6-26-2022

Career Advancement of Women in Engineering Disciplines at Two-Year Degree Institutions: Documenting Challenges and Potential Solutions to Raise Inclusivity

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ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #36642

Career Advancement of Women in Engineering Disciplines at Two-Year Degree Institutions: Documenting Challenges and Potential Solutions to Raise Inclusivity

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Introduction

Institutions of higher education that offer two-year degrees have student-centered missions with support structures to address the unique needs of a diverse student body [14]. Many two-year degree institution types are open access and have institutional priorities focused on increasing diversity and inclusive practices among both the students and faculty [1]. Although the inclusion of women traditionally underrepresented in STEM disciplines in higher education settings is a national concern, the advancement of women at institutions that offer support networks and institutional practices such as two-year degree institutions contribute to women's advancement and diversity in the talent pipeline. This research study investigates systemic approaches at two-year degree offering institutions that have led to the progression of women in STEM fields and the inclusion of women in academic leadership positions in higher education with the authority to promote gender equity practices at their institution [6], [9], [18]. Institutional commitments related to achieving goals to increase diversity in STEM require systematic changes in departmental policies and processes to increase STEM participation [7], [11].

This study used a Delphi technique, a consensus building method, to explore barriers and support systems that impact women's professional advancement in STEM disciplines. Through four rounds of data collection, 15 panelists reached a group consensus on nine factors supporting the advancement and three factors inhibiting advancement for a total of 12 factors.

Research Questions

This research was guided by two specific questions that were addressed through data collection and analysis:
1) What factors have the most impact on women's professional advancement and success in leadership positions within STEM and workforce education-related disciplines at two-year institutions?
2) What factors inhibited women's professional advancement and success in leadership positions within STEM and workforce education-related disciplines at two-year institutions?

Methods

The study relies on the work of Schmidt [13] that provides a framework for using the Delphi technique to produce a systematic, controlled interaction with multiple rounds. The consecutive rounds allow for each group member to contribute independent thought and the process assists experts who serve as panelists in the study through a problem-solving process until a unified opinion emerges and is decided upon by group consensus. The study addresses the need to examine factors related to institution type through this "gradual formation of a considered opinion" [16, p. 62]. This approach is limited to the experts' interests in the findings and willingness to make meaningful contributions, but an informed judgment can be reached based on the re-submission of the results after the data in the previous round have been analyzed [12].

Size and Demographics of the Panel

The panelists were selected on criteria including educational background, diversity in STEM disciplines, experience as a former or current female administrator within STEM, leadership in a women's advocacy organizations in STEM. The research participants served as principal investigators over externally funded STEM programs or research projects, department chairs, directors, deans, associate vice presidents, and vice presidents within STEM fields. The targeted small panel size considered the group estimation process in achieving experimental results [2].

The study had a panel size of 20 to ensure a panel of 10 after attrition between rounds for each subset of participants. After the initial selection process, 20 expert panelists committed to participate in the study and 15 panelists completed all four rounds. The panel was composed of members who had expertise in a variety of STEM disciplines, experience, knowledge, and skill in offering sound judgement on the factors being explored [3]. The study used a purposive sample that required specific criteria from the panelists regarding their role in academia and knowledge of barriers and support systems of women in STEM fields. The eligibility criteria required panelists to be female and hold a Ph.D. or terminal degree in a STEM-related field. Table 1 provides a breakdown of the STEM areas that each panelist represents.

Table 1

Panelists' Area of Responsibility by STEM and Workforce Education Program Affiliation

STEM and Workforce Education Program	# of Panelists
Mathematics and Related Fields	6
Workforce and STEM Education	4
Health	3
Engineering	2
Aeronautics	1
Environmental Sciences	1
Total	17

Deans within a STEM department represented eight of the panelists. Six of the panelists served as a director or principal investigator and provided administrative oversight for a federally funded STEM and STEM-related workforce education program. Three of the panelists served as Assistant Vice Presidents responsible for STEM and workforce education-related programs. All panelists had a minimum of three years of experience in a leadership role.

Data Collection and Analysis

The study consisted of four rounds of data collected through email responses. The design follows Schmidt's [13] framework for rating factors in the panelists' responses. The panelists were asked to participate in the following ways for each round. First, identify factors related to both research questions. Second, review the aggregated list of factors identified by the group at large and identify missing factors. Third, rate each item based on perceptions of each item. Fourth, agree on final factors that were previously identified and rated. To accelerate the turnaround time and thus response rate, panelists were asked to choose three factors for each research question in the first round and add a two or three-sentence description for each factor.

Round one collected qualitative data that required the panelists to be more creative in their responses compared to the subsequent rounds that requires a judgment of opinions and decision-making to rate the factors. The aggregated list of factors was sent back to panelists in Round 2 based on emerging themes. Similar responses were categorized. The factors and descriptions were randomly ordered from the first round and panelists were asked to review and agree on an established list of factors that are relevant to the research questions.

In Round 3, the panelists reviewed the final lists of factors and were asked to rate each factor identified in Round 2. The factors were rated by relevance to the research questions [13]. The rating scale consists of a five-point Likert-type scale with a numeric value (5 point = Most Relevant Factor, 4 point = Significant Relevant Factor, 3 point = Moderate Relevant Factor, 2 point = Limited Relevant Factor, and 1 point = Not Relevant Factor).

A factor was established as relevant based on a mean score of 3.50 or higher on the 5.00 scale based on previous Delphi studies [8]. The panelists reached a consensus for factors that had an interquartile range (IQR) 2.00 or below [4]. Factors with an interquartile range (IQR) over 2.00 indicate that consensus were not achieved due to the high dispersion of the ratings for each factor. The panelists were sent their individual ratings from Round 3 along with the group mean (M), median (Mdn), IQR, and standard deviation (SD) for each factor in Round 4. Panelists reviewed the group ratings and had the option to change their ratings in Round 4 after considering their individual ratings in Round 3 compared to the group response.

Findings

The following factors were identified as relevant for supporting advancement: Support Systems, Personal Attributes, Willingness to Advance, Leadership Skills, Curiosity about New Experiences, Role Models, Opportunities for Leadership Roles, Experiences in Undergraduate and Graduate Studies, and Awareness of Institutional Environments; and those for inhibiting advancement: Conflicting Family Obligations, Lack of Compensation, and Personal Concerns. The study revealed panelists had strong beliefs that institutional support during a women's career may contribute to advancement as indicated by the high mean score for the factor Opportunities for Leadership Roles and Professional Development. These findings indicate that organizational structure can create common patterns of perception, thought, and feelings toward the room for advancement. The panelists' experiences illuminate that structural and cultural inclusiveness and strategic goals set by leadership can promote and grow leaders within STEM, who will be competitive and prepared to meet the gap in leadership.

One of the most significant barriers to advancement was lack of compensation for the work required. The consensus was reached by panelists that felt women faced challenges when they were given more work without a change in title, pay or recognition for the work being accomplished. Further research is needed to address how leaders across institution types in STEM fields anticipate perceived gender and salary gaps while incorporating institutional policies and practices that create organizational support for rising female professionals. The results of the Delphi study can be used as a conceptual framework to inform administrators and researchers in higher education on the relevant factors concerning organizational climate, institutional policies, and departmental conditions that impact women's advancement or hinder their advancement in STEM fields.

Figure A offers a conceptual framework that shows how the factors identified relate to a women's career pathways from recent graduates through early and mid-career transitions within the context of support and the context of barriers.

<table>
<tr><th colspan="4">Figure A: Conceptional Framework</th></tr>
<tr><th>Recent Graduates</th><th>Early and Mid-Career Transitions</th><th colspan="2">Context of Support</th></tr>
<tr><td>Math and science self-efficacy builds</td><td>Intent and willingness to advance in STEM</td><td>Entrance into an overall STEM community and network of support</td><td>Entrance into discipline-specific STEM and workforce positions of leadership</td></tr>
<tr><td>Exposure to career mentors and role models</td><td>Self-confidence and self-efficacy build</td><td>STEM identity development through a support network and role models</td><td>Identity development and engagement in a community of STEM leaders</td></tr>
<tr><td>Early achievements and skills development in STEM leadership</td><td>Connection to the STEM community</td><td>Understanding of personal attributes that influence career trajectory</td><td>Development of leadership competencies and awareness of institutional environments</td></tr>
<tr><td>Community of peer graduate support</td><td>Work-life integration</td><td>Exposure to career opportunities</td><td>Engagement in institutional systems of support</td></tr>
<tr><td colspan="4">Context of Barriers
Life/Career Stages: Prolonged time to the advancement and limited recognition for work achieved along the STEM pathway. Social and Cognitive Development Needs: Conflicting family obligations and detachment from a STEM community; Limited support and lack of compensation from institutions; Personal concerns and lack of connection to peers and faculty.</td></tr>
</table>

This study explores both support factors and barriers related to the advancement of women in STEM fields and is centered on the experiences of women who have previously or currently serve in senior level ranks over STEM departments at this specific institution type. These experiences may differ from women who advance in STEM disciplines at public research institutions since the two-year institutions have policies in place that prioritize teaching practices rather than research in the faculty tenure and promotion process. The aim of the study is to generate new knowledge on the unique conditions available at these institutions. These conditions offer additional support within the promotion process leading to the advancement of faculty from groups with low representation in the STEM field. Based on the findings of the study, these conditions may be more present at institutions with relevant workforce education and career and technical education programs that create opportunities for a wide variety of students and faculty. As a result, these institutions place a greater priority on service efforts and inclusive teaching practices that is reflected in the requirements for promotion (Mellow & Heelan, 2008; Shattuck et al., 2018).

Conclusion

Two-year degree offering institutions attract faculty that are focused on teaching and service within programs designed to address regional STEM workforce needs (Stout et al, 2018). This study revealed how the workplace climate, support structures and opportunities for professional development available at two-year degree offering institutions created pathways to advancement for women in STEM. These findings are consistent with research on the mission of the two-year degree offering institutions that prioritize service and teaching for promotion and tenure (Cohen & Brawer, 2008). The experiences of the women panelists in this study who served at these institution types show that women faculty may be associated with higher levels of productivity at specific points in their career where work/life balance is well supported, and less emphasis is on research productivity outside of the classroom. Prior research shows that a positive department climate can increase productivity for all faculty even in male-dominated professions such as STEM and academia (Sheridan, 2017). Therefore, this study was aimed at identifying factors that enhance or impede women's abilities to advance in positive environments such as those a two-year degree offering institutions with institutional structures of support. Identifying these factors is critical to future growth of the STEM academic workforce and may inform policy moving forward on best practices to support women who seek to advance.

Next steps in the research will focus on documenting successful strategies implemented at two-year institutions focused on developing a diverse representation of academic leaders in the STEM higher education workforce. This includes further exploration of core questions surrounding the factors that positively impact female academic professionals' advancement and retention in STEM-related administrative and senior-ranked positions. As institutions build more equitable conditions for women, women have greater opportunities to move into these types of leadership positions that can help others in the promotion processes.

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