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Navigating Pathways: Qualitative Insights into Personal and Professional Trajectories of Non-Traditional Groups across Engineering-Related Academic Disciplines

Ms. Kimberly A Luthi, Embry-Riddle Aeronautical University - Worldwide

Dr. Kimberly Luthi is a Department Chair for the Applied Aerospace Sciences, and Faculty Member at Embry-Riddle Aeronautic University-Worldwide in the College of Aviation. Her research background is in workforce development education and engineering education.

MICHAEL KOSLOSKI, Old Dominion University
Bettina Mrusek, Embry-Riddle Aeronautical University - Worldwide

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Abstract

This paper examines structural support systems that lead to the advancement and hindrance factors that have potential to catalyze the career acceleration of non-traditional groups, specifically women in engineering and STEM academic pathways in aerospace related disciplines. Through a consensus-building approach, the aggregated perceptions of 17 Delphi panelists provided insight into best practices to support a diverse and equitable pipeline of leaders based on nine factors supporting advancement and three factors inhibiting advancement. Attendees will learn about the importance of mentorship in promoting career development and how to improve access to education and training for non-traditional groups. The factors related to understanding barriers faced by non-traditional groups in accessing and advancing in engineering careers; strategies for addressing bias in promotion; and ways to create environments that support diversity and promote equity in academic engineering careers will be discussed.

Introduction

Institutions with a core mission to be a leader in workforce development often have student-centered missions with support structures to address the unique needs of a diverse student body. These institutions prioritize diversity and inclusive practices among both the students and faculty in an effort to meet the needs of a non-traditional student population [1]. The acceptance of all individuals and genders traditionally underrepresented in the engineering and STEM workforce is necessary as these institutions work to influence government and corporate funding policies to support their mission and offer interventional support structures. These institutional types, specifically two-year degree offering institutions, provide support networks and institutional practices that provide access to underrepresented groups in engineering. The research findings from the current study can be used to guide best practices to promote equity in academic engineering-related STEM careers. An expert panel identified twelve factors that provide insight to understand barriers faced by underrepresented groups, including ways to access and advance in academic engineering-related careers, strategies for addressing bias in promotion, and opportunities to create work environments that support diversity.

This study investigated systemic approaches at two-year degree offering institutions that have led to the progression of women in academic leadership positions in STEM disciplines in higher education with the authority to promote gender equity practices at their institution [6] [9] [16].

A consensus building technique is used to explore hinderance factors and support systems that impact women's professional advancement through four rounds of data collection. At the end of the fourth round, panelists reached a group consensus on nine factors supporting the advancement and three factors inhibiting advancement for a total of 12 factors.

Research Methods

The Delphi technique was used to create controlled, systematic interactions between the panelist over multiple rounds [13]. The structure gave opportunity for group member to give independent thoughts through a problem-solving process. The aim was for group consensus to emerge gradually as a unified opinion throughout four rounds. An informed judgement can be reached depending on the experts' interests in the findings and willingness to make meaningful contributions [11]. This research was guided by two specific questions that were addressed through data collection and analysis:

What factors impact women's professional advancement and success in leadership positions within STEM and workforce education-related disciplines at two-year institutions? What factors inhibit women's professional advancement and success in leadership positions within STEM and workforce education-related disciplines at two-year institutions?

In order to be eligible to participate, panelists had to currently or previously serve in a professional position as a principal investigator over a sponsored STEM program 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].

After the initial selection process, 20 expert panelists committed to participate in the study and 15 panelists completed all four rounds. A purposive sample was used that required specific criteria from the panelists regarding their role in academia and knowledge of barriers and support systems of non-traditional groups in higher education STEM departments and programs. Table 1 shows 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
Other	3
Engineering	2
Aeronautics	1
Environmental Sciences	1
Total	17

Data Collection and Analysis

Data was collected over four rounds. In the first round, panelists identified factors related to the research questions. Next, the list was consolidated by similarities and sent back to the panelists

who reviewed the list and identified missing factors. Third, the panelists' rated each item based on perceptions of each. Last, they were asked to rate the final factors. Panelists were requested to offer up to three factors with descriptions on experiences that most support the advancement and success of women in academic leadership positions as well as hinderance factors within engineering-related STEM and workforce education disciplines.

In Round 3, the panelists rated each factor identified in Round 2 by relevance to the research questions. 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 mean score of 3.50 or higher on the 5.00 scale based on the methodology from previous Delphi studies was used to determine relevancy [8]. If factors had an interquartile range (IQR) 2.00 or below, consensus was assumed [4]. Due to the high dispersion of the ratings for factors with an interquartile range (IQR) over 2.00, those students were removed as an indicator that consensus was not achieved. The final round included the remaining factors along with the panelists' individual ratings from Round 3 that showed the group mean (*M*), median (*Mdn*), *IQR*, and standard deviation (*SD*) for each factor. Panelists reviewed the group ratings and had the opportunity to change their ratings in Round 4 after considering their individual ratings in Round 3 compared to the group response. Table 2 shows the results from the group response after four rounds based on the relevance of each factor.

Table 2: *Round 4 Results from Group Response on Relevance*

Factors Supporting Advancement	*M*	*Mdn*	*SD*	*IQR*
Support Systems*	4.40	4.00	0.51	1.00
Personal Attributes*	4.13	4.00	0.74	1.00
Willingness to Advance*	4.07	4.00	1.10	1.00
Leadership Skills*	4.00	4.00	0.53	0.00
Curiosity for New Experiences*	3.73	4.00	0.70	1.00
Role Models*	3.73	4.00	0.70	0.75
Opportunities for Leadership Roles and Professional Development*	3.73	4.00	0.80	0.75
Experiences in Undergraduate and Graduate Programs*	3.67	4.00	0.62	0.75
Awareness of the Institutional Environment*	3.60	3.50	1.12	1.50
Knowledge of Institutional Assessment	3.20	3.00	0.86	1.00
Industry Experience	2.93	3.00	0.88	1.25
Desire to See Women in Leadership	2.60	2.00	0.91	1.00
Faith	2.40	2.00	1.59	2.50

Continued Table 2: *Round 4 Results from Group Response on Relevance*

Factors Inhibiting Advancement	*M*	*Mdn*	*SD*	*IQR*
Conflicting Family Obligations*	4.00	4.50	1.20	2.00
Lack of Compensation*	3.67	4.00	0.98	1.00
Personal Concerns*	3.53	4.00	0.92	1.00
Lack of Support	3.47	4.00	1.25	1.75
Feeling of Isolation	3.40	3.00	0.91	1.00
Failing to Perceive Room or Opportunity for Advancement	3.33	3.50	1.23	1.75
Discrimination	3.20	3.50	1.08	1.75
Limited Skills Training and Ability	3.20	3.00	1.01	1.00
Lack of Desire	2.93	3.00	1.33	1.50
Stereotype Threat	2.87	3.00	1.19	2.00
Limited Experience or Degree	2.60	3.00	1.06	1.00
English as a Second Language	1.93	2.00	1.07	1.00

* Factors that were both relevant and reached consensus.

Findings

The panelist reach consensus on the following nine factors 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. Additionally, the following three factors were identified for inhibiting advancement: Conflicting Family Obligations, Lack of Compensation, and Personal Concerns. Overall, panelists came to a strong agreement that institutional structures to support non-traditional groups contribute to advancement as indicated by the high mean score for the factors: Opportunities for Leadership Roles and Professional Development. These findings show that an organizations of higher education's strategic priorities as well as distribution of resources can create common patterns of perception, thought, and feelings toward the space for advancement.

The panelists' experiences show that structural and cultural inclusiveness and the goals set by leadership can promote and grow leaders within STEM, who will be competitive and prepared to meet the gap in leadership. The experiences of the panelists who all served in leadership positions at a specific institution type that focuses on workforce development through two-year pathways 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 [14].

A significant barrier identified was lack of compensation for the work required. Women faced challenges when they were given more work without a change in title, pay, or recognition for the work being accomplished. As women take on more service, the factor identified highlights how institution types that promote based on service allow for women to advance at a higher pace than

those that do not value service and teaching above research. This is specifically evident in STEM fields where the perceived gender and salary gaps are the greatest in four-year research institutions. The opportunity for changes within institutional policies and practices can create organizational support for rising female professionals.

The results of the study can support a 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. In Table 3, a framework is described based on the findings to show how the factors 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 3: *Conceptional Framework*

Recent Graduates	Early and Mid-Career Transitions	Context of Support	
Math and science self-efficacy builds	Intent and willingness to advance in STEM	Entrance into an overall STEM community and network of support	Entrance into discipline-specific STEM and workforce positions of leadership
Exposure to career mentors and role models	Self-confidence and self-efficacy build	STEM identity development through a support network and role models	Identity development and engagement in a community of STEM leaders
Early achievements and skills development in STEM leadership	Connection to the STEM community	Understanding of personal attributes that influence career trajectory	Development of leadership competencies and awareness of institutional environments
Community of peer graduate support	Work-life integration	Exposure to career opportunities	Engagement in institutional systems of support

The framework illustrates how institutions can support non-traditional groups as they acclimate to new phases of their career progression in engineering-related STEM fields. The experiences as well as understanding of support factors and barriers identified by women who represent others in senior level ranks in STEM departments can mirror similar challenges faced by underrepresented groups who seek positions in industry as well as higher education. These experiences may differ depending on institution type based on the climate and policies in place that prioritize service and teaching practices rather than research in the faculty tenure and promotion process. The results of the study meet the intended goal to generate new knowledge on the unique conditions available at these types of institutions focused on workforce development. These conditions offer additional support within the promotion process leading to the advancement of faculty from groups with low representation in the engineering and related-

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. The findings offer further evidence that institutions that place a greater priority on service efforts and inclusive teaching practices tend to be more favorable towards the upward career mobility for non-traditional groups, specifically in the promotion process into senior leadership.

Conclusions

Institutions that prioritize workforce development and offer two-year degrees attract faculty that are focused on teaching and service within programs designed to address regional engineering-related workforce needs [15]. This study revealed how the workplace climate, support structures and opportunities for professional development available at these institution types have potential to build pathways to accelerate non-traditional groups into positions of leadership. 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 [5].

Identifying factors that enhance or impede women's abilities to advance is critical to future growth of the engineering-related STEM academic workforce and may inform policy moving forward on best practices to support women who seek to advance. Future research will focus on documenting successful strategies implemented at institutions focused on developing a diverse representation of academic leaders in the 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 all genders, non-traditional groups have greater opportunities to move into leadership positions that can help others in the promotion processes.

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