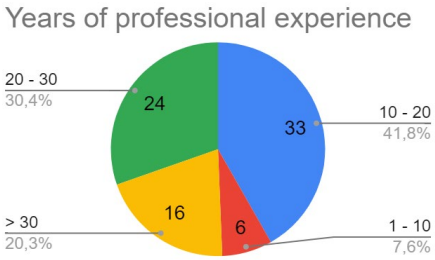

Fig. 3 Years of professional experience.

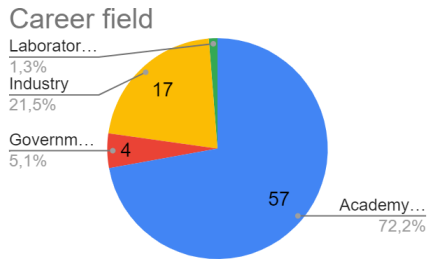

Fig. 4 Career field.

Figs. 5 and 6 show the current leadership positions or the highest leadership positions held by women and men. The most common roles for women are dean, program director, project manager, and vice-dean. In the case of men, the most common roles are research group director, dean, coordinator, and vice-dean.

B. *Factors that influence leadership*

Figs. 7 and 8 show the barriers women and men face in their path to leadership. The most common barrier for both genders is balancing work and home life. This factor was selected by 61% of women and 85% of men. The next two factors are the devaluing of their achievements, which was selected by 42% of women and 40% of men, and discouragement from peers and superiors, chosen by 55% of men and 42% of women. The imposter syndrome was chosen by 42% of women and 40% of men, and microaggressions by 32% of women and 25% of men. Four women and one man reported having experienced sexual harassment at work.

Fig. 5 Women's leadership roles.

Fig. 6 Men's leadership roles.

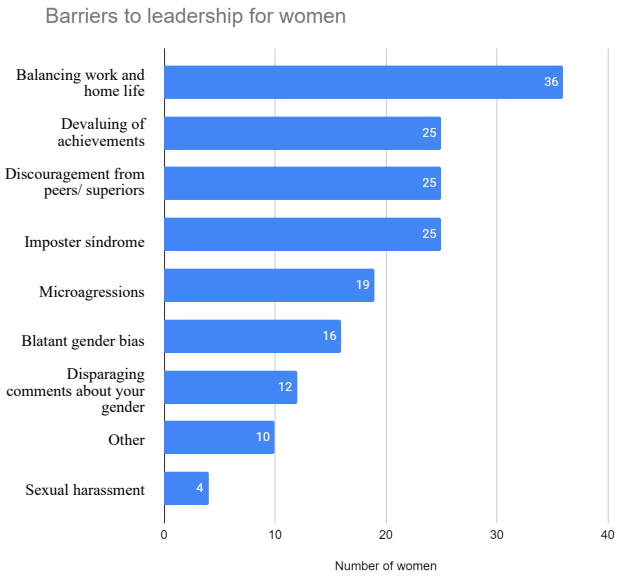

Fig. 7 Barriers to leadership for women.

There are several differences between women and men regarding the barriers to leadership. The most notable is that 16 women (27%) and only one man (5%) reported blatant gender bias as a barrier to leadership. Another difference is that the share of women who reported having received disparaging comments about their gender is four times the share of men (20% vs 5%).

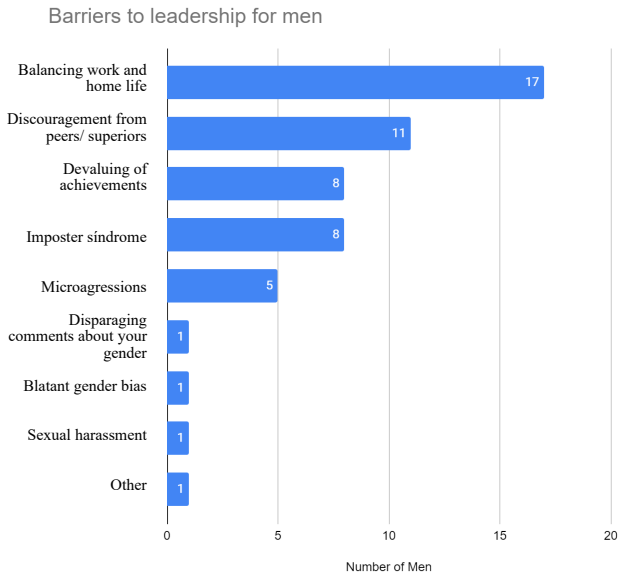

Fig. 8 Barriers to leadership for men.

In the "other" section, women mentioned ageism (discrimination for being too young), origin discrimination, workplace disregard, mansplaining, exclusion, ethnic discrimination, and workplace harassment. With respect to men, only one selected "other" and wrote "envy from peers."

Fig. 9 shows the assistance that the participants have received in their careers. The most important support comes from the family and the partner. Then, encouragement from peers, sponsorship/financial support, and encouragement from superiors.

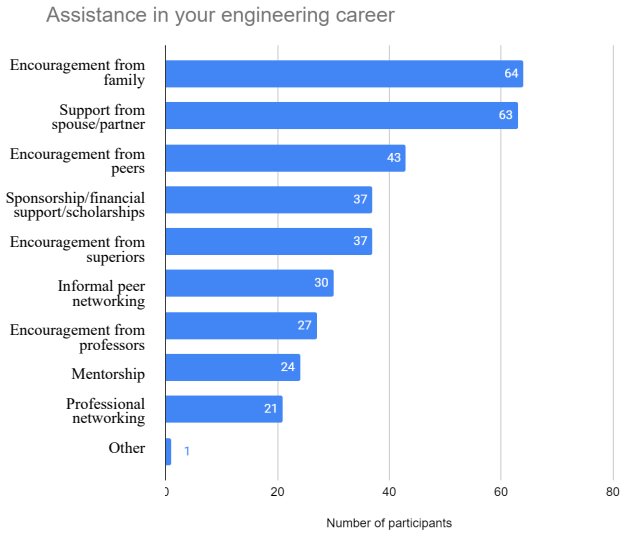

Fig. 9 Assistance received throughout the engineering career.

Table I shows the reported gender bias experiences. Three men selected "other" and commented: "I have not suffered gender bias, but I have seen it applied in corporate practices without being able to do much about it," "lack of credibility in my work due to my origin," and "I haven't had any problems." One woman selected "other" and wrote, "I have not experienced gender bias, but I have experienced age bias." In all these cases, the participants stated that they had not experienced gender bias.

TABLE I
GENDER BIAS EXPERIENCES

Which of the following best describes your experience in engineering and leadership?	Women	Men
Dealing with gender bias in engineering helped me deal with gender bias as a leader	**26**	1
Dealing with gender bias in engineering did not prepare me for gender bias as a leader	5	1
I have not experienced gender bias as a woman in engineering, but I have as a leader	7	-
I have not experienced gender bias as a leader, but I have as a woman in engineering	9	-
I have not experienced gender bias either as a leader or as a woman in engineering	**6**	-
I have not experienced gender bias in my professional career	**5**	**15**
Other (please explain)	**1**	**3**

Notably, most of the men, 18 out of 20 (90%), and a small number of women, 12 out of 59 (20%), have not experienced gender bias in the working environment. In other words, 80% of women in engineering in leadership positions have experienced gender bias in their careers. Seven women reported not having experienced gender bias as women in engineering but having experienced it as leaders. In some cases, women leaders seem to be more exposed to bias than other women in engineering. The most common gender bias experience reported was dealing with bias as women in engineering prepared them to deal with gender bias as leaders, chosen by 26 women (44%).

When asked about leadership aspirations, it's interesting that men are more inclined to pursue leadership roles at an earlier age. 55% (11 out of 20) of men and 39% (23 out of 59) of women stated having always planned to move up into leadership positions. Some women start considering taking leadership positions as they advance in their careers. About one-third of the women and one-fourth of the men never planned to go into leadership.

TABLE II
LEADERSHIP ASPIRATION

When did you consider taking a leadership position?	Women		Men	
I've always planned to move up into leadership	23	39%	11	55%
In my late career	3	5.1%	0	0%
In my mid career	8	13.6%	2	10%
In my early career	4	6.8%	1	5%
I never planned to go into leadership	20	33.9%	5	25%
Other (please explain)	1	1.7%	1	5%

IV. Discussion

Previous studies show that women in engineering and other STEM fields around the world report multiple barriers to accessing leadership positions: masculinized culture, gender inequality, work-life balance, devaluing of achievements, imposter syndrome, and gender bias, among others. Our study investigated the factors that affect and promote leadership in women and men in engineering fields. We used the instrument proposed in McCullough's study that was applied in the US [4]. That study included 62 women in academic leadership positions in STEM. Our results agree with [4] that the two most common barriers for women in leadership are balancing work and home life and devaluing their achievements. On the other hand, US women leaders reported experiencing imposter syndrome more frequently (65%) compared to Latin American women (42%).

Both studies demonstrated the importance of support from the partner in the path to STEM. It was the most common assistance reported by US participants and the second for Latin American participants. In Latin America, the first assistance is the encouragement from the family. In the US study, the second assistance reported was encouragement from peers.

Regarding the interaction of bias in STEM and leadership, 72% of US women and 44% of Latin American women reported that dealing with gender bias in STEM had helped them deal with gender bias as leaders. There is a notable difference between the two studies regarding the percentage of women who have not experienced gender bias; in McCullough's study, it is 2%, and in our study, it is 20%.

Although the figure is not as high as in [4], a significant proportion of women engineers in leadership positions (80%) reported having experienced gender bias in the workplace. Additionally, women have had to tolerate discrimination based on their origin, race, and age, workplace disregard, mansplaining, exclusion, and workplace harassment. All of these behaviors affect women's well-being at work and discourage them from advancing in their careers and assuming leadership positions. This is serious considering that our study suggests that women have less intention to assume leadership positions than men, and discouraging those who do have the intention may widen the gender gap.

A positive workplace climate with assertive leaders is fundamental to preventing women from opting out of male-dominated fields such as engineering. A recent study by Spoon et al. with US tenure-track and tenured professors found that women leave the academy more often due to workplace climate (43%) than because of reasons related to work-life balance (29%) [8]. In our study, the most common barrier for women and men on their path to leadership was work-life balance, followed by the devaluing of achievements and discouragement from peers and superiors. Considering that work-life balance can be affected by organizational factors such as high job demands, inflexible hours, and limited job resources [9], it is fundamental for organizations to identify and address the factors that negatively influence workplace climate to promote women's persistence and promotion. A study developed by Stamarsky and Hing showed that gender inequalities in an organization that affect women's hiring, training, remuneration, and promotion stem from structures, processes, and practices rooted in the organizations, and decision-makers play a critical role in gender discrimination and sexism practices [10]. At the individual level, people can develop strategies to combat discrimination and bias, but these can be constrained by the organization. Therefore, the most effective strategy to promote gender equality is through collective action [10].

This work highlights the factors that affect women's leadership. The main limitations of our study are the sample size and that the dataset is not balanced. We expect to obtain more data from men and leaders engineers working outside the academy and include representation from other Latin American countries for future work.

IV. Conclusions

The promotion of women to leadership positions in engineering can be an effective strategy to provide role models that encourage young women to pursue a career in STEM. Additionally, women leaders can foster the appointment and promotion of other women in their organizations. This study shows that most women leaders (80%) have experienced gender bias and other negative attitudes and behaviors from peers and superiors, such as devaluing their achievements, discouragement, microaggressions, mansplaining, disregard, discrimination, exclusion, ageism, and sexual harassment. In contrast, only 2 out of 20 (10%) men reported having experienced gender bias in their workplaces. Women can manage and even get used to gender bias and advance in their careers, but it does not mean that a change is needed. It has been demonstrated that positive working environments can help people to feel more engaged and motivated, which leads to improved productivity, persistence, and overall well-being. In addition, as suggested by this study, a respectful and inclusive working climate can break the barriers and encourage leadership intention in women.

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