Exploring the Impact of Program Name Change on Gender Diversity in STEM

Introduction

Gender disparities persist as a significant challenge within the Science, Technology, Engineering, and Mathematics (STEM) disciplines, drawing attention to the urgent need for targeted interventions. Of particular concern is the underrepresentation of women in engineering fields because, as of 2020, they earned only approximately a quarter of engineering degrees at the bachelor's, master's, and doctoral degree levels [1]. Recognizing this issue, this research delves into a specific aspect of gender disparity, that is, understanding the potential influence of program nomenclature on the gender balance of applicants in undergraduate research programs.

It is evident that STEM fields are pivotal in driving innovation and technological advancements. Yet, the persistent gender gap undermines the diversity and creativity vital for sustained progress. Efforts to address this gap often focus on systemic issues such as biased curricula, lack of mentorship, gender stereotypes, and early interventions [2], [3]. However, the impact of subtle factors, such as the names of STEM educational research programs, remains a relatively underexplored topic. Therefore, this concise research paper investigates the hypothesis that changing the name of an undergraduate research program can influence the gender distribution of applicants. Specifically, we examine the transition from "*Nanotechnology REU with a Focus on Community Colleges*" to "*Climate and Sustainability Research in Nanotechnology and Electrochemical Devices for Community College Students*" [Climate and Sustainability REU for short] within the field of engineering research experience for undergraduate students. Understanding the implications of program nomenclature in attracting women to STEM fields is crucial for developing effective strategies to promote inclusivity. By exploring this aspect, we aim to contribute to the broader conversation on fostering gender diversity in STEM education and ultimately creating a more equitable and inclusive environment.

Literature Review

The existing body of literature addressing gender disparities within STEM fields consistently highlights the underrepresentation of women, particularly in fields like engineering. Studies have delved into the factors that contribute to this gender gap, including stereotypes, biased curricula, and limited mentorship opportunities [2], [3], [4]. Additionally, research reveals that females exhibit lower levels of interest, persistence, and inclination toward STEM fields [5]. Furthermore, women's career choices in STEM are influenced by their preference for people-oriented work environments, as opposed to things-oriented work environments [6]. However, if women enter STEM, they encounter numerous barriers and challenges that impede their professional growth, limiting the overall diversity of STEM teams [7], [8].

Efforts to address the shortage of females in STEM careers include various programs designed to spark interest [7], [9] - [11], as well as professional societies aimed at supporting women's retention and professional development in STEM [12] - [14]. While extensive work is being done, it is imperative to look at subtle factors also that may have a lasting impact on

gender distribution in STEM fields. Therefore, this study seeks to explore program nomenclature's impact on gender distribution and contribute to the broader understanding of gender dynamics within STEM.

Methodology

Data were collected over three consecutive academic years from a Research Experience for Undergraduates (REU) program. The first two years represented the application cycle for "*Nanotechnology REU*." In the following year, the program underwent a name change to "*Climate and Sustainability REU*." All program components remained the same before and after the name change, including the research topics, faculty members, and the duration of the program. After the name change, the REU webpage and the recruiting materials, including new social media posts, were updated with the new title. To gather data for the study to compare the gender distribution of applicants between "*Nanotechnology REU*" and "*Climate and Sustainability REU*," we gathered gender information from the applications submitted. We retrospectively looked at submitted applications and retrieved gender information, which was then analyzed, as detailed below.

Data Analysis

For the years 2021 and 2022, during "*Nanotechnology REU*," we had 176 applicants; 95 self-reported to be male, and 74 self-reported to be female. For the year 2023, "*Climate and Sustainability REU*", we had 43 applicants, with 21 male and 22 female students. To determine the statistical significance of any observed differences in gender distribution, a two-sample proportion test was conducted using R programming. The test compared the proportion of female applicants in the "*Nanotechnology REU*" to that in the "*Climate and Sustainability REU.*" A *p*-value was calculated to assess the likelihood of obtaining the observed results due to random chance. This was followed by another two-sample proportion test within each applicant pool to examine the gender distribution in further detail. The expected gender distribution was set at 50% for both male and female applicants. The proportion test allowed us to assess the significance of any deviation from the expected 50/50 distribution. By employing this methodology, we aimed to look into the role of program nomenclature in influencing the gender composition of applicants in STEM education, with a particular emphasis on engineering research programs for undergraduates.

Findings

In the "*Nanotechnology REU*," there was an initial gender disparity, with fewer female applicants compared to male applicants, see Table 1. Following the transition to "*Climate and Sustainability REU*," there was a shift, with the number of female applicants increasing to nearly match the number of male applicants.

Table 1.

Number of Applicants for Each Program Based on Gender

	Male	Female	Not provided	Total

Nanotechnology REU	95	72	7	174
Climate and Sustainability REU	21	22	0	43

A two-sample proportion test comparing the overall gender distribution between " *Nanotechnology REU* " and "*Climate and Sustainability REU* " yielded a p-value of 0.149. This indicated insufficient evidence to claim a significant difference in the proportions of female applicants between the two programs (χ^2= 1.08, p=0.149).

Further in-depth analysis of each program yielded some unexpected results. It is expected that 50% of applicants will be male applicants and 50% will be females. However, within the "*Nanotechnology REU*" applicant pool, an unexpected gender distribution was observed as the proportion of female applicants was significantly lower than the expected 50%, yielding a p-value of 0.042. This finding suggests that, despite the anticipated equal gender distribution, "*Nanotechnology REU*" had a lower-than-expected number of female applicants, indicating a potential issue in attracting women to this specific program.

Discussion

The findings of this study provide insights regarding program nomenclature within the context of undergraduate research programs in engineering. While the overall comparison between the two program names, "*Nanotechnology REU*" and "*Climate and Sustainability REU*," did not yield statistically significant differences in the gender distribution of applicants, a deeper analysis within "*Nanotechnology REU*" revealed a discrepancy from the expected 50/50 gender distribution. The lower-than-expected number of female applicants in "*Nanotechnology REU*" suggests that program naming might play a role in shaping students' decisions regarding pursuing STEM fields. The observed positive shift in female applicants following the transition to "*Climate and Sustainability REU* " indicates that altering the name can have an impact, albeit a little. Therefore, we will continue to monitor the applicants in the next few years and see if this trend continues.

However, there are several limitations that should be addressed. Firstly, the data for " *Climate and Sustainability REU* " only span a single year, limiting the validity of the conclusions drawn. As we continue to collect data and finalize applicants for the 2024 cycle, we will reassess these numbers to ascertain the observed trends. Moreover, recruitment for the "*Climate and Sustainability REU*" cycle in 2023 began much later than normal recruitment for research experience programs due to funding decisions that came later than expected, which impacted the overall application numbers. Additionally, this study only considered completed applications and not incomplete applications. There were a significant portion of applications that were incomplete. Future research endeavors could delve into the gender composition of incomplete applicants as well to provide an understanding of gender disparities between application completion and program interest. By addressing these limitations, future studies can further look at program nomenclature and student involvement in STEM fields.

Conclusion

While the overall comparison between the two program names did not reveal statistical significance, the in-depth analysis within "*Nanotechnology REU*" underscored a significant

gender difference. The study highlights the nuanced influence of program nomenclature on gender diversity in STEM education. The shift observed in "*Climate and Sustainability REU*" indicates that a name change alone may not be sufficient but could contribute positively. The findings emphasize the importance of program nomenclature in fostering gender diversity in STEM education. While this study does not demonstrate a significant overall effect, the detailed analysis suggests that program names may play a role in attracting or deterring specific applicants. Future research and interventions should consider a holistic approach, including program marketing, outreach strategies, and a supportive environment, to address gender disparities in STEM fields.

References

[1] Diversity and STEM: women, minorities, and persons with disabilities. Report. [Online]. Available: https://ncses.nsf.gov/pubs/nsf23315/report/science-and-engineering-degrees-earned#science-and-engineering-degrees-earned. [Accessed Jan. 15, 2024]

[2] M. T. Wang, J. L. Degol, "Gender gap in science, technology, engineering, and mathematics (STEM): current knowledge, implications for practice, policy, and future directions," *Educational Psychology Review*, vol. 29, no. 1, 2017. [Online]. Available: http://dx.doi.org.ezproxy.rice.edu/10.1007/s10648-015-9355-x. [Accessed Jan. 15, 2024]

[3] W. S. Saeed Alawi, and M. M. Saeed Al-Mubarak, "Gender gap in science, technology, engineering, and mathematics (STEM): barriers and solutions," *International Journal of Economics and Financial Issues*, vol. 9, no. 6, pp 225-231, 2019. [Online]. Available: http://ezproxy.rice.edu/login?url=https://www.proquest.com/scholarly-journals/gender-gap-science-technology-engineering/docview/2485440362/se-2?accountid=7064. [Accessed Jan. 20, 2024].

[4] M. Martinez, F. Segura, J. M. Andujar, and Y. Ceada, "The gender gap in STEM careers: An inter-regional and transgenerational experimental study to identify the low presence of women," *Education Sciences,* vol. 13, no. 7, 2023. [Online]. Available: http://dx.doi.org.ezproxy.rice.edu/10.3390/educsci13070649. [Accessed Jan. 2, 2024].

[5] G. Saw, C. N. Chang, and H. Y. Chan, "Cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status," *Educational Researcher,* vol. 47, no. 8, pp. 525-531, 2018. [Online]. Available: https://doi-org.ezproxy.rice.edu/10.3102/0013189X18787818. [Accessed Jan. 10, 2024].

[6] R. Su, and J. Rounds, "All STEM fields are not created equal: people and things interests explain gender disparities across STEM fields," *Frontiers in Psychology,* vol. 6, 2015. [Online]. Available: https://doi.org/10.3389/fpsyg.2015.00189. [Accessed Jan. 12, 2024].

[7] D. Bilimoria, S. Joy and X. Liang, "Breaking barriers and creating inclusiveness: Lessons of organizational transformation to advance women faculty in academic science and engineering," *Human Resource Management*, vol. 74, no. 3, pp. 432-441, 2008. Available: https://doi.org/10.1002/hrm.20225. [Accessed Jan. 26, 2024].

[8] E. López-Iñesta, C. Botella, S. Rueda, A. Forte, and P. Marzal, "Towards Breaking the Gender Gap in Science, Technology, Engineering and Mathematics," *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 15, no. 3, pp. 233-241, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/9137264. [Accessed Jan. 23, 2024].

[9] T. Tyler-Wood, A. Ellison, O. Lim, and S. Periathiruvadi, "Bringing up girls in science (BUGS): the effectiveness of an afterschool environmental science program for increasing female students' interest in science careers," *Journal of Science Education and*

Technology, vol. 21, no. 1, 2012. [Online]. Available at: http://dx.doi.org.ezproxy.rice.edu/10.1007/s10956-011-9279-2. [Accessed Jan. 20, 2024].

[10] N. Blum, "A mentoring programme to spark girls' interest in STEM," *Nature Reviews Materials,* vol. 8, no. 4, 2023. [Online]. Available: https://doi.org/10.1038/s41578-023-00542-4. [Accessed Jan. 20, 2024].

[11] P. N. Beymer, J. M. Rosenberg, J. A. Schmidt, and N. J. Naftzger, "Examining relationships among choice, affect, and engagement in summer STEM programs," *Youth Adolescence,* vol. 47, pp. 1178-1191, 2018. [Online]. Available: https://doi.org/10.1007/s10964-018-0814-9. [Accessed Jan. 15, 2024].

[12] D. S. Shelton, et al., "Expanding the landscape of opportunity: Professional societies support early-career researchers through community programming and peer coaching," *Journal of Comparative Psychology, vol. 135, no. 4, pp. 439-449, 2021. [Online]. Available:* https://doi.org/10.1037/com0000300. [Accessed Jan. 15, 2024].

[13] J. R. Steele, and J. H. Challis, "Pioneering women of the international society of biomechanics," *Journal of Biomechanics,* vol. 152, 2023, 2023. [Online]. Available: https://doi.org/10.1016/j.jbiomech.2023.111547. [Accessed Jan. 15, 2024].

[14] R. Campbell-Montalvo, et al., "The influence of professional engineering organizations on women and underrepresented minority students' fit," Frontier Education, vol. 6, 2021. [Online]. Available: https://doi.org/10.3389/feduc.2021.755471. [Accessed Jan. 15, 2024].