

Board 192: Identifying and addressing the barriers to advancement for women in the engineering professoriate: A systematic review of literature

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Identifying and addressing the barriers to Advancement for Women in the Engineering Professoriate - a systematic review of literature

Abstract

This work-in-progress paper shares ongoing findings from a mixed-methods systematic literature review that seeks to examine the retention of women in the engineering professoriate. We identified literature from EBSCOHost and Engineering Village that discussed women in the engineering professoriate in relation to either retention or persistence or both, as explicitly stated in their abstract. Following an initial review of 191 titles, 48 papers passed our inclusion criteria; further qualitative analysis of abstracts yielded 31 papers, which underwent a full paper review. Our ongoing findings suggest the following: a) research on the retention of women in engineering professoriate is being supported by grants and funding opportunities; b) the reviewed literature documented six barriers faced by women in the engineering professoriate: *isolation of women faculty*, *work/life balance*, *inequitable distribution of service*, *underrepresentation of women faculty*, *implicit bias*, and *departmental resources*; and c) although journal scholarship on this topic is not limited to popular engineering education publishing venues, conference scholarship are mainly from those popular in the field, such as the ASEE Annual Conference and the Frontiers in Education Conference. Future work will share the extent to which the reviewed literature discussed interventions to recruit or retain women in the engineering professoriate, and whether these interventions vary by the type of institution.

Introduction

There have been considerable efforts towards increasing the representation of women in science and engineering, which have resulted in an increase in the number of women earning advanced degrees in these fields, including PhDs. However, these gains have not translated into a significant increase in the representation of women in the engineering professoriate [1]. There are funding opportunities available to institutions who seek to address concerns regarding retaining women faculty in engineering, such as the *Organizational Change for Gender Equity in STEM Academic Professions* (ADVANCE) program, supported by the National Science Foundation. ADVANCE aims to “increase the representation and advancement of women in academic science and engineering careers,” and supports institutional programs and interventions towards achieving this goal [2], [3]. Despite the availability of support, a decline in the number of faculty in STEM who identify as women faculty has been noted [4]; and more women faculty in the engineering professoriate who start their careers as assistant professors leave the academy, without obtaining tenure, than their male counterparts [5]. The disruptions as a result of the COVID-19 pandemic and the resultant disproportionate impact [6,7] on faculty, additionally necessitates urgent calls for broadened participation to support research on and for engineering faculty across institutions.

The intended impact of our ongoing work is two-fold - 1) we hope to raise awareness of resources and research to help those who identify as women in the engineering professoriate, and 2) we seek to draw attention to the unique challenges faced by this community.

We begin our work by exploring existing literature on women in the engineering professoriate, through a mixed-methods systematic literature review, focusing on work related to retention and persistence. Our initial literature search and preliminary appraisal yielded 48 papers [elaborated in 8]. A qualitative analysis of abstracts resulted in the inclusion of 31 papers, which were analyzed guided by the following research questions:

RQ1: What are the barriers already identified in literature for retaining women in the engineering professoriate?

RQ2: What proportion of literature discuss interventions to recruit or retain women in the professoriate?

RQ3: How have the authors contextualized the need to recruit and retain women faculty? How do these interventions vary by university type?

For this work-in-progress paper, we share the preliminary findings related to our first research question, after reviewing the full papers that met our inclusion criteria. We highlight the professional venues in which the literature on retention of women faculty in engineering are disseminated; we believe that knowledge of these venues will help those who identify with this

group find the resources and support that address their unique circumstances. We also discuss the barriers that impact the retention of women in the engineering professoriate.

Methods

Systematic reviews typically begin with defining an inclusion criterion [9]–[13]. Our inclusion criteria allowed papers that discussed women in the engineering professoriate in relation to either retention or persistence or both, as explicitly stated in their abstract. The articles identified and included in the review were then appraised to ensure relevance of the publications included in the review to the research purpose and research questions. Following an initial review of 191 titles, 48 papers passed our inclusion criteria, of which we reviewed 31 post-exclusion of those with low quality. Figure 1 (adapted from [14]) details the steps in the review process, using the Search-Screen-Appraise method described in [10].

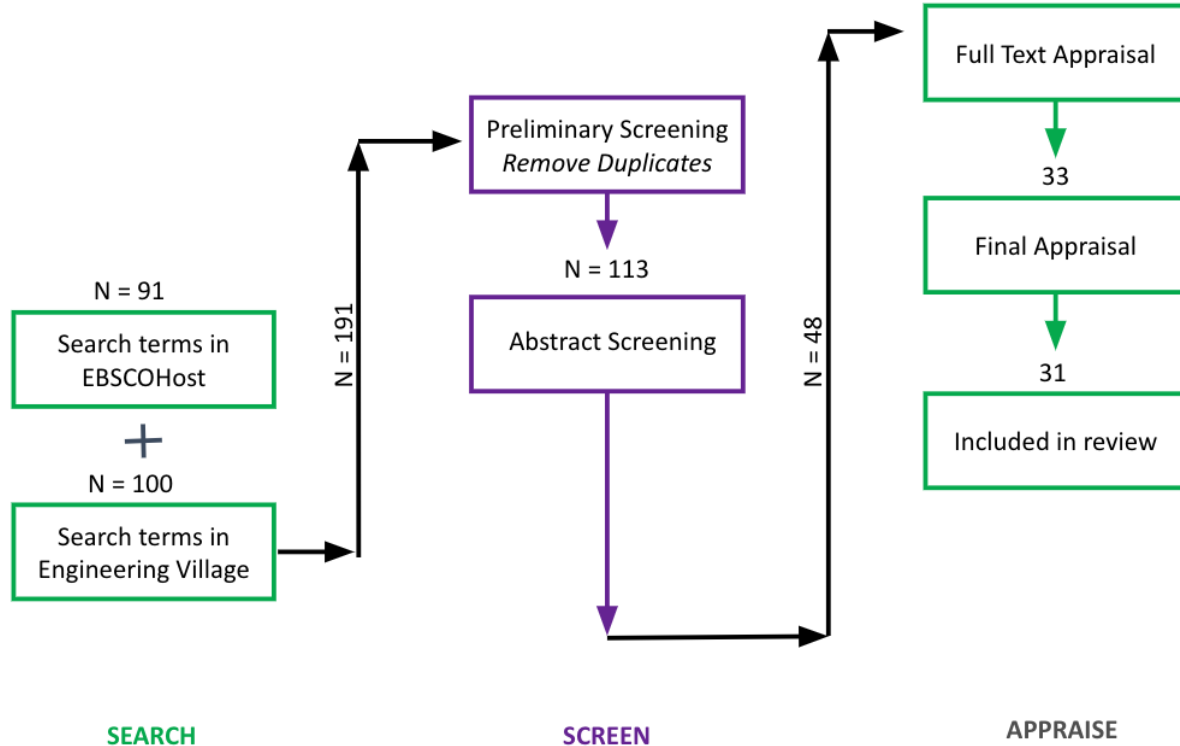


Figure 1: Papers reviewed in various steps of this Systematic Review Process

Analysis

We found and listed the texts from each of the papers that indicated the barriers to retaining women in the engineering or STEM professoriate. On those texts, we conducted a thematic analysis in our study [15]. To start with, the two primary authors of the paper independently read

the texts to familiarize themselves with the data. We then individually used an inductive approach to find codes that identified the barriers. Following that, we discussed the resulting codes, looked for patterns among the codes, and reached a consensus about the categories that most accurately captured each of the codes. All authors then reviewed the themes and collaboratively organized these categories by similarity and identified themes for each grouping. Finally, we reviewed the themes and compared them once again with the texts to assess whether they captured all the barriers.

Preliminary Results

Our overall study is guided by three Research Questions:

RQ1: What are the barriers already identified in literature for retaining women in the engineering professoriate?

RQ2: What proportion of literature discuss interventions to recruit or retain women in the professoriate?

RQ3: How have the authors contextualized the need to recruit and retain women faculty? How do these interventions vary by university type?

In this work-in-progress paper, we present our findings related to the first research question around identifying and addressing barriers to recruit and retaining women in the professoriate.

Barriers identified on recruiting and retaining women in the engineering professoriate

Our analysis identified six barriers that hinder the retention of women in the STEM professoriate as shown in Figure 1.

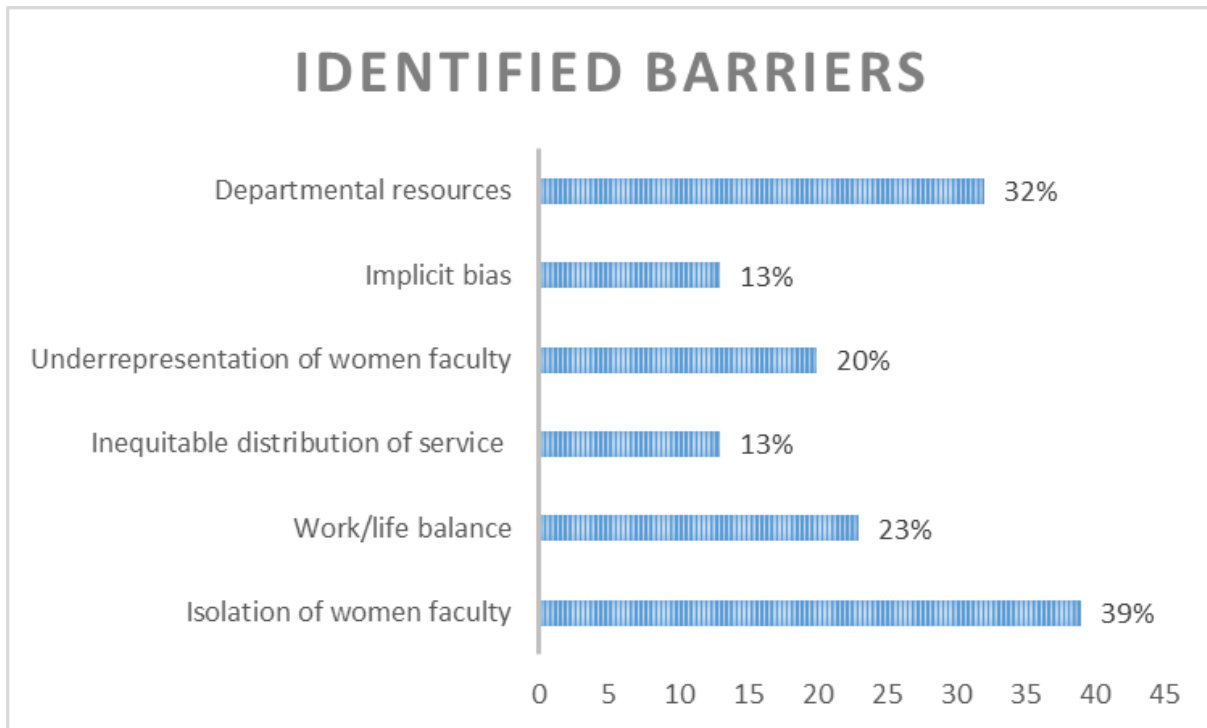


Figure 1. Barriers and percentage of papers indicating each barrier that hinders the retention of women in the engineering professoriate.

1) ***Isolation of Women Faculty:*** About 39% of the papers presented show that women feel isolated in their departments, which is one of the biggest barriers to the success of women faculty. The theme of isolation includes experiencing a lack of connection or sense of belonging in ones' department or college. The departmental climate also includes perceived injustice and ineffective communication.

2) ***Departmental resources*** - About 32% of the papers highlighted the need for departmental resources for the success of women in the engineering professoriate. For example, a departmental resource may include support from the departmental chair, who can provide start-up funds or grant writing assistance or resources for women faculty to boost their research profile during the initial years. The departmental resource can also include mentoring support or help with navigating the career of a woman faculty.

3) ***Work/Life balance:*** Around 23% of the literature reviewed indicated barriers related to achieving work-life balance among women faculty. These barriers encompassed several challenges, including inadequate job flexibility, familial responsibilities, insufficient support for child care, and teaching-related concerns, such as negotiating workload.

4) ***Underrepresentation of women faculty:*** About 20% of the literature highlighted an underrepresentation of women faculty in many areas of academics. For example, there are fewer

women in the upper ranks, leadership roles, collaborative research groups, and academic committees. This affects the dynamics of the academic environment in different ways. Women's underrepresentation on promotion and tenure committees, for instance, may affect deciding criteria that are unfavorable to them.

5) ***Implicit bias***: Around 13% of the papers indicated implicit bias that exists within academia and how it can impact the selection, retention, and promotion of women faculty in academia. For example, a study found that black women with lighter skin color are favored over darker skin color in the selection process [16]. Also, women face the impact of different stereotypes, including irrational, overly assertive, and unstable. As a result of these stereotypes, women face additional barriers in academic systems, which are often based on subjective perceptions of compatibility and personality.

6) ***Inequitable distribution of service***: This theme was presented in about 13% of the literature. It included two main issues: a lack of clear and consistent understanding of the service role and a failure to acknowledge and reward individual contributions and accomplishments.

Concluding Thoughts and Future Work

Our primary findings from a preliminary review of literature on women faculty uncovered that: a) research on the retention of women in engineering professoriate is mainly supported by grants and funding opportunities (e.g. NSF Advance); b) six themes emerged from the barriers faced by women in the engineering professoriate: *isolation of women faculty*, *departmental resources*, *work/life balance*, *underrepresentation of women faculty*, *implicit bias*, and *inequitable distribution of service*; and c) journal scholarship on this topic is not limited to popular engineering education publishing venues, conference scholarship are mainly from those popular in the field, such as the ASEE Annual Conference and the Frontiers in Education Conference. We find that such themes around isolation, lack of belonging or work-life balance, among others are parallel to those uncovered in prior research through studying engineering students' perceptions (e.g., [17] - [19]). Opportunities for future work include deeper dives into the interventions themselves and investigating whether these interventions to recruit and retain women in the professoriate vary by institution type (e.g., based on the mission and vision of the institution [20]). Echoing Smith's argument in Diversity's Promise for Higher Education [21], this research insists that if excellence is sought in diverse society (such as in increasingly diverse engineering academia), then diversity cannot be an afterthought. Improving gender diversity, inclusion, and equity among engineering education faculty must be among top priorities for the field.

Interventions to address barriers identified as part of this review might include multi-faceted efforts such as building a supportive community, promoting inclusivity, providing networking

opportunities, fostering collaborations where women can work together on projects, proposals, and other initiatives, mentorship programs, flexible work arrangements, professional development programs that prioritize work-life balance, and recognition programs where women feel valued and respected.

References

- [1] D. J. Nelson and D. C. Rogers, *A national analysis of diversity in science and engineering faculties at research universities*. Citeseer, 2003.
- [2] J. DeAro, S. Bird, and S. Mitchell Ryan, “NSF ADVANCE and gender equity.,” *Equal. Divers. Incl.*, vol. 38, no. 2, pp. 131–139, Mar. 2019.
- [3] K. P. Constant, “ISU ADVANCE - Sustaining and institutionalizing efforts to enhance recruitment, retention and advancement of women faculty in engineering,” in *118th ASEE Annual Conference and Exposition*, 2011.
- [4] S.-N. C. Liu, S. E. V. Brown, and I. E. Sabat, “Patching the ‘leaky pipeline’: Interventions for women of color faculty in STEM academia,” *Arch. Sci. Psychol.*, vol. 7, no. 1, pp. 32–39, Nov. 2019, doi: 10.1037/arc0000062.
- [5] M. Gumpertz, R. Durodoye, E. Griffith, and A. Wilson, “Retention and promotion of women and underrepresented minority faculty in science and engineering at four large land grant institutions.,” *PLoS ONE*, vol. 12, no. 11, pp. 1–17, 11/01/2017 2017.
- [6] S. Bhaduri, L. Virguez, D. Basu, and M. Soledad, “A Grounded Theory Analysis of COVID-19 Information and Resources Relayed Through University web pages: Implications for a more inclusive community”, in *128th ASEE Annual Conference and Exposition*, 2022.
- [7] K. Pakala and S. Bhaduri, “Opportunities from Disruption-How lifelong learning helped create more connected classrooms”, in *CoNECD (Collaborative Network for Engineering & Computing Diversity)*, 2022.
- [8] M. Soledad, D. Basu, S. Bhaduri, and L. Virguez, “WIP-Retention of women in engineering professoriate: A Systematic Review” in *129th ASEE Annual Conference and Exposition*, 2022.
- [9] M. Borrego, M. J. Foster, and J. E. Froyd, “Systematic Literature Reviews in Engineering Education and Other Developing Interdisciplinary Fields,” *J. Eng. Educ.*, vol. 103, no. 1, pp. 45–76, Jan. 2014.
- [10] M. Borrego, M. J. Foster, and J. E. Froyd, “What is the state of the Art of systematic review in engineering education?” *J. Eng. Educ.*, vol. 104, no. 2, pp. 212–242, 2015.
- [11] G. Brunton, A. Harden, A. Oakley, and G. Brunton, “Evidence for Policy and Practice Information and Co-ordinating Centre”.
- [12] M. Petticrew and H. Roberts, *Systematic reviews in the social sciences: A practical guide*. John Wiley & Sons, 2008.
- [13] M. Sandelowski, “Reading, writing and systematic review,” *J. Adv. Nurs.*, vol. 64, no. 1, pp. 104–110, 2008.
- [14] Bhaduri, S. (2018). NLP in Engineering Education-Demonstrating the use of Natural Language Processing Techniques for Use in Engineering Education Classrooms and Research, *Doctoral dissertation*, Virginia Tech.
- [15] J. Green et al., “Generating best evidence from qualitative research: the role of data

- analysis,” *Aust. N. Z. J. Public Health*, vol. 31, no. 6, pp. 545–550, 2007.
- [16] M. S. Harrison and K. M. Thomas, “The Hidden Prejudice in Selection: A Research Investigation on Skin Color Bias,” *J. Appl. Soc. Psychol.*, vol. 39, no. 1, pp. 134–168, 2009, doi: 10.1111/j.1559-1816.2008.00433.x.
- [17] W.C. Lee, B. Lutz, H. M. Matusovich, S. Bhaduri, “Student perceptions about learning about diversity, and it’s place in engineering classrooms in the United States”, *International Journal of Engineering Education*, 2021
- [18] SE Brady, GE Little, LL Crumpton-Young, S. Bhaduri “An Assessment of HBCU STEM Student Experiences: Towards the Development of a Student Persistence Model” in 125th *American Society for Engineering Education (ASEE) Annual Conference*, 2018.
- [19] A. Taylor, R. Waters, S. Bhaduri, B. Lutz, W. C. Lee, “Student Attitudes about Diversity: “If the field of engineering were more diverse, what would that mean for you?”, *Frontiers in Engineering (FIE) Annual Conference*, 2017
- [20] S. Bhaduri, T. Roy, “Demonstrating use of Natural Language Processing to compare college of engineering mission statements”, in 124th *American Society for Engineering Education Annual Conference & Exposition* proceedings, 2017.
- [21] D.G. Smith, “Diversity's promise for higher education: Making it work.” *JHU Press*, 2020.