PERSISTENCE OVERCOMES RESISTANCE:

THE JOURNEY OF WOMEN TO FULL PROFESSORS IN STEM

A Dissertation in Practice

Presented to

The Faculty of the Graduate School

At the University of Missouri-Columbia

In Partial Fulfillment

Of the Requirements for the Degree

EdD in Educational Leadership

By

MELANIE E. CARDEN-JESSEN

Dr. Kennedy Ongaga, Dissertation Supervisor

December 2023

The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled:

PERSISTENCE OVERCOMES RESISTANCE:

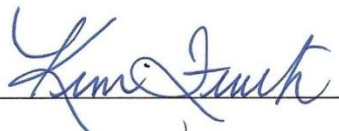
THE JOURNEY OF WOMEN TO FULL PROFESSORS IN STEM

Presented by Melanie Carden-Jessen, a candidate for the degree of Doctor of Education, and hereby certify that, in their opinion, it is worthy of acceptance.

Dr. Kennedy Ongaga, Dissertation Chair

Dr. Cynthia MacGregor, Committee Member

Dr. Ximena Uribe-Zarain, Committee Member



Dr. ~~Kim~~ Finch, Committee Member

Dedication

Like the women in this study, I owe much to my family, who supported me and provided many STEM experiences in my early years. Although pitching tents in 2 feet of snow in Montana was not the experience I thought I needed, all those trips made us kids confident and capable. Thanks, Clyde and Rebecca. We love you both to the moon and back.

ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. Kennedy Ongaga and Dr. Cynthia Macgregor. We all owe you a debt for sticking with us and taking on more than anyone could ask. You are undoubtedly two of the finest, most dedicated, most caring, and most knowledgeable people I have met. When I felt discouraged, I remembered you saying you could "fix anything but quitting," and I would get back to work. Thank you for the encouragement, guidance, and endless feedback. I could not have gotten through this without you. You have given me an incredible opportunity. I will try to do it justice.

Dr. Ongaga, thank you for hanging with me, sharing your time and talent, and helping me complete this study. I appreciate the academic and, just as important, the moral support you have provided through this process.

To my dissertation committee – thank you for taking the time from your busy schedules to help me complete this dissertation. I will be forever grateful that you are all such giving people, and I am proud to have had the opportunity.

TABLE OF CONTENTS

List of Tables and Figures

Figures

Tables

Abstract

Women currently earn half of the doctorates awarded in the United States but hold 37% of the full professor positions (NCSES, 2019). Demographic inertia alone cannot explain this fact (Laursen & Austin, 2020). This qualitative, phenomenological study, through the critical theory framework, sought to understand the lived experiences of five women STEM full professors in professional doctorate-granting institutions (R3) and their perception of the impact of these experiences on their promotion to full professor. Data for the study included analysis of curriculum vitae, demographic surveys, and in-depth semi-structured interviews that were coded using the constant comparative method (Seidman, 2019). The commonalities of the participants included childhood STEM empowerment, exploration, expectation (E3), communal spirit, alliances, philanthropic investment, the Lily Hard effect, and institutional first aid. Critical theory provided an understanding of the participants' experiences through the themes of forced to comply, bias against women, heavier service loads, and challenging the status quo. The limitations of the study included no participants of color and only R3 institutions with ADVANCE grants were included. Although the findings are not generalizable (Patton, 2015), they may be transferable. Future research could consist of intersectional identities and maternal wall bias. The findings of this study offer a framework for institutional leaders to develop policies, procedures, and programs that increase women faculty and leadership in STEM disciplines. Increasing the number of women full professors in STEM is slow. Strategies that may help address inequities include reformatting women's socials to promote collaboration between disciplines, continuing early career funding opportunities, providing incentives for senior faculty to invest in junior faculty (i.e., course release), and investing in youth programs for early STEM E3.

Section I. Introduction to the Dissertation-in-Practice

Introduction to the Background of the Study

Pre-colonial America first established universities to groom young men as future leaders (Thelin, 2018). It was not until the 1800s that women were allowed into the academy (Eisenmann, 1997), primarily in the Midwest (Thelin, 2018). Today, the Civil Rights Act of 1964 protects the rights of women to attend college or become part of academia. According to the National Center for Education Statistics (NCES), the ratio of male to female college students leans toward females (2019). McCarty stated that by 2019, 50% of the doctorate degrees conferred in the Science, Technology, Engineering, and Mathematics (STEM) fields were to females (2021). However, women have not achieved a critical mass of females in leadership positions in higher education, including full-professor (Austin & Laursen, 2020). Through an interview process and document analysis, this study aimed to determine some of the significant factors influencing the successful promotion of female STEM professionals to full professors in professional doctorate-granting (R3) institutions. There are numerous reasons to address the lack of women STEM full professors.

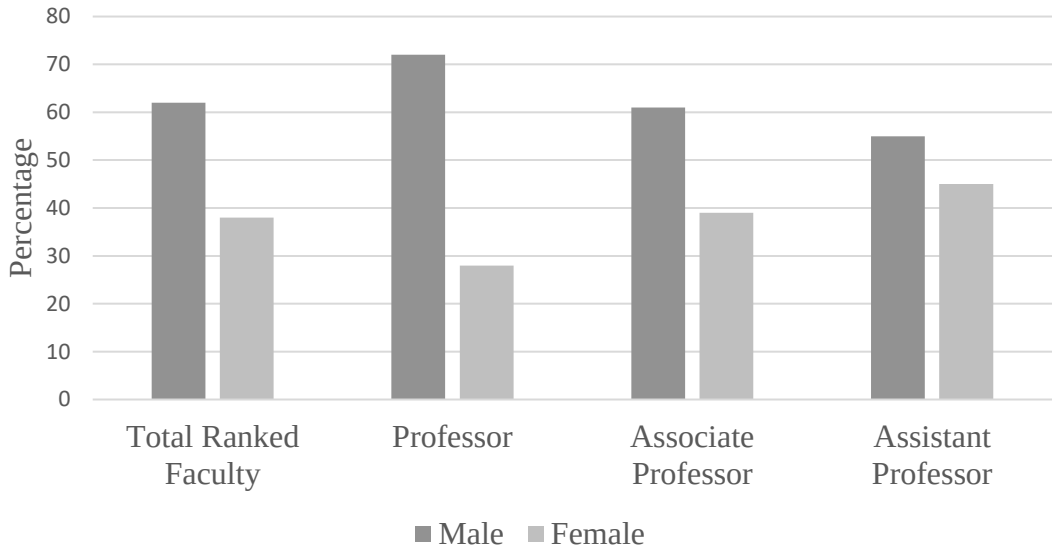
According to Hofhuis et al. (2016), members of a diverse workgroup experience "increased knowledge sharing, flexibility, creativity and, as a result, better team performance" (p. 2). There may be a better sense of inclusion, better trust, and higher job satisfaction in working groups with a more diverse working environment, as well as increased creativity and a decrease in conflict (Landry et al., 2016; Catalyst, 2004; Ely & Thomas, 2001; Forsyth, 2018; Nielsen & Huse, 2010). Workgroups that include females tend to be more effective in producing more timely and successful outcomes (Levi, 2017; Johnson, 2018).

There is a significant amount of research on the impact of female faculty at higher learning institutions on students. For example, female faculty exhibit greater leadership skills and improve work groups' cohesiveness, contributing to the success of workgroups (Levi, 2017; Johnson, 2018; Zenger & Folkman, 2019). Male and female undergraduates are more likely to achieve higher academic success with female advisors (Alexander & Eckland, 1974; Johnson, 2017). When looking at the impact of female faculty on female students in academia, studies have shown that having a female role model may reduce the dropout rate of females, improve their success in STEM programs, and increase a feeling of belonging to the academic community (Bettinger & Long, 2005).

Although having female faculty benefits production and student success, in 2017, the number of female professors in higher education still fell well below the student body's demographics, with 57% of college students identified as female (NCES, 2019). In 2019, just 38% of all STEM faculty identified as female (NSF, 2019). Figure 1 shows the number of ranked STEM faculty divided by male and female. While there is a 24% gap in total STEM faculty, there is a 44% gap in male and female STEM full professors. The difference narrows in the ranks of associate and assistant professors compared to male colleagues (NSF, 2019). See Figure 1.

Figure 1

Percentage of Higher Education STEM Faculty by Rank and Gender in the U.S., 2019

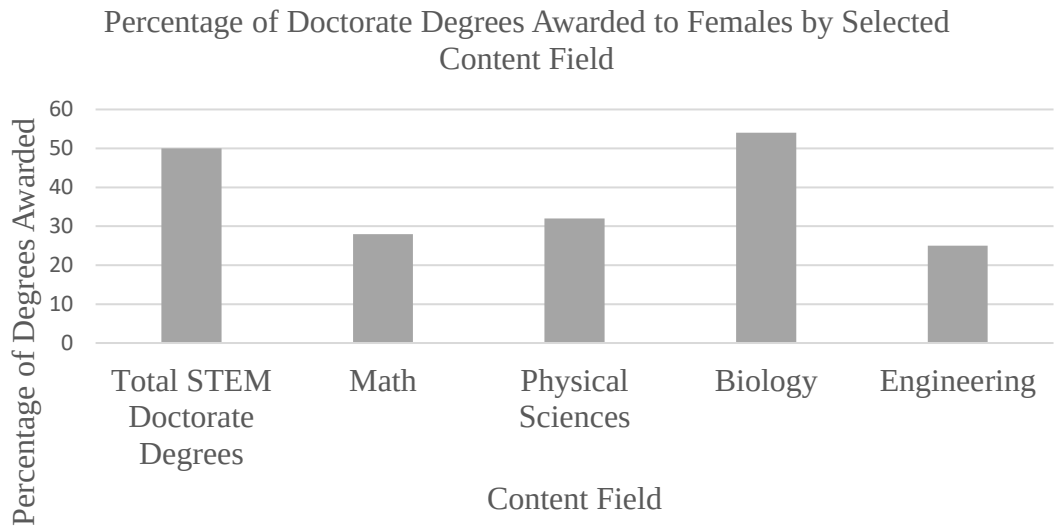


Note. National Center for Science and Engineering Statistics, 2019. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019*. Special Report NSF 19-304. (https://www.nsf.gov/statistics/wmpd)

Figure 2 reflects the percentage of doctorates in each STEM field awarded to women. In 2019, 50% of the STEM doctorate degrees, including Ph.D., Ed.D., and Psy.D., awarded in the United States were to females (McCarthy, 2021). There is, however, an uneven distribution in the percentage of female doctoral candidates. For example, of the biology doctorates awarded in 2019, 54% were to females, but only 25% of the engineering doctorate degrees were to females (NSF, 2019).

Figure 2

The Percentage of Doctorate Degrees Awarded to Females by STEM Content Field in the U. S., 2019



Note: Adapted from National Science Foundation, National Center for Science and Engineering Statistics, 2019a. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019*. Special Report NSF 19-304. (https://www.nsf.gov/statistics/wmpd)

Although the overall number of STEM doctorate degrees is comparable for males and females, the number of female STEM full professors has not kept pace with their male counterparts. Many studies investigate the barriers to women entering and advancing in academia. Misra (2021) recently conducted a meta-analysis of more than 250 articles that examined the leadership status of women in higher education and determined that women are underrepresented in leadership. Further, Misra (2021) stated that although women may be better prepared for the presidency in academia, serving as interim, having advanced degrees, and formal training, they are less likely to be appointed, as evidenced by the lower numbers of female presidents throughout the United States, about 32.8% in the United States (Jesse, 2023).

Laursen and Austin (2020), in their book *Building Gender Equity in the Academy: Institutional Strategies for Change,* classified the barriers identified through institutional self-evaluation and strategies implemented by 77 institutions that received National Science Foundation (NSF) ADVANCE grants. Barriers identified by Laursen and Austin (2020) included bias in evaluation, masculinized workplace, work-life conflict, inadequate resources, and inequitable service loads. Case studies of three ADVANCE recipients examined the key elements of strategies to improve gender equity, including focused faculty development, recruitment efforts, institutional policies and procedures (Laursen & Austin, 2020).

Ellemers et al. (2004) suggested that advancing in academia may be a more significant challenge for women as male and female advisors may be biased against female graduate students, perceiving them as less committed even when there are no observable differences. This assertion is consistent with Moss-Racusin et al. (2012) who found that female graduate students may not receive support in mentoring and research opportunities, publishing collaboration, and social support such as networking, introductions to contacts, and recommendations as consistently as male graduate students. Perhaps this is one factor in what Grogan (2018) called the leaky pipeline in STEM, the loss of females at each stage of STEM education and academia.

Work-life conflict is one factor Laursen and Austin (2020) and Misra (2021) identified as a barrier to women's success in STEM. Of tenured STEM professors, only 44% of women are married with children, compared with 77% of men (Laursen & Austin, 2020). Young female STEM professors are typically unmarried, and women are usually in their late thirties before they have children (Grunert, 2010). Women who achieve tenure are more than

twice as likely as men to be single 12 years after earning a Ph.D. (Laursen & Austin, 2020). Females are also more likely to leave academia due to work-life balance issues and hostile working environments (Laursen & Austin, 2020; Ceci & Williams, 2011). Hostile work environments may result from a masculinized work environment and include harassment, microaggressions, incivility, and inequitable workspace, to name a few (Austin & Laursen, 2020).

While these issues are essential and should be addressed, the primary reason to address the differential in gender among higher education faculty is equity. UNESCO defines equity as the fairness of treatment for men and women (Pavlec et al., 2000). The number of women who hold full professor ranks, 21.7%, has not yet achieved critical mass. Critical mass theory states that having 30% female faculty, while not equality, is enough to promote gender equity (Helitzer et al., 2017). This lack of female leadership has resulted in a culture where women promote more slowly, do not enjoy the same collaborations as men colleagues, and bear a more significant portion of service work (Laursen & Austin, 2020; Falci & Watanabe, 2020; Guarino & Borden, 2017; Misra et al., 2011; Mitchell & Hesli, 2013; Rosser, 2004). In addition, although women carry the service load, they must meet the same research and publishing standards (Laursen & Austin, 2020; Falci & Watanabe, 2020; Flaherty, 2020; Guarino & Borden, 2017). This service load inequity gives men faculty an advantage in career advancement (Bentley & Adamson, 2003).

Statement of the Problem

Spousal hire, tenure clock suspension, and implicit bias training are just a few of the strategies institutions of higher learning employ to support women STEM faculty (Laursen & Austin, 2020). Although the number of females awarded doctorates has been growing

steadily since 1950 (Duffin, 2019), the rate of women progressing to professors in STEM fields is increasing much slower than the number of women earning doctorates (NSF, 2018). Recognizing that women were not advancing at the same rate as men and that having a gender-diverse faculty has advantages, the NSF has awarded more than 70 Organizational Change for Gender Equity in STEM Academic Professions (ADVANCE) Catalyst grants since 2001 (NSF, 2018). Laursen and Austin (2020) compiled case studies and strategies from ADVANCE grant recipients in their book *Building Gender Equity in the Academy: Institutional Strategies for Change.* The NSF ADVANCE program aimed to expand the implementation of evidence-based systemic change strategies that promoted gender equity for STEM faculty in higher education.

Current research focuses on the lack of mentors and role models, work-life balance issues, implicit bias, and other barriers (e.g., Laursen & Austin, 2020; Misra, 2021). Grogan (2018) described how fewer numbers of females' progress in STEM at each stage from high school through the doctoral program and on to academia as a leaky pipeline. The metaphor of a highway with many off-ramps that divert females from a STEM pathway is preferred by Branch (2016). Whatever metaphor is used, women are not advancing in the faculty rank at the same rate as their male co-workers. This study addressed the problem that although women are attaining STEM doctorate degrees in similar numbers to their men counterparts, they are not advancing to full professors at the same rate. The current research path of identifying barriers has not had the desired effect of increasing the number of full-time female professors in STEM departments to critical mass. Measures that improve the situation for a single or small group of female STEM faculty is not a sustainable practice as each new hire will need the same supports, time, and resources. Mentoring, tenure clock extension, and

implicit bias training can be seen as fixing the female, not addressing the institutional factors that impact the promotion of women STEM faculty. Although barriers to women in STEM promotion to full professor have been well documented, a search of four databases resulted in just two studies investigating the catalysts of women's successful promotion to full professor in STEM, revealing a gap in the current research.

Purpose of the Study

This study investigated supports that influenced the success of women STEM full professors at professional doctoral granting (R3) institutions in the Midwest and provide insight that may impact other women faculty and R3 institutions. A better understanding of their experiences before achieving their doctoral degree and professional academic careers was essential to addressing inequity in higher learning institutions and their perceptions of support policies and professional experiences in their journey to full professors. The research on barriers and ADVANCE grants to address inequities has not produced the desired effect. Women full professors are not increasing as timely as expected factoring in current faculty retirements. The findings from this study offered a framework for institutional leaders to develop policies, procedures, and programs that increase the number of women faculty in higher ranks and women leadership in STEM disciplines.

Research Questions

The overarching research question: What are the lived experiences of women full professors in STEM at professional doctorate degree-granting (R3) institutions?

1. For women, what experiences put them on the path to becoming full professors in STEM at R3 institutions?

2. What factors contributed most to the success of women full professors in STEM at R3 institutions?
3. What institutional supports do women full professors in STEM consider beneficial in the promotion process at R3 institutions?
4. In what ways, if any, does critical theory provide understanding of the path for women into full professorship in STEM at R3 institutions?

Theoretical Framework

This study used critical theory, an approach to social philosophy that seeks to change power dynamics, as a guiding framework. According to Rasmussen (2012):

> Critical theory is a metaphor for a certain kind of theoretical orientation that owes its origin to Kant, Hegel, and Marx, its systematization to Horkheimer and his associates at the Institute for Social Research in Frankfurt, and its development to successors, particularly to a group led by Jürgen Habermas, who have sustained it under various renditions to the present day. (p. 295)

Critical theory has its roots in pre-WWII Germany with Marx's writings and his idea to make philosophy practical and change practices so societies could realize their ideals (Bohman, 2001). According to the Stanford Encyclopedia of Philosophy, critical theory "must explain what is wrong with current social reality, identify the actors to change it, and provide both clear norms for criticism and achievable practical goals for social transformation" (Bohman, 2001, p. 1).

Critical theory guided this inquiry and was a good fit for this study for several reasons. According to Bohman (2021), critical theory connects empirical and social sciences to "normative claims of truth, morality, and justice" (p. 1). Critical theory, which targets

claims about social and political practices, illustrates how those in power violate the conditions of rationality (Bohman, 2021). Meriam and Tisdell (2016) suggested that critical theory envelopes these multiple social realities and recognizes multiple truths – the truth of the subject, the one in control, and that of the object, the oppressed.

Critical theory was a good fit for this study because it focuses on historically marginalized populations (Hartlep, 2009). Higher education in the United States initially excluded women. Today, women attend universities and act as faculty, although a disproportionate number of full professors are men in the STEM disciplines, as discussed earlier in this paper. Although women must meet the same research and publishing criteria for tenure, as they carry a larger portion of the service load, they have less time to devote to those activities (Larsen & Austin, 2020; Falci & Watanabe, 2020; Flaherty, 2020; Guarino & Borden, 2017). With less time to devote to these endeavors, male faculty may have an advantage in achieving tenure and promotion (Bentley & Adamson, 2003).

Critical theory also speaks to the power differential. With men STEM faculty holding 64% of the full professor positions, they have a position of power. Interest convergence is a term used to describe when the interests of those in power briefly coincide with those of the oppressed (Milner et al., 2013). According to Bell (1980), interest convergence may be present where the body in control releases a portion of its power when it benefits them. When the dominant group relinquishes a bit of its power, they are commended as forward-thinking and generous when they have nothing to lose (Bohman, 2001; Hartlep, 2009). In addition to interest convergence, a false meritocracy may be at work. The meritocracy idea translates that if women worked harder, they could be promoted or awarded a grant when the research does not bear this out (van Dijk et al., 2020). This gives the group in control a clear

conscience because they are not responsible for the females' inability to promote (Bohman, 2021; Harltep, 2009).

A final reason that critical theory was used as a guide is that critical theory challenges the status quo and current assumptions (Bohman, 2001). Addressing political issues such as human rights and other moral issues is the function of critical theory. "Inquiry that aspires to the name 'critical' must be connected to an attempt to confront injustice" (Kincheloe et al., 2011, p. 164). Identifying issues is the first step in addressing the power differential that exists in higher education. Exploring the participants' lived experiences will help unveil the type of power differential and provide beneficial information to make changes for the next generation of female STEM professors.

Design of the Study

This study was qualitative and framed by critical theory and used the phenomenological approach. “Qualitative methods typically produce a wealth of detailed information about a much smaller number of people and cases. This increases the depth of understanding of the cases and situations studies but reduces generalizability” (Patton, 2002, p. 14). According to Creswell (1998),

> Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting. (p. 15)

This study aimed to determine the shared, lived experiences of women full professors in STEM through a series of interviews, a demographic survey, and an analysis of the participant's curriculum vitae in alignment with the overarching question. All participants

were from R3 institutions that have applied for a National Science Foundation (NSF) ADVANCE grant. Selecting institutions that had an interest in an NSF ADVANCE grant was essential to the study as it demonstrated the STEM school's or college's commitment to gender equity. Findings may reveal policies or programs that may benefit Missouri State University's efforts.

Phenomenology is the study of people by describing their experiences (Husserl, 1913/1962) and interpreting those experiences (Merriam & Tisdell, 2016). This study utilized the phenomenological approach as it attempted to understand the experiences and choices of the participants, the knowledge they gained from these choices and experiences, and how they made sense of their experiences in their journey to become full professors in STEM. According to Creswell (2013), phenomenology focuses on the singular essence of experiences within a particular group, and the researcher strives to describe the nature of these shared experiences or phenomena. According to Patton (2015), to conduct phenomenological research is to subscribe to the following:

> The assumption is that there is an essence or essences to shared experience. These essences are the core meanings mutually understood through a phenomenon commonly experienced. The experiences of different people are bracketed, analyzed, and compared to identify the essences of the phenomenon, for example, the essence of loneliness, the essence of being a mother, or the essence of being a participant in a particular program. The assumption of the essence, like the ethnographer's assumption that culture exists and is essential, becomes the defining characteristic of a purely phenomenological study. (pp. 116-117)

The phenomenological approach emphasizes the participants' reality, and their perception is essential (Patton, 2002). Understanding the lived experiences of these women in their journey to full professor will provide insight to future female professors.

Setting

In this study, faculty at universities that met the Carnegie Classification of Institutions of High Education for doctoral/professional degree-offering institutions (R3) and applied for NSF ADVANCE grants were interviewed. The R3 designation signifies teaching focus, although research is often required. Each institution chosen for this study has expressed the desire to improve gender equity in STEM professors, as evidenced by their ADVANCE grant application. ADVANCE encourages STEM departments in higher education and not-for-profits to address institutional structures that may impact women faculty, including intersectional identities, through grants to conduct self-studies and to develop and implement strategies for institutional change. STEM departments have conducted studies and evaluated their STEM departments for equity issues regarding tenure, promotion, and balanced service for females.

R3 institutions located in the United States Midwest region were included in the study. There are 29 institutions in this classification in the United States. Of these, seven have also applied for an NSF ADVANCE grant. Four of these are in the study area of the Midwest United States. The research findings at these institutions will be more likely transferrable to Missouri State University, an R3 institution. In addition, institutions that have applied for this grant may be more interested in participating in gender equity research reducing the nonresponse error (Mertens, 2020). There was a participant from each of the four institutions identified as R3 in the Midwest.

Participants

Participants were selected using the purposeful sampling method. According to Merriam and Tisdell (2016), the purposeful sampling method is a strategy to choose the participants for a study based on what the researchers want to discover. Participants were selected based on whom the researcher could gain the most insight. Examination of faculty websites for each of the selected R3 institutions revealed 129 women STEM, biology, chemistry, physics, mathematics, and earth sciences were included, full professors at the time of this writing. An email (Appendix A) was sent to each full professor at the four selected institutions requesting their participation. The respondents agreed to participate in the study by returning the consent form (Appendix B), submitting a current curriculum vitae, and completing a short demographic survey (Appendix C). After the initial solicitation, there were five responses. A second solicitation sent out two weeks later resulted in no additional responses. Tables 1-3 present demographic information from the surveys and curriculum vitae.

Table 1

Participant Demographic Data Derived from Curriculum Vitae and Survey

Participant	Age Range	Race	Marital Status	Discipline	Children	Spouse
I	55-65	White	Married	Math	Y	Professional
II	45-55	White	Married	Biology	Y	Academic
III	55-65	White	Married	Chemistry	Y	Academic
IV	45-55	White	Married	Chemistry	Y	Academic
V	45-55	White	Married	Biology	Y	Professional

Table 2

Participant Academic Timelines Derived from Curriculum Vitae and Survey

Participant	Years Post Doc	Ph.D. to Professor	Years as Asst	Years as Assoc	Leadership Positions
I	0	11	5	6	N
II	2	12	7	5	Y
III	3	16	5	6	Y
IV	3	18	6	7	N
V	0	14	7	5	Y

Table 3

Academic Productivity Derived from Curriculum Vitae and Survey

Participant	Publications	First Author	Conference Presentations	Research Funding	Publish With Spouse
I	20	15	15	Yes, but $ Not Provided	N
II	31	4	>50	>$1,000,000	Y
III	75	40	35	>$1,000,000	Y
IV	11	6	>40	Yes, but $ Not Provided	Y
V	17	6	>12	>$250,000	N

Data Collection Tools and Procedures

Interviews and document analysis were utilized in the study. Participants provided their perspectives and personal history through in-depth semi-structured interviews. Interviews were chosen as a data collection method as they offered the opportunity for follow-up questions and allowed a two-way conversation. The reasons behind the responses could be explored. Interviews also allowed the time needed for participants to reflect and

open up about possible sensitive experiences. While the survey provided basic demographic data, analysis of the participant curriculum vitae uncovered vital information regarding the professional productivity of each as well as a professional timeline. Each participant had the opportunity to review and verify the information on the transcript as a means to member check. The triangulation of these data sets and information can be verified and cross-checked, strengthening the study (Patton, 2002).

Interviews

Participants from the selected universities were interviewed using a single, semi-structured interview protocol (Appendix D). A semi-structured interview is one in which there are a few predetermined questions. A semi-structured interview was chosen as the prepared questions guided the conversation and allowed for open-ended, more in-depth responses. An initial list of possible follow-up questions was developed to seek clarification or amplify the participants' comments. Additional follow-up questions were developed after the interview with each participant. The participants were provided a confidentiality statement and consent form (Appendix B) at least two days before the interview and selected an appointment for the 60- to 90-minute interviews using Survey Monkey. The interviews were conducted through the Zoom platform, beginning with verbal consent, and were recorded on an external hard drive. Interviews were conducted on Zoom to obtain the maximum number of interviews and reduce travel time and costs. Seidman (2019) cited a challenge in conducting long-distance interviews, especially when the interviewer chooses the method rather than the participant. Because the interviewer gained something from the participants, yet the participants did not benefit from the interview, the interviewer was purposeful in their contacts (Seidman, 2019). When emailing, scheduling, and obtaining

consent, the interviewer ensured genuine interest was expressed, and the participant and the subject matter were properly respected (Seidman, 2019; Meriam & Tisdell, 2016).

After securing consent and establishing the time and procedure for the interview, participants were asked to describe their experiences from childhood to becoming a full STEM professor. Because the investigation is of the path of female STEM professors in higher education, it was advantageous to determine previous educational experience, both formal and informal. Jottings were taken during the interviews if the participants said something unclear or a follow-up question was needed. Seidman (2019) suggested taking jottings or notes as the interview progresses. Rowan (1981) used the term dialectical process to describe the relationship between the participants' words and how the researcher responds. Explaining the need for notes beforehand helped put the participant at ease and minimized distractions.

Additional questions focused on the participants background and experiences regarding their academic career and their lived history regarding their journey to full STEM professor. Questions included how they chose their career, the type of institution they attended, and the process of their hiring, promotion, and tenure to a professor. Also included were questions as to the relationship with their doctoral program institution, instructors, and mentors. Appendix C contains a final list of questions used in the interviews.

Because each word a participant choose is part of their understanding of the phenomenon, a recording of each one-hour interview was essential for the interview process (Seidman, 2019). Still, as anonymity was of utmost importance (Seidman, 2019), the hard drive was kept locked and secure in the researcher's office.

Documents

Curriculum vitae and demographic surveys were collected for this study. Document analysis of these documents was used in addition to the interviews to establish a timeline for each participant. Document analysis is often combined with other qualitative research methods as a means of triangulation—"the combination of methodologies in the study of the same phenomenon" (Denzin, 1970, p. 291). The qualitative researcher is expected to draw upon multiple (at least two) sources of evidence, that is, to seek convergence through different data sources and methods. Like other qualitative methods, document analysis requires that each document be examined and interpreted by the researcher to gain meaning and understanding (Corbin & Strauss, 2008). The documents analyzed in this study were the curriculum vitae provided by the participants and short demographic surveys.

Data Analysis

Patton (2015) stated the importance of context and rich, thick descriptions when exploring participants' shared experiences using the phenomenological methodology. Interviews were coded by a Roman numeral I through V to trace information to its original transcript location using the line number. According to Creswell (2018), the analysis requires separating the researcher's experiences from the data utilizing reduction and bracketing. The transcript did not contain the names of the participants but instead had colors for each participant. The list of participants, transcripts, and the external hard drive were kept in separate and secure locations to protect participant confidentiality. For the writing process, pseudonyms were used rather than Roman numerals.

Document Analysis

The survey provided demographic data, including marital status, gender identity, publications, grants, age range, and race. The curriculum vitae detailed their publications, publication colleagues, grants, presentations, and a timeline of their undergraduate and graduate experience and their advancement through their academic careers. These data are provided in Tables 1 through 3.

Interview Analysis

After each interview, Otter.ai transcription software was used for transcription, and line numbers were added. After transcription, listening to the interview recording while reading the transcription provided the opportunity to make corrections. Identifying information was removed from each transcript, and a Roman numeral was assigned. After the accuracy of the transcript was confirmed, each transcript was printed on colored paper corresponding to the color code assigned to the participant and provided as a working document. During the second reading of the transcripts, data points were highlighted, underlined, and paraphrased in the margins without any attempt to categorize the information. The phenomenological reduction, or bracketing, was employed during the second reading and set aside the researcher's perspective and focus on the participant’s meaning of her experience (Merriam & Tisdell, 2016).

This study collected and analyzed data throughout the process called the constant comparative method (Mertens, 2020). The first step in the constant comparative method is open coding or separating information into discrete data items. The participants' experiences were separated into discrete items and organized in a document under the interview questions without any attempt to assign themes or trends. This process was repeated after the interview

with each of the five participants. The analysis followed the method described by Seidman (2019, pp. 127-136). Two copies of the discrete items document were copied onto colored paper coded to the participants. One set was kept as a working document, and one was separated into slips of paper each containing one discrete item from the participant interview, known as open coding. These were the data points that were used in the winnowing process.

After the interview with each participant, the reading and rereading of the transcript and the discrete items were organized under the question headings, participant experiences were sorted and grouped thematically (Seidman, 2019; Meriam & Tisdell, 2016; Krueger & Casey, 2015). Similar items were grouped to permit the researcher to discover themes and were determined inductively without predetermined categories (Seidman, 2019). Related participant experiences were grouped to reveal codes and categories. Grouping of related data to reveal patterns and trends is the axial process. As coding progresses, development of themes, arranging and rearranging passages, phrases, and themes continues. The researcher begins to pare down the information to only the most relevant to the research. Horizontalization is the process of developing a list of significant participant statements. It allows for processing data giving equal weight to all experiences in the initial stages of analysis but removing repetitive data (Merriam & Tisdell, 2016). The experience is essential, not the number of times it was mentioned.

Seidman (2019) warned to "err on the side of inclusion" (p.127). All interview data were considered since eliminating data in the early stages of the interviews may result in missing trends and relationships (Krueger & Casey, 2015; Merriam & Tisdell, 2016). By not eliminating any data initially, the participant’s voices and words were heard, an essential piece in exploring the essence of their lived experiences. Experiences that arose were the

basis for additional questions for future interviews. This information was used to present the thematic findings. The slips of paper, the discrete pieces of information, were searched for keywords used as initial labels. Individual pieces of information were sorted into the keyword labels identified. Although computer programs will assist researchers by holding the data, Seidman (2019) suggested completing the exercise on paper first, cautioning that information can be lost when looking at a computer screen. Reading through the transcripts also allows follow-up questions to be developed for the remaining participant interviews (Krueger & Casey, 2015; Lincoln & Guba, 1985; Strauss & Corbin, 2014).

Efforts to Support Quality Research

The final product should "seek connections, explain connections, and build interpretive categories" (Seidman, 2019, p. 135). The findings section included a complete description of the participants' experiences, revealing what these successful STEM professors had in common, exploring their successes, and presenting the contradiction in their career paths. Replication of a qualitative study will not have the same results. Social sciences do not lend themselves well to reliability since, as Merriam and Tisdell (2016) stated, "human behavior is not static" (p. 250).

Respondent Validation

Member checks are when data and information are verified or tested with the participants from which the data, interpretation, or conclusion was gleaned. Member checks or respondent validation were conducted to ensure the findings were accurate and honest (Merriam & Tisdell, 2016; Mertens, 2020; Patton, 2002). After the interviews were transcribed, the participants were allowed to review and comment. Consulting the initial interview transcript and recording also ensured the reporting of the participants' accurate

perceptions. According to Maxwell (2013), this is the most critical way of ruling out the possibility of misinterpreting the meaning of what the participants say or do.

Cultural Bias

It is also vital to help identify personal biases and ensure the researcher correctly interprets the participants' words (Merriam & Tisdell, 2016; Mertens, 2020; Patton, 2002). Observations and previous research contribute to preconceived notions. It is, however, the role of the researcher to remain neutral to the extent possible. A journal was kept to mitigate researcher bias and to record reflections, personal feelings, and emotions arising from the interviews. Referring to the journal and using it to keep track of decisions, thoughts, and ideas helped the researcher stay aware of personal biases. As the study unfolded, beliefs and prejudices were noted and bracketed (Meriam & Tisdell, 2016). The journaling and bracketing helped the researcher be more aware of their bias and improved confirmability.

Research Positionality

This study examined the experiences and perceptions of female STEM professors in professional doctorate degree-granting, R3, institutions. Although the researcher was from the same culture, it was as an instructor and graduate student, an outsider to the professor rank. This relationship is what Merriam and Tisdell (2016) referred to as an insider/outsider relationship with the participants. This similar positionality may result in a more accessible and higher level of trust with the participants (Vicars, 2012). However, according to Johnson-Bailey (2004), a portion of the researchers' positionality does not match the participants. "The point of critical research is generally to do research with people, not on people" (Merriam & Tisdell, 2016, p. 64).

Transferability

Applicability to other settings or circumstances is the transferability of qualitative research (Noble & Smith, 2015). Universities that share the same Carnegie Classification and the desire to improve gender equity in the academy, as evidenced by their application for the NSF ADVANCE grant, ensure a high probability that the findings may apply to Missouri State University as well as other R3 institutions.

Limitations of the Study

A limitation of this study was that the focus was on one type of institution. As a result, the results may not apply to other types of institutions. Another issue of the study was the small sample size. However, qualitative methods "permit inquiry into selected issues in depth … and typically produce a wealth of detailed data about a much smaller number of people and cases" (Patton, 2002, p. 227). Although ten was the planned sample size, a second solicitation did not result in additional participants. There were no further efforts to solicit participants.

Self-reported data were another limitation of the study. When analyzing data, including the participant's words as much as possible allows readers to form their own opinions regarding the experiences and perceptions of the participants. However, as with any data collected years, sometimes decades, after the events occurred, recall may be an issue. Issues with self-reported data include honesty or participants tailoring their responses to protect themselves (Mertens, 2020). As this phenomenological study focused on participant perceptions, all statements were considered pure and taken at face value from the participants. Further, participants may provide the information they think the researcher is

expecting (Seidman, 2019). Possible issues with self-reporting data were minimized by asking follow-up questions in a neutral tone and avoiding confirming gestures and reactions.

Significance of Study

The number of STEM women doctorates has increased more than women promoted to professor. Numerous studies have documented the barriers women face in the career path to STEM full professors. Mitigation efforts to address these barriers have been in place for over two decades. As reported by the works of researchers such as Laursen and Austin (2020), policies to reduce obstacles and the resulting changes and successes are well established. While these measures have not failed, progress is limited. This study aimed to investigate the lived experiences of women STEM full professors at R3 institutions. Understanding the common beneficial experiences of these women may provide insight into the supports needed and where they will have the most impact on young women.

Interviewing female STEM professors in the Midwest R3 universities provided insights into their obstacles and how they overcame them. These interviews, surveys, and document analysis brought forward the experiences and formal and informal policies that benefit or deter women in promoting to full professor.

Summary

The number of women full professors in STEM remains low despite the number of STEM doctorates awarded to women being similar to men. A review of the literature revealed that barriers to the promotion of women in STEM promoting to full professor has been well studied. Less studied are the catalysts to the success of women full professors in STEM. This study aimed to determine the factors influencing the successful promotion of women in STEM to full professor. Guided by critical theory, this qualitative,

phenomenological sought to explore the lived experiences of five full professors from STEM departments at four R3 universities in the Midwest. Curriculum vitae and a demographic survey provided timeline and demographic data, while a semi-structured interview provided the rich-thick descriptions and singular essence of the participant experiences. Discrete items were arranged into themes using the constant comparative method through open coding and axial coding. Limitations of the study included the low number of participants and a limited number of universities included in the study. Understanding the common beneficial experiences of these women may provide insight into the supports needed and where they will have the most impact on young women.

Section II. Practitioner Context for the Study

Introduction

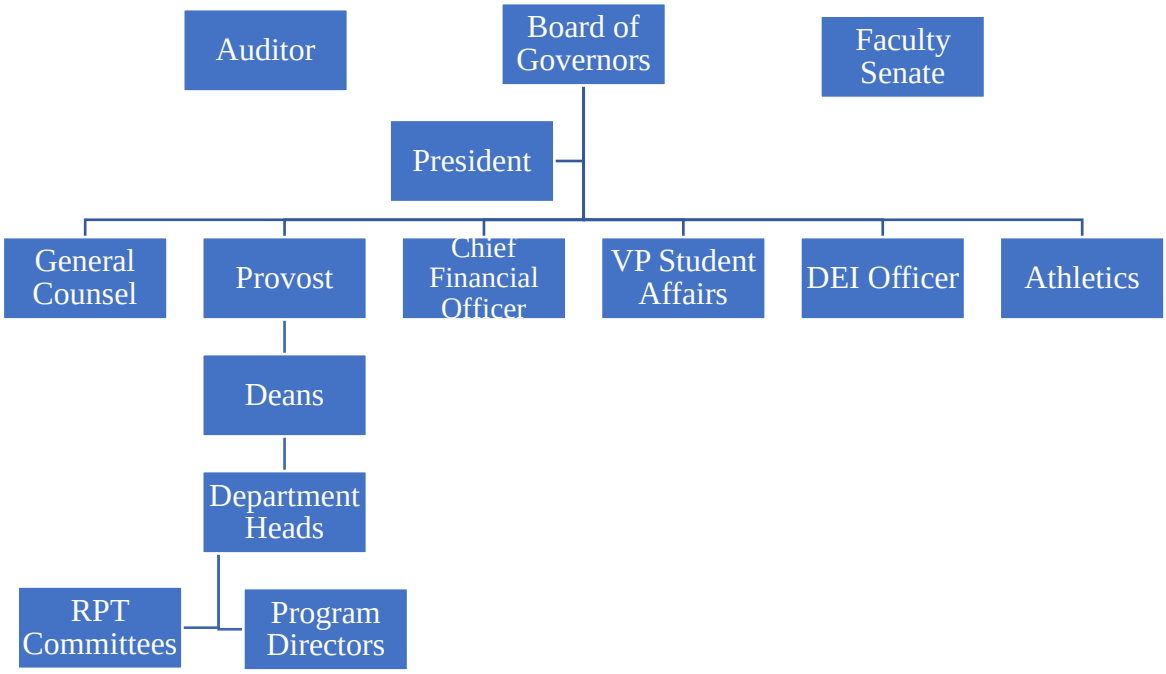
This section will address the context for the study, including the history of higher education in the United States, the common leadership structure in higher education, and policies impacting gender inequity in leadership positions and faculty. A discussion of the study's broader implications in the practitioner context will follow, specifically, what factors contribute to the success of women academic experiences who have attained full professors in STEM and document the preparatory experiences for academia for women in the STEM fields.

History of Higher Education in the United States

The first universities in North America were pre-colonial, including Harvard, The University of New Jersey (Princeton), Yale, and William and Mary (Thelin, 2018). Established initially by the Puritans, each of these had, at least on paper, a course of study on divinity (Gardner, 2018). The general organizational structure more closely followed that of the Scottish institutions of the day, with a president endowed with legitimate power (Thelin, 2018). In contrast, the faculty of Cambridge and Oxford had the actual authority at their institutions. Although professors maintain autonomy regarding the content of their teaching, the college or university's goals, mission, and direction are dictated by the president under the direction of the board of governors. Table 3 is an illustration of the generic structure of colleges and universities in the United States.

Figure 3

Generic University Leadership Structure in the United States



According to Thelin (2018), colonial college was "trying to impart on their privileged sons a sense of responsibility and public service' (p. 26). Although these colonial colleges later became known as the Ivy League with a sense of elitism, this was not the original intent. Colonial leaders felt it essential that the next generation be literate and instill a sense of duty.

Kings College described its mission as "to enlarge the mind, improve the understanding, polish the whole man, and qualify them to support the brightest character in all the elevated stations of life" (Columbia University, 1993, para. 3). The entrance exam might have been given to women as a courtesy. If they performed satisfactorily, the female applicant might have been given a certificate that acknowledged their satisfactory performance, but they were not allowed to enter a course of study (Pierson, 1976).

College enrollment for women was still small in the mid-1800s during the "new national period." However, between 1800 and 1860, at least 14 colleges accepted women (Eisenmann, 1997). The first colleges for women opened in the 1840s and 1850s, with the Midwest being the most welcoming, with Michigan, Wisconsin, and Ohio each having three colleges (Thelin, 2018). Early curriculum for women would focus on conventional feminine roles such as managing the household, supervising servants, and becoming a proper hostess, wife, and mother (Farnham, 1994).

In the mid-1800s, women were not considered agents of change. Universities hired women only as a concession when their male spouses were employed and only in minor roles (Thelin, 2018). This often resulted in women looking outside academia for opportunities in museums and laboratories (Rossiter, 1982). Grunert (2010) noted women still look outside academia for opportunities.

After the Civil War, admission became more open to women, although women tended to apply to smaller programs and had a history of many years to complete (Thelin, 2018). In the early 70s, it was apparent women were not applying to graduate programs in Science, Technology, Engineering, and Math (STEM) (Sandler et al., 1982). In their book, *The Classroom Climate: A Chilly One for Women,* Sandler and Hall described the 1970s university climate as "chilly" toward women (1982, p. 4).

Policies Impacting Gender Inequity in Higher Education

From the outset, women were prohibited from participating in the higher education system in the United States. It was not until after the Civil War that women became more accepted as students, but the acceptance did not necessarily translate to teaching positions in college. There was a fundamental belief that women were not physically capable of

withstanding a rigorous course of study (Thelin, 2018). Women would be susceptible to various physical ailments such as fever and, at the very least, become unfeminine (Thelin, 2018).

Although the Equal Employment Opportunity Act of 1972 makes it illegal to discriminate based on race, color, religion, sex, or national origin (EEOC, 1972), policies and biases have remained in higher education (Laursen et al., 2020). Promotion and tenure policies are on a set timeline. Females wishing to have families are sometimes forced to choose between tenure and having children or having the number of children they would like (Laursen & Austin, 2020). The research and publication requirements can be an inequitable burden on females as they are more often than not the caregiver for young children and, increasingly, elder parents. Meaning during breaks and summer vacation, when most research and writing are accomplished, they split time between caring for family and caring for their career. Applying for and bringing in grant money are much the same issue. Universities have tenure clock policies and Family Medical Leave Act to assist women. Still, as Laursen and Austin (2020) suggested, women do not use these policies due to their stigma. They offer that policies such as these are simply trying to fix the women, not the cultural problem.

Another factor that impacts women is the lack of a dual career hire policy. Women are more likely to have a spouse in the sciences as well. If the spouse cannot find fulfilling work in their field, the female is likelier to leave their position. Even when such policies exist, women may be reluctant to ask for such concessions, fearing it will negatively impact their application.

Implications for the Research in the Practitioner Setting

There remains a tremendous need for gender equity across the academy in the STEM departments. According to the NSF (2014), 26% of faculty in the United States are tenured female STEM faculty. Numbers this low cannot be explained by a lack of doctoral graduates or demographic inertia, a lag in the retirements of the present staff. A natural result of the more significant number of male professors is a greater number of males in leadership positions. This topic remains as relevant for colleges and universities across the United States as when Sandler and Hall described the chilly climate in 1970.

There are 30 universities or colleges with the Carnegie classification of professional doctorate-granting institutions in the United States (Carnegie Classification of Institutions of Higher Learning, 2021). Of these 30 institutions, only six have applied for an NSF ADVANCE grant to address gender inequity at their institution. One institution was excluded as it is the home institution for the researcher. Another was excluded as it is a virtual university. This study is being undertaken to learn the shared experiences of women STEM professors at these institutions. By revealing these similarities, it may be possible to adopt new procedures and policies at MSU to improve gender equity within the STEM fields.

Organizational Analysis of Missouri State University

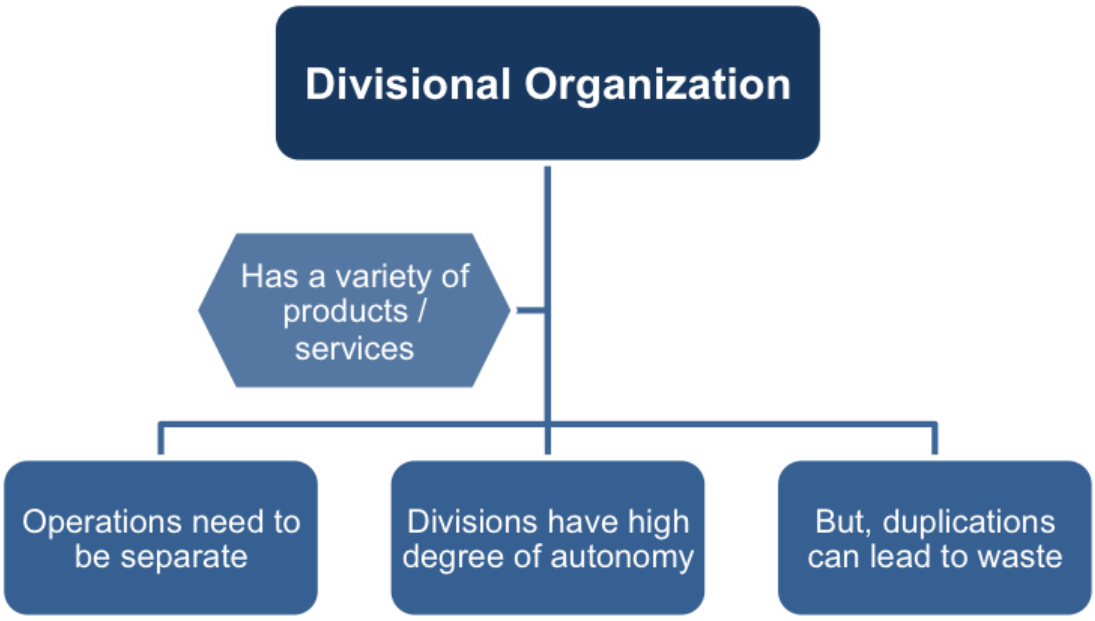
Missouri State University (MSU) follows the structure of Mintzberg's (1979) divisionalized organization. United by a shared vision and mission, each college has much freedom in accomplishing its goals. Figure 5 illustrates how each division falls under the direction of the primary leadership. Still, each has a high degree of freedom in their daily operations, competes for resources, and has the potential for greater repetition in their operations, leading to waste. Clear goals and lines of communication are necessary to keep

operations efficient and productive in such divisionalized structures (Mintzberg, 1979). This is true of MSU as well. For the organizational analysis, it is helpful to view the institution through the four frames of Bolman and Deal (2017).

The four organizational frames of Bolman and Deal (2017) include human resource (HR), political, structural, and symbolic. The human resource frame emphasizes the needs of its people, rewards them for excellence, and enables them to do their jobs well and with a high degree of satisfaction. The HR frame also places a high degree of focus on the well-being of their people, supporting personal growth and human interaction.

Figure 4

Mintzberg's Divisional Organization Chart



Note: From Mintzberg's Management Roles. Free Management e-Books.

Evidence of the human resource frame includes the many professional development opportunities available to faculty and staff. Although these opportunities exist, there is sometimes a lack of communication. Information filters through the layers of the Mintzberg divisional model. With so much information, the deans sometimes find it necessary to filter

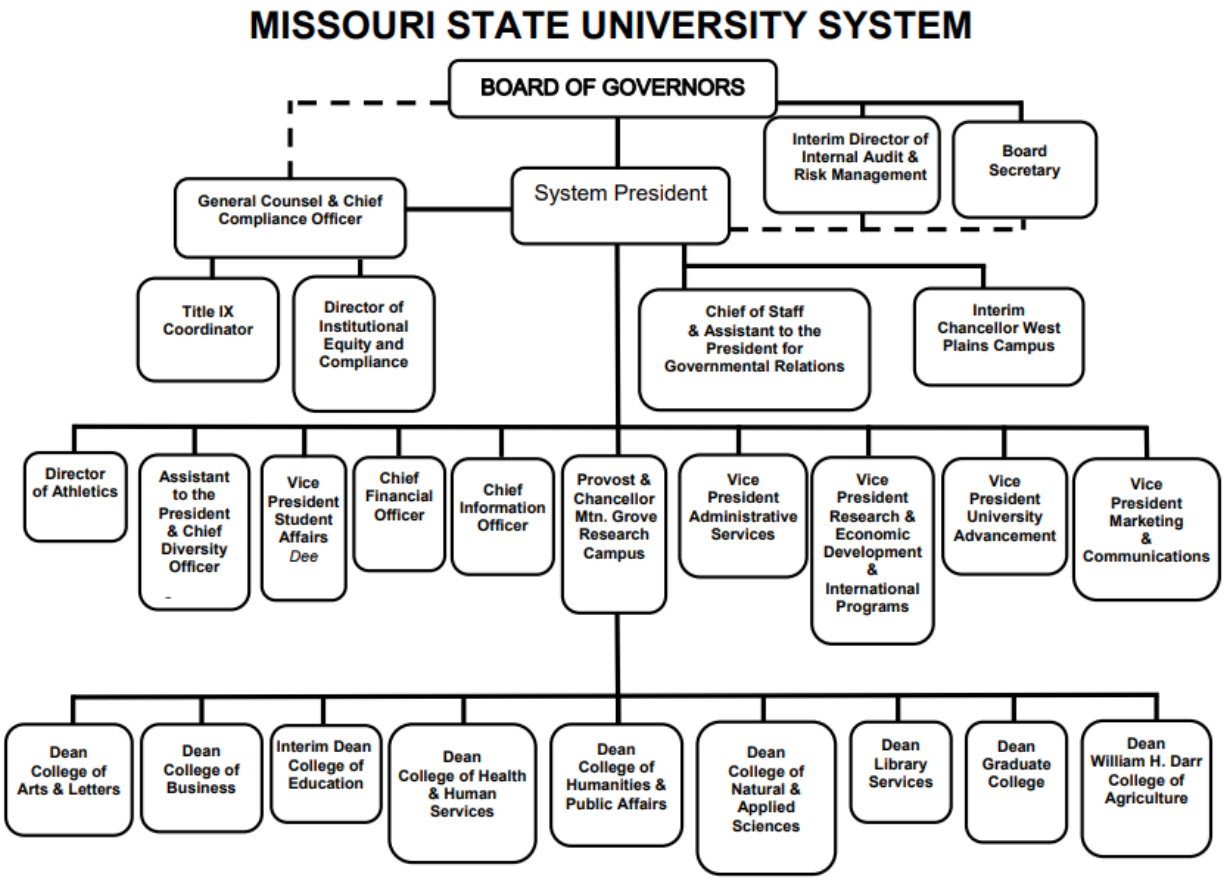
information and opportunities. The workshops are always listed in the My Learning Connection tab of MyMissouriState.edu, but faculty must keep looking at the site. Training is available, just not targeted to individuals the professional development opportunity might best serve.

The political frame addresses conflicts and coalitions between individuals and special interest groups and the use of power. The Governor of Missouri appoints the MSU Board of Governors. The board includes representatives from each district, from both political parties, and for a limited term. They are representative of the population of Missouri and accountable to it. Because the board members are from different backgrounds, coalition building and compromise are part of the process, especially in times of finite resources. When resources are limited, hard choices must be made (Bolman & Deal, 2017). During the recent pandemic, the political frame allowed some tough choices possible.

The structural frame (Bolman & Deal, 2017) is task-oriented and focuses on the necessary steps for a successful operation and change. There is a focus on the mission, including SMART goals (specific, measurable, realistic, and time-specific) (University of California, 2017). Figure 6 illustrates the current organizational structure of MSU as outlined in the Missouri State University Fact Book 2020-2021. There are clear lines of hierarchy, similar to the incident command structure used by emergency management personnel. As seen recently with the COVID pandemic and other emergency issues, these lines of communication allow for a rapid response in times of crisis. Strategy can be installed quickly, and information disseminated through the set chain of command. This ensures that all faculty and staff are informed of changing policies, another positive characteristic of the structural frame.

Figure 5

Organizational Chart for Missouri State University 2021



Note. Adapted from https://www.missouristate.edu/Assets/about/Missouri-State-University-System-6-2021.pdf (MSU, 2021a).

According to Bolman and Deal's (2017) structural frame, change is facilitated by developing a strategy and setting responsibilities and tasks. During the COVID pandemic, faculty and staff members knew their duty and contacts in case of questions. A recent event with a student teaching experience required immediate action and strategy development. The robust structural frame of MSU allowed the required action plan and communication structure to be disseminated rapidly.

The symbolic frame (Bolman & Deal, 2017) is evident within the MSU institution by establishing meaning and a sense of purpose within the faculty and staff. A vital aspect of the symbolic frame is inspiring the workforce through a motivating mission and vision statement and recognition of outstanding performance through celebrations and awards. Missouri State University exhibits a robust structural frame. The mission statement refers to "educating global citizen scholars dedicated to public affairs" (MSU, 2021a, para. 1). The values include words of excellence, commitment to integrity, respect, pride, and responsibility. Faculty and staff accomplishments and student body members are celebrated at lunches and dinners and announced publicly in university press releases. The president leads the way, ensuring that all the divisions have mission statements supporting the university's mission and vision. He announces accomplishments in his weekly communication—the three pillars of the public affairs mission guide programs at all levels.

MSU administration can successfully navigate into the future with a solid structure, supports established, and a pledge of collaboration and innovation. Having parts of all the frames in place allows MSU to inspire students and faculty who understand the public affairs mission and commitment to its Bear Family. Some pieces of the institution could use additional attention, such as communication of professional development (PD). Announcement of these opportunities could help women and underrepresented groups progress more quickly in the ranks. Offering these PD opportunities suggests that at least some of the Scientific Management may be at play.

Taylor (2005) reviewed the principles of scientific management in the Classics of Organizational Theory. Discussed are the four parts of scientific management: gathering and reducing this knowledge to formula and law, the scientific selection of workers and

subsequent training, bringing together the science and worker, and a division of work in which the management takes half the responsibility. MSU excels at gathering data. Although data are expensive and time-consuming if the information is collected but not helpful, it is a waste of resources and not in keeping with the scientific management theory. One must only examine the MSU website to verify the data collected. A missing piece is that data sets are not usable when examining multiple identities. For example, a committee working on a grant application needed demographic information to complete the paperwork, but the data sets were not searchable in different offices.

The second principle, scientific selection, may be illustrated by offering awards for teaching innovation and grants for innovation development. Innovations are encouraged and rewarded. Innovations are shared, and management and workers are brought together through the annual Faculty Teaching and Learning Showcase each year. Finally, providing mentors and counseling to faculty and staff who receive inadequate teaching evaluations or are not making sufficient progress toward tenure are examples of management taking responsibility for worker performance.

Leadership Analysis

The University is under the president's direction, supervised by the Board of Governors, acting as the strategic apex. The president supervises ten middle management positions, including the provost, who oversees the colleges (divisions). There is financial, legal, technical, and administrative support staff, to name a few. As a type of checks and balances, the elected Faculty Senate reports directly to the Board of Governors.

Visions in universities are not manufactured: they are harvested. The president's role is to take the lead in cultivating an institutional climate where openness, mutual respect, and

the release of creative energies are valued as acts of leadership in themselves. (Downey, 2001, p. 93)

Although the president may be the ultimate authority and CEO of the University, his openness to ideas and his messages to the "Bear Family" illustrates a characteristic of the transformational leader. Acting as the University's biggest supporter, the president provides inspirational messages. This would also indicate what Northouse (2019) would classify as a transformational leadership style. The president is trying to inspire those in the Bear Family to accomplish more than what would typically be possible. One example is a reception for all new faculty at the president's home to welcome them to the family and begin establishing a relationship.

The president can routinely be seen walking the campus greeting students and faculty alike, not as the CEO but a fellow Bear, not as a manager but as a leader. "Those who prioritize management over leadership will fail to tap into the vision and commitment of the constituents to bring about excellence" (Morris, 2016). Management differs from leadership. Management reduces chaos, allows more efficient and effective operation, and produces change and movement (Northouse, 2019). The current president of MSU seems to understand this. With a good support staff to manage the day-to-day, the president can focus on leading the University and helping steer it into the future. He is free to talk to leaders in the university community as well as community and state leaders. Today's university leaders need transparency, honesty, and equity (Morris, 2016). High-quality relationships based on trust, loyalty, and mutual respect are characteristics of a successful transformational leader (Notgrass, 2014).

Although the current president may not be a truly transformational leader, they exhibit a strategist's characteristics. Particularly successful in transformation, strategists believe that every aspect of their organization is open to discussion and change (Rooke et al., 2017). MSU leadership has demonstrated its commitment by establishing diversity, equity, and inclusion as integral to the three pillars of ethical leadership, cultural competence, and community engagement (*MSU Fact Book*, 2019). However, females have not been readily accepted as diversity hires, and gender equity is not recognized as a need. This reluctance indicates additional data must be assembled and presented to upper management to support continued advancement in female recruitment, promotion, and retention.

Policies Impacting Gender Inequity in Higher Education

From the outset, women were prohibited from participating in the higher education system in the United States. It was not until after the Civil was that women became more accepted as students, but the acceptance did not necessarily translate to teaching positions in college. There was a fundamental belief that women were not physically capable of withstanding a rigorous course of study (Thelin, 2018). Women would be susceptible to various physical ailments such as fever and, at the very least, become unfeminine (Thelin, 2018).

Although the Equal Employment Opportunity Act of 1972 makes it illegal to discriminate for reasons of race, color, religion, sex, or national origin (EEOC, 1972), policies and bias has remained in higher education (Laursen et al., 2020). Promotion and tenure policies are on a set timeline. Females wishing to have families are sometimes forced to choose between tenure and having children or having the number of children they would like (Laursen & Austin, 2020). The research and publication requirements can be an

inequitable burden on females as they are often the caregiver for young children and, increasingly, elder parents. Meaning during breaks and summer vacation, when most research and writing are accomplished, they split time between caring for family and caring for their career. Applying for and bringing in grant money is much the same issue. Universities have tenure clock policies and Family Medical Leave Act to assist women. Still, as Laursen and Austin (2020) suggested, women do not use these policies due to their stigma. They offer that policies such as these are simply trying to fix the women, not the cultural problem.

Another factor that impacts women is the lack of a dual career hire policy. Women are more likely to have a spouse in the sciences as well, 49.6% for women compared to 36.3% for men (Laursen & Austin, 2020). If the spouse cannot find fulfilling work in their field, the female is likelier to leave their position. Even when such policies exist, women may be reluctant to ask for such concessions, fearing it will negatively impact their application.

Implications for the Research in the Practitioner Setting

According to the NSF (2014), 26% of faculty in the United States are tenured female STEM faculty. When examining the intersectionality of females and persons of color, the percentage is reduced to 2.3. Numbers this low cannot be explained by a lack of doctoral graduates or a lag in the retirements of the present staff. Although some recent hires at MSU have slightly improved the male-to-female ratio in the STEM departments, this trend continues. However, two College of Natural and Applied Science Departments have just one tenured female professor. There remains a tremendous need for gender equity across the academy in the STEM departments. A natural result of the more significant number of male professors is a greater number of males in leadership positions in the university. According to

the MSU Fact Book (2019), only two of ten vice presidents and three of nine deans are female. This topic remains as relevant for colleges and universities across the United States as when Sandler and Hall described the chilly climate in 1970.

MSU is one of 29 universities or colleges with the Carnegie classification of professional doctorate-granting institutions in the United States (Carnegie Classification of Institutions of Higher Learning, 2021). Of these 29 institutions, only seven, including MSU, have been awarded an NSF ADVANCE grant to address gender inequity at their institution. These institutions are similar to MSU and share a desire to achieve gender equity, evidenced by their commitment to the NSF ADVANCE grant program. This study is being undertaken to learn the shared experiences of women STEM professors at these institutions. By revealing these similarities, it may be possible to adopt new procedures and policies at MSU to improve gender equity within the STEM fields.

Summary

From the outset, the academic institutions in the United States have been male-dominated and a means to impart knowledge and a sense of responsibility to the next generation of male leaders. Females were excluded from the institutions even when they could demonstrate the ability. After the Civil War, the admission policy and the number of colleges for women increased. What changed much more slowly was the attitude toward women in teaching positions in colleges and universities. Females sought other opportunities to utilize their degrees partially due to the "chilly climate" and policies limiting options or stigmatizing women as something to be accommodated. According to Laursen and Austin (2020), this trend continues. Men remain in control of leadership positions. These and other

factors may contribute to the number of women STEM full professors remaining below critical mass.

The four universities and colleges chosen for this study are similar in structure, as demonstrated by their Carnegie Classification. Their application for the NSF Advance grant illustrates their desire to address gender equity. By determining the success factors of women in these similar institutions, we may gain insights that may be applied to the promotion and retention of female faculty at MSU.

Section III. Scholarly Context for the Study

Introduction

More than three decades after the civil rights movement, the United States has the highest income and advancement disparities for women and persons of color (Massey, 2008; Keister, 2000). Women continue to be victims of bias in their professional and personal lives (Massey, 2008). Both implicit and conscious biases have resulted in inequitable advancement in the job market that continues to impact earnings and quality of life (Castilla, 2008; Lempert, 2010; Tsang & Dietz, 2001). This trend is particularly evident in higher education's Science, Technology, Engineering, and Mathematics (STEM) faculty positions.

Occupational gender segregation, both horizontal and vertical, is found throughout STEM departments (DeWelde & Stepnick, 2015; Frehill et al., 2015). Horizontal segregation, the distribution into fields or subfields, is seen in the low proportions of women earning doctorates. Examples of horizontal segregation include females earning 55% of the doctorates in life sciences compared to just 25% of the engineering degrees (NSF NCSES, 2019b). In addition, when comparing the arts and humanities to mathematics and computer sciences, women earn 51% compared to 25%, respectively (NSF NCSES, 2019b). The faculty ranks in higher learning institutions also illustrate horizontal segregation, where women hold just 17% of the faculty positions in engineering compared to 39% in the life sciences (NSF NCSES, 2019b). The disproportionate number of female faculty in the instructor, assistant, and associate professor positions illustrates vertical segregation. In addition, vertical segregation is shown in the classification of the institution as well. Women are likelier to hold full-time faculty positions in bachelor's and master's degree-granting institutions. Women faculty in these institutions are 36% and 34%, respectively, compared to 23% in doctorate-granting institutions (AMS, 2019). Thus, despite the growing number of

female doctorates and increased awareness of the value of diverse workgroups (Johnson, 2018; Levi, 2017), occupational gender segregation persists.

The data are similar at Missouri State University (MSU), with male faculty holding 80% of full professor positions in the Science, Technology, Engineering, and Mathematics (STEM) departments. Male faculty comprises 68% of MSU (MSU, 2019). Despite efforts at MSU, including university-wide diversity initiatives, the numbers remain inequitable. Measures to encourage the hiring and promotion of female STEM faculty remain mostly unsuccessful, yet recognizing the importance of a diverse workgroup is growing (Rosser, 2004). While demographic inertia, the pace of change in faculty demographics, may be a factor, it cannot entirely explain the continuing trend (Marschke et al., 2007; Shaw & Stanton, 2012; Thomas et al., 2015). This occupational segregation also leads to another inequity, salaries (Bertrand, 2018; Umbach, 2007). More than three decades after the Civil Rights Movement, the United States has the highest income and advancement disparities (Keister, 2000; Massey, 2008). Women continue to be victims of bias in their professional and personal lives (Massey, 2008).

Since 2001, the National Science Foundation has approved more than 70 Organizational Change for Gender Equity in STEM Academic Professions (ADVANCE) grants totaling $270 million (NSF, 2018). These funds have provided institutions with resources to research, reflect on, and initiate measures to mitigate the barriers women face in higher education STEM departments. Findings are made public as a requirement for these grants and have provided valuable and consistent information. However, unfortunately, none of these publications have researched what makes female STEM professors successful when many are not.

Review of Literature Related to the Study

The literature research presented here will be divided into five subsections. The first subsection will include the perception of how a male-influenced climate and workplace impedes the progress of females in higher education STEM faculty positions. The second will include information on perceived barriers to women in higher education STEM fields regarding mentoring and workplace friendships. Also known as blended friendships, these workplace friendships that develop over time and extend beyond the workplace have positively impacted workplace productivity (Bridge & Baxter, 1992).

The third subsection will focus on female faculty work-family conflict issues in higher education STEM positions, and the fourth subsection will include inequalities in workload. The final and possibly the most difficult to address will be the implicit bias women face in higher education institutions. Because these impact decisions and actions unconsciously and without intent, people do not realize they are making judgments based on gender, race, age, or appearance. Although they may impact decisions positively or negatively, they are a deep-seated part of a person's background, and these may be unrecognizable to the person as bias.

Male-Influenced Climate and Workplace

The chilly climate, a metaphor first introduced by Hall and Sandler (1982), described women's unwelcoming academic environment. The data presented earlier in this document illustrated how STEM in higher education institutions is dominated by male faculty. Consequently, the climate at these institutions has "become masculinized, and women may be ignored, excluded, harassed or pressured to cover by denying aspects of their identity"

(Laursen & Austin, 2020, p. 13). This situation is widespread, inescapable, and permeates the system (Britton, 2017).

The chilly climate described by Hall and Sandler (1982) is not limited to the faculty. Women may experience this unfriendly or masculinized environment as undergraduate students. They may be dismissed, harassed, or given inequitable assignments. By the time a female is in her graduate or doctoral program, they will have certainly faced even more instances of a hostile climate that may include disrespect or microaggressions from students as well as colleagues, inappropriate posters in the workplace, intimidation, and isolation (Laursen & Austin, 2020). Davis (1989) defined microaggressions as an attempt to punish an offending behavior. These microaggressions may be intentional or unconscious actions.

Unfortunately, implicit biases have changed little over the past 30 years (Carnes et al., 2015). Male stereotypes include agentic traits, while women, perceived as deficient in these traits, are expected to be community-minded. They are tasked with more of the service work to keep the department operating efficiently. These stereotypes are a disadvantage to women. Because of their assumed nurturing nature, women are perceived as less capable of leadership, less competent, and less likely to succeed (Carnes et al., 2015). Females are expected to be more caring, and when they step outside those expectations behaving more confidently, students and faculty alike may react with microaggressions (Carroll, 2017; Laursen & Austin, 2020; Pleck, 1990). In addition, a lack of respect may be prevalent in departments, conferences, and field camps (Avallone et al., 2013).

Workplace climate is directly related to job satisfaction, retention, and productivity (Archie et al., 2015). Although there may be policies at the institutional level, it is at the departmental level where the workplace climate is incredibly impactful (Archie et al., 2015;

Britton et al., 2012; McCoy et al., 2013). The faculty connections to the institution happen at the departmental level, where specific and intentional actions by the leadership and colleagues can make the most significant impact (Campbell & O'Meara, 2014). As a result, efforts to demasculinize the workplace climate for women may result in the most significant improvement in retention and productivity for women (Archie et al., 2015; Britton, 2012).

The Role of Mentors for Women in STEM Fields

While many formal barriers to women's advancement in higher education STEM faculty have mitigation measures in place, the overall environment continues to be less than welcoming to women and underrepresented groups (Ponjuan et al., 2011). A shortage of female professors may result from the absence of mentors of the same demographic group (Hsieh & Nguyen, 2019; Johnson, 2014, 2017; Mazerolle et al., 2018). In an informal survey of the top 50 universities and medical schools in the United States conducted by the U.S. World Report in 2005, of the 33 that responded, only 16 had formal mentoring programs for junior faculty. When checking further, only six had specifically female faculty programs (Kosoko-Lasaiki, 2006). These mentoring relations take on additional importance when considering the intersectionality of race and gender. Although female faculty and faculty of color bring unique talents and a critical perspective to the academic world, they are often overlooked, slower to be promoted, and often treated with hostility leading to matriculation (Hsieh & Nguyen, 2020). When female STEM faculty have internal mentors of the same demographic group, there is a reduction in the number of departures from higher education (Mazerolle et al., 2018; Schmidt & Faber, 2016).

The type of mentoring relationship is also essential. Junior faculty can benefit from both internal and external mentoring relationships. For example, internal faculty mentors

facilitate faculty members' growth within higher education, including tenure, promotion, and expected service. These internal mentors are expected to have institutional knowledge that will help guide the junior faculty member. An external mentor, often a doctoral advisor, offers support and counsel over the faculty member's professional career. Both types of mentors are essential (Mazerolle et al., 2018).

Work-Life Balance Conflicts

Workplace friendships were another factor impacting female faculty's promotion and tenure, along with a demasculinized culture. Watanabe and Falci (2020) conducted a network analysis study to determine the family-friendly culture of 744 faculty in 26 departments in a midwestern research-based university. Data collected included colleagues disrespecting family obligations, making family obligations compatible with work responsibilities, and workload and climate perceptions. The conclusion was that departments that spend free time together and with whom they can discuss family issues have a more family-oriented culture.

Since more women have joined academia, the timetable for tenure and promotion developed from the masculinized model of the ideal worker has become problematic. Female careers may not follow the same pathway. The tenure clock can be overwhelming when household duties, child or parental care, or other responsibilities are outside their research (Williams, 2000). Females may have what Hoshschild (1989) called a second shift when they get home from work resulting in women taking longer to complete their education or even putting their goals on hold for family reasons. These delays, once again, may impact their advancement and salaries. Although many institutions have policies for maternity leave and tenure clock extensions, there is a stigma attached to utilizing these policies and the resulting salary implications (Laursen & Austin, 2020).

Having children early in one's career exemplifies the differing work-life balance impact on male and female faculty in higher education. According to Mason and Goulden (2004), men with children within the first five years of earning their doctorate in a STEM field are 20-24% more likely to earn tenure than women. Female faculty may delay having families more than other careers requiring advanced degrees due to tenure. Doctors and lawyers do not face the same advancement pressure seen in academia (Mason et al., 2013). The result is that tenured women may not have children, have fewer children than they would like, or be single. Female faculty with children have less time for research impacting their advancement (Misra et al., 2012).

Graduate students are aware of the challenges of their female mentors. They may question the ability to have a family, continue their research, and pursue a career in academia, contributing to the loss of females who advance in the profession (Mason & Goulden, 2002). Worth noting is that women in academia are more likely than men to have a partner in academia who may or may not be within the same discipline. A man's career is more likely to be considered during the job search and the determining factor when accepting a position (Schiebinger et al., 2008).

However, parental status is perceived differently depending on the gender of the faculty. When male faculty bring their children to work or leave to pick up children from school, they are considered devoted family men. They support the family and exceed expectations by taking on these responsibilities (Watanabe & Falci, 2017). Seen as the breadwinner, men may get better assignments, promotions, and higher pay. On the other hand, female faculty are perceived as not as devoted to their research and as unorganized.

They could have a sitter if they planned better (Falci & Watanabe 2020; Watanabe & Falci, 2017).

Family considerations are not the only deterrent to graduate and post-doctorate students pursuing an academic career. Many feel the demands of research and duties of higher education institutions are incompatible with their desires to have time for personal pursuits such as recreation, hobbies, and social life (Rice et al., 2000). The conflict between work and personal life strongly correlates with job satisfaction. When combined with a welcoming work environment, having a personal life and family are critical factors when female faculty decide whether to continue with their position or leave (Archie et al., 2015). These decisions may have much broader impacts as the next generation of faculty observes these challenges and decides to pursue academia based on their perceptions of how the department and the institution interact with female faculty and their choices (Austin et al., 2007).

The work-life conflict has been reinforced and exaggerated in the post-pandemic world since March 2020. Before the pandemic, 80 percent of two-career families paid for child care outside the home. Since the pandemic, more than two-thirds of working mothers say they are the sole caregiver (Smith & Johnson, 2020). Moreover, caregiver duties have increased, including homeschooling while on Zoom meetings or writing proposals. The increase in childcare has resulted in less time available for research and, by extension, fewer submissions by female researchers since March 2020, as reported by the *British Journal of Philosophy of Science, Nature*, and *Forum for European Philosophy* (Flaherty, 2020) and the *Brown Daily Herald* (Walker, 2021). Although these journals do not necessarily indicate a widespread trend, they present a question that begs further inquiry.

Inequities in Workload

Inequities in teaching assignments and service loads may also contribute to women taking one to three and a half years to advance to a full professor than their male counterparts (Guarino & Borden, 2017; Misra et al., 2011). Women are 10 percent less likely to achieve promotion to full professor even when factoring in productivity, race, and educational background due to entrenched institutional practices (Misra et al., 2012; Misra et al., 2011). These practices include the difference in service work performed by male and female associate faculty (Guarino & Borden, 2017). A survey of 1400 faculty conducted by Mitchell and Hesli (2013) found women spent more service hours advising and counseling students and served on more committees than men. Interestingly, women were less likely to chair committees (Misra et al., 2011). In addition, women were less likely to become department heads (Carnes et al., 2015).

While assistant professors are often somewhat protected from service to work on tenure-related activities, associates are tenured and lose some protections. Full professors are experiencing a decline due to retirements, and the remaining full professors defer service work to the junior faculty (Guarino & Borden, 2017; Misra et al., 2011). Male and female junior faculty work the same hours per week, 64 on average (Misra et al., 2011). Women teach more and contribute more service work to the university. On the other hand, men spend seven and one-half hours more per week on average researching than their female counterparts. Over two semesters, this results in 220 hours more hours of research. This disparity is not due to female faculty's preference for service work. According to Misra et al. (2011; 2012), women are offered and accept service work more because it is necessary to keep the university going, but they prefer to conduct research. Although evaluators may

acknowledge uncompensated service work when conducting yearly performance appraisals, it does not carry the weight of research or external service (Guarino & Borden, 2017).

Implicit Bias

The final barrier discussed in the literature review is implicit bias, the unconscious application of stereotypes and prejudices (Brownstein, 2019). Gender, race, or age are just a few characteristics that may result in implicit bias. These biases are the “result of direct and indirect messages, starting early in childhood, from family, friends, schools, neighborhoods, the media, and other interactions” (Laursen & Austin, 2020, p. 9). These mental schemas may help us make sense of the world (Vilian, 1999). However, when applied unjustly based on membership in a particular group, they can undercut personal values and result in decisions or actions opposing one's stated belief system. Empirical research in psychology has shown that even the most committed to equality and fairness have deep-rooted personal biases (Greenwald & Krieger, 2006). While most favor their social group, some will be biased against their group. These tendencies can be recognized, challenged, and changed (Laursen & Austin, 2020). Biases can also be cumulative, and identifying and intentionally making changes will allow individuals to alter personal inclinations.

This accumulation of small decisions biased against female faculty is impacting the careers of female faculty in higher education. These biased decisions may begin with their first letter of recommendation to attaining tenure – from gaining funding from a prestigious organization to their application for promotion. Martel et al. (1996) conducted a computer simulation that determined a 1% bias against women at each evaluation stage resulting in a 2:1 advantage for men after eight evaluation stages. Martel et al. (1996) stated that "a little

bias hurts women a lot" (p. 158). Laursen and Austin (2020) found similar results in their research.

Unknowingly, references reinforce this bias. When writing letters of recommendation for women, references write shorter letters and support characteristics thought to be feminine, such as good teachers or collaborators (Dutt et al., 2016; Trix & Psenka, 2003). In contrast, letters written for men more often describe the candidate as a promising researcher and leader (Madera et al., 2009). This bias continues with the evaluation of the candidate's application. Faculty ranked identical applications higher if they had a masculine name, offered higher salaries, and more significant start-up funds (Moss-Racusin et al., 2012). Both men and women were more likely to recommend the male candidate (Reuben et al., 2014), although Fine et al. (2014) found that implicit bias training before the search resulted in a more equitable result. It is not only the job search where bias occurs; women can expect to have a series of inequitable decisions rendered against them throughout their careers.

Women are less likely to win awards and fellowships and are often in out-of-the-way conference venues (Ford et al., 2018; Lincoln et al., 2012; Sheltzer, 2018). Identical conference proposals are ranked lower when submitted by names sounding feminine (Knobloch-Westerwick et al., 2013). This changes when women are on the selection committee resulting in a more equitable mix of presenters (Casadevall & Handelsman, 2014; Sardelis & Drew, 2016).

Publications are another area where bias is prevalent, and this more rigorous standard may be just one reason women are underrepresented in journals. Although women's papers were better written, they are more likely to be in review longer and face stricter scrutiny (Hengel, 2017). In addition, women's research is cited at a much lower rate than their male

counterparts (Holman et al., 2018). Male academics are more likely to be invited to review journal articles (Lerback & Hanson, 2017). This bias comes from colleagues and students alike.

Although students do not directly impact the tenure and promotion of female professors, student evaluations are a part of the tenure and promotion materials submitted to the committees. When male and female actors deliver identical lectures, the male lecturer will receive higher student evaluations. Instructors with feminine names will be ranked lower than identical online classes offered by professors with masculine-sounding names.

On the other hand, men have quite the opposite situation with perceived competence and benefit of the doubt along their career path (Muhs et al., 2013). Societal schemas characterize women as nurturing, caring, and social (Valian, 1999). This perception may be particularly true in STEM fields where society perceives science and engineering as logical, analytical, decisive, and action-oriented. Even the more female-friendly disciplines, such as the life sciences, have limited females in the higher ranks. For example, in a 2015 study, Carnes et al. found that 32% of associate professors, 20% of full professors, 14% of department chairs, and 11% of deans at medical schools in the United States were female. Females have difficulties breaking through the glass ceiling across the STEM field disciplines.

Summary

Indeed, factors other than a lack of mentors, work-life conflicts, inequitable workloads, and implicit bias have contributed to the shortage of female professors. Stereotypes and occupational interests are factors that Wang and Degol (2016) identified as contributors to the loss of female faculty in higher education in their research review over the

past 30 years in psychology, sociology, economics, and education. While early-career matriculation was more common in the literature, advancement from associate to full professor was less studied (Van-Miegroet et al., 2018). However, as previously stated, successful female professors made up 20% of the higher education faculty at MSU. Suppose these faculty had difficulties finding mentors, work-life conflicts, inequitable workloads, and faced implicit bias as often as other female candidates. What characteristics do these successful female professors have in common? A search of five databases revealed no relevant articles on this topic. Replication of particular traits will not be possible. However, supportive program components were uncovered by identifying common themes from female full professors in other professional degree-granting institutions in the Midwest. These findings offer a framework for institutional leaders to develop policies, procedures, and programs that increase women faculty and leadership in STEM disciplines.

Section IV. Contribution to Practice

Executive Summary

Introduction and Statement of Purpose

- Statement of Problem: Women in STEM in higher education are not promoted at the same rate as their male counterparts.
- Women are earning half of the doctorate degrees in the U.S. (NCSES, 2019).
- Women account for 37% of STEM full professors in higher education (NCSES, 2019.
- The difference cannot be attributed to demographic inertia (Laursen & Austin, 2020).

Research Questions

The overarching research question: What are the lived experiences of women full professors in STEM at professional doctorate degree-granting (R3) institutions?

- For women, what experiences put them on the path to becoming full professors in STEM at R3 institutions?
- What factors contributed most to the success of women full professors in STEM at R3 institutions?
- What institutional supports do women full professors in STEM consider beneficial in the promotion process at R3 institutions?
- In what ways, if any, does critical theory provide understanding of the path for women into full professorship in STEM at R3 institutions?

Review of Literature

- Higher education is a male-influenced workplace (Britton, 2017; Hall & Sandler, 1982; Laursen & Austin, 2020).
- A lack of mentors from the same social group (Hsieh & Nguyen, 2019; Johnson, 2014, 2017; Mazerolle et al., 2018)
- Work-life balance conflicts (Misra et al., 2012; Hoshschild; 1989; Watanabe and Falci, 2020; Williams, 2000)
- Inequities in workload (Guarino & Borden, 2017; Misra et al., 2012; Misra et al., 2011; Mitchell & Hesli, 2013)
- Implicit bias (Martel et al., 1996; Laursen & Austin, 2020)
- Research Gap: few studies exist that explore catalysts in the successful promotion of women to full professor in STEM.

Design of the Study

- Qualitative – "typically produce(s) a wealth of detailed information about a much smaller number of people and cases. This increases the depth of understanding of the cases and situations studied but reduces generalizability" (Patton, 2015, p. 14). May be transferrable to other R3s.
- Phenomenological approach - attempts to understand the experiences and choices of the participants (Husserl, 1913/1962; Merriam & Tisdell, 2016)
- According to Bohman (2001), critical theory "must explain what is wrong with current social reality, identify the actors to change it, and provide both clear norms for criticism and achievable, practical goals for social transformation."

Methods

- Setting – R3 institutions in the Midwest that had applied for NSF ADVANCE funding
- Participants – Five women full STEM professors.

- Semi-structured interviews.
- Curriculum vitae analysis determined timelines.
- Demographic surveys.
- Constant comparative method (Seidman, 2019).
- Open coding then axial coding.

Findings

- RQ1: Formative Influences
    - Childhood STEM E3 (Empowerment, Exploration, Expectation).
    - Communal spirit.
- RQ2 – Contributions to Success
    - Alliances.
    - Philanthropic investment.
    - The Lily Hardy effect.
- RQ3- Institutional First Aid
    - Early internal funding.
    - Useless women's socials
    - Institutional guides are not mentors.
- RQ4 – Viewed through Critical Theory
    - Coerced to comply.
    - Bias against women.
    - Heavier service loads.
    - Challenging the status quo.

Limitations

- Small number of participants
- No participants of color
- Only R3 institutions with ADVANCE grants

Discussion

- Findings consistent with the literature.
- Exceptions are:
    - Time that the women took to promote to full professor.
    - Leadership positions.
    - Second shift shared by spouse.

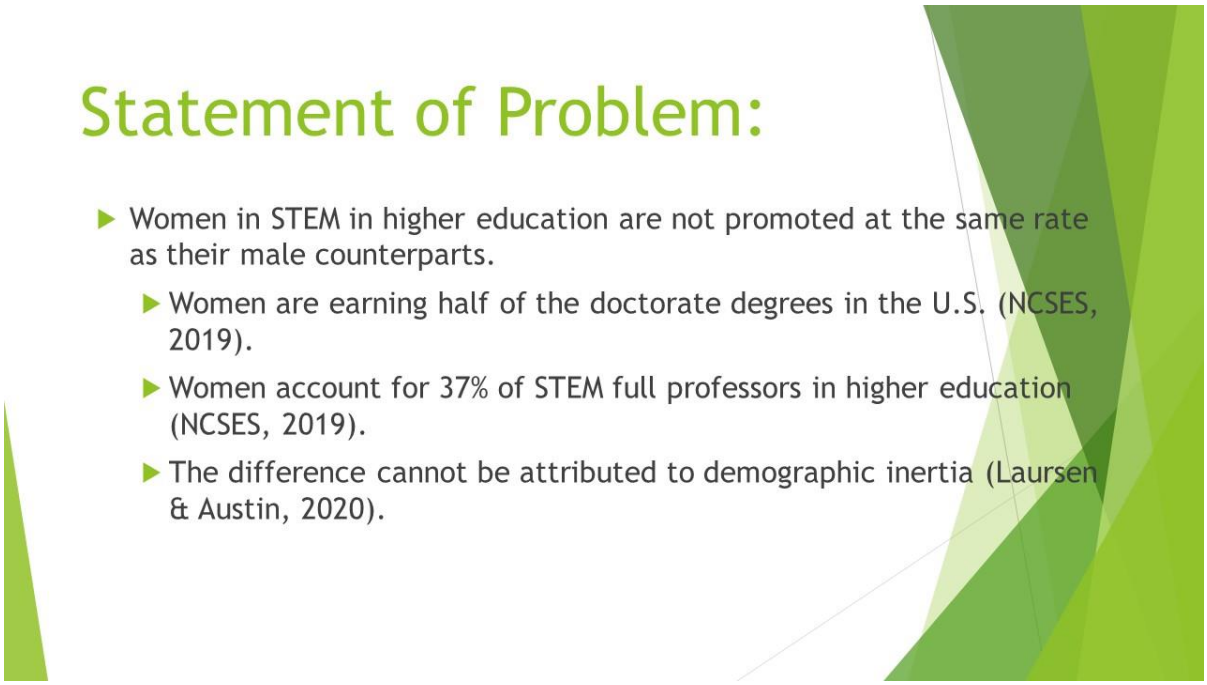
Significance

- Understanding the common beneficial experiences of these women may provide insight into the supports needed and where they will have the most impact on young women.

Conclusion

- There is a slow, steady progress in the number of women full professors in STEM.
- Strategies that may be helpful in addressing inequities:
    - Reformat women's socials so they promote collaboration between disciplines.
    - Continue early career funding opportunities.
    - Provide incentives for senior faculty to invest in junior faculty (i.e. course release)
    - Invest in youth programs for early STEM E3.

Presentation



Research Questions:

- The overarching research question: What are the lived experiences of women full professors in STEM at professional doctorate degree-granting (R3) institutions?
  - 1. For women, what experiences put them on the path to becoming full professors in STEM at R3 institutions?
  - 2. What factors contributed most to the success of women full professors in STEM at R3 institutions?

Research Questions (Continued)

- 3. What institutional supports do women full professors in STEM consider beneficial in the promotion process at R3 institutions?
- 4. In what ways, if any, does critical theory provide an understanding of the path for women into full professorship in STEM at R3 institutions?

Review of Literature

- Higher education is a male-influenced workplace (Britton, 2017; Hall & Sandler, 1982; Laursen & Austin, 2020).
- A lack of mentors from the same social group (Hsieh & Nguyen, 2019; Johnson, 2014, 2017; Mazerolle et al., 2018)
- Work-life balance conflicts (Misra et al., 2012; Hoshschild; 1989; Watanabe & Falci, 2020; Williams, 2000)

Review of Literature (continued.)

- Inequities in workload (Guarino & Borden, 2017; Misra et al., 2012; Misra et al., 2011; Mitchell & Hesli, 2013)
- Implicit bias (Martel et al., 1996; Laursen & Austin, 2020)
- Research Gap: Few studies exist that explore catalysts in the successful promotion of women to full professors in STEM.

Design of the Study

- Qualitative - "typically produce(s) a wealth of detailed information about a much smaller number of people and cases. This increases the depth of understanding of the cases and situations studied but reduces generalizability" (Patton, 2015, p. 14). May be transferrable to other R3s.
- Phenomenological approach - attempts to understand the experiences and choices of the participants (Husserl, 1913/1962; Merriam & Tisdell, 2016)
- According to Bohman (2001, p. 1), critical theory "must explain what is wrong with current social reality, identify the actors to change it, and provide both clear norms for criticism and achievable, practical goals for social transformation."

Methods

- Setting – R3 institutions in the Midwest that had applied for NSF ADVANCE funding
- Participants – Women full professors in STEM.
- Semi-structured interviews.
- Curriculum vitae analysis determined timelines.
- Demographic surveys.
- Constant comparative method (Seidman, 2019).
- Open coding then axial coding.

Findings

Participant Demographic Data Derived from Curriculum Vitae and Survey

Participant	Age Range	Race	Marital Status	Discipline	Children	Spouse
I	55-65	White	Married	Math	Y	Professional
II	45-54	White	Married	Biology	Y	Academic
III	55-65	White	Married	Chemistry	Y	Academic
IV	45-54	White	Married	Chemistry	Y	Academic
V	45-54	White	Married	Biology	Y	Professional

Participant Academic Timelines Derived from Curriculum Vitae and Survey

Participant	Years Post Doc	Ph.D. to Professor	Years as Asst	Years as Assoc	Leadership Positions
I	0	11	5	6	N
II	2	12	7	5	Y
III	3	16	5	6	Y
IV	3	18	6	7	N
V	0	14	7	5	Y

Academic Productivity Derived from Curriculum Vitae and Survey

Participant	Publications	First Author	Conference Presentations	Research Funding	Publish With Spouse
I	20	15	15	Yes, but $ Not Provided	N
II	31	4	>50	>$1,000,000	Y
III	75	40	35	>$1,000,000	Y
IV	11	6	>40	Yes, but $ Not Provided	Y
V	17	6	>12	>$250,000	N

Research Question 1 – Formative Influence

- Childhood STEM E3(Empowerment, Exploration, Expectation).
  - "a ton of cousins were always running around in the bayou. I was surrounded by other kids who were not afraid of the outdoors." Betty
  - "We had this humongous field across from us… we put firecrackers down the storm drain, magnifying glasses on daddy long-legs, and I suspect my brother ended up putting the field on fire." Alice
  - "Our parents made us take four years of math, science, and English in high school. We were prepared for college." Darla
  - "My mom got me going on an old type of adding machine that you punch in, and (the) tape came out. I was always so happy when it balanced! I absolutely loved doing it. I did it every day." Alice

Research Question 1 (continued)

- Communal spirit
  - Girl Power event has "bolstered me over the last six or seven years. It has been a huge mental and emotional boost over the years." The girls participating in the one-day event comment, "I'm going to be a powerful woman in medicine," or "my power goal is to finish high school." Charlene smiled and stated, "we kind of kick-ass, right?" Charlene
  - At the research field station Emma "collaborate(s) with many of the folks there and the research and writing we do. And they're always willing to help me and I'm always willing to help them."
  - Speaking of her lab partner, Darla said, "I think we both helped in each other's lives… in positive ways."

Research Question 2-Contributions to Success

- Alliances.
  - Emma has had long-term collaborations with the Missouri Department of Conservation and the United States Fish and Wildlife Service.
  - All of the participants had a strong, long-term collaborator.
  - For Betty, Charlene, and Darla, those collaborators are spouses.

Research Question 2

- Philanthropic investment.
  - "She believed in me and saw that I had a lot of potential, and I was a hard worker. It really changed the trajectory of not just my career but personally." Alice
  - "Do you just want to teach, or do you really enjoy science?" She told him "both." Rather than recommend her for a tutoring position, he hired her as a research assistant. "I basically put fish in a swim tunnel. I loved it. I thought, wait, I can do science and it doesn't have to be with people?" Charlene
  - "He really shaped my career… and supported me as an individual." Darla

Research Question 2

- The Lily Hardy effect
  - Each participant in this study stated that they did not come from a privileged background and felt it gave them a broader perspective and understanding of their students.
  - Recognize how the support and encouragement they received early in their careers made a difference and now want to pay it forward. Each is actively involved in the success of their students.
  - Emma mentioned that she felt fortunate to have so many students from underrepresented groups. She wants to ensure that "I … don't leave them out."

Research Question 3-Institutional First Aid

- The women found that these measures were limited in impact on their careers.
- Early internal funding.
  - Allowed them to start research earlier in their careers and took off some pressure to find outside funding.
  - Helped provide their students with research opportunities. Emma

Research Question 3

- Useless women's socials.
  - Alice indicated she did not "hang out in groups of all women." Social events set up to be supportive were "pleasant but made her feel uncomfortable."

Research Question 3

- Institutional guides are not mentors.
  - Not a good pairing, but it "got (her) questions answered when needed." Emma

Research Question 4 – Viewed Through Critical Theory

- Coerced to comply.
  - Even though there were policies for maternity leave at these women's institutions, they were still asked to come back to work and take care of their work responsibilities even though they were on maternity leave.
  - "we have two other search committees going. It would be nice if you could sit on those as well." Charlene
  - "you just have to handle those things or be ostracized." Charlene
  - Darla said there continues to be a double standard for men and women.
  - "the younger generation isn't going to put up with it." Charlene

Research Question 4

- Bias against women.
  - "There is an unfairness in how women are treated, but you just have to shrug it off." Darla
  - Alice indicated that she will sometimes "just give up trying to talk" in meetings unless she feels strongly about the topic.

Research Question 4

- Heavier service loads.
  - Emma believes “female faculty are more likely to be asked to do more service.”
  - “you feel like you have to do more than men.” Charlene
  - “Not only do we have a larger advising load, but students come to us more often for advice even when we aren’t their advisor.” Emma
  - “They respect our advice but don’t respect our title.” Betty

Research Question 4

- Challenging the status quo.
  - All feel that their careers could have been derailed if they had not had such a good support.
  - “still a lot of work to do but we are making progress”. Darla
  - More women are promoting to positions of power, and this is needed not just for the next generation of women in STEM but also for the men to see that women are capable. Charlene
  - All these women are involved in work supportive of women in STEM.

Limitations

- Small number of participants.
- No participants of color.
- Only R3 institutions with Advance grants.

Significance of the Study

- Understanding the common beneficial experiences of these women may provide insight into the supports needed and where they will have the most impact on young women.

Discussion

- Findings are consistent with the literature.
- Exceptions are:
  - Time to promote to full professor.
  - Leadership positions.
  - Second shift shared by spouse.

Conclusion

- There is a slow, steady progress in the number of women full professors in STEM.
- Strategies that may be helpful in addressing inequities:
  - Reformat women's socials so they promote collaboration between disciplines.
  - Continue early career funding opportunities.
  - Provide incentives for senior faculty to invest in junior faculty (i.e. course release)
  - Invest in youth programs for early STEM E3.

Section V. Contribution to Scholarship

Abstract

Women currently earn half of the doctorates awarded in the United States but hold 37% of the full professor positions (NCSES, 2019). Demographic inertia alone cannot explain this fact (Laursen & Austin, 2020). This qualitative, phenomenological study, through the critical theory framework, sought to understand the lived experiences of five women STEM full professors in professional doctorate-granting institutions (R3) and their perception of the impact of these experiences on their promotion to full professor. Data for the study included analysis of curriculum vitae, demographic surveys, and in-depth semi-structured interviews that were coded using the constant comparative method (Seidman, 2019). The commonalities of the participants included childhood STEM empowerment, exploration, expectation (E3), communal spirit, alliances, philanthropic investment, the Lily Hard effect, and institutional first aid. Critical theory provided an understanding of the participants' experiences through the themes of forced to comply, bias against women, heavier service loads, and challenging the status quo. The limitations of the study included no participants of color and only R3 institutions with ADVANCE grants were included. Although the findings are not generalizable (Patton, 2015), they may be transferable. Future research could consist of intersectional identities and maternal wall bias. The findings of this study offer a framework for institutional leaders to develop policies, procedures, and programs that increase women faculty and leadership in STEM disciplines. Increasing the number of women full professors in STEM is slow. Strategies that may help address inequities include reformatting women's socials to promote collaboration between disciplines, continuing early career funding opportunities, providing incentives for senior faculty to invest in junior faculty (i.e., course release), and investing in youth programs for early STEM E3.

Introduction

More than three decades after the civil rights movement, the United States has the highest income and advancement disparities for women and persons of color (Massey, 2008; Keister, 2000). Women continue to encounter bias in their professional and personal lives (Massey, 2008) that has resulted in inequitable advancement in the job market (Castilla, 2008; Lempert, 2010; Tsang & Dietz, 2001), including in Science, Technology, Engineering, and Mathematics (STEM) faculty positions (Laursen & Austin, 2020; Lee, 2013; Misra, 2021).

Occupational gender segregation, both horizontal and vertical, is found throughout STEM in academia (DeWelde & Stepnick, 2015; Frehill et al., 2015), where women hold just 17% of the faculty positions in engineering compared to 39% in the life sciences (NSF NCSES, 2019b). There is a disproportionate number of female faculty in the instructor, assistant, and associate professor positions. In addition, vertical segregation is shown in the classification of the institution as well. Women are more likely to hold full-time faculty positions in bachelor's and master's degree-granting institutions. Women faculty in these institutions are 36% and 34%, respectively, compared to 23% in doctorate-granting institutions (AMS, 2019). Thus, despite the growing number of female doctorates and increased awareness of the value of diverse workgroups (Johnson, 2018; Levi, 2017), occupational gender segregation persists. While demographic inertia, the pace of change in faculty demographics, may be a factor, it cannot entirely explain the slow increase in women in STEM (Marschke et al., 2007; Shaw & Stanton, 2012; Thomas et al., 2015).

Since 2001, the National Science Foundation (NSF) has approved over 70 Organizational Change for Gender Equity in STEM Academic Professions (ADVANCE)

grants totaling $270 million (NSF, 2018). These funds have provided institutions with resources to research, reflect on, and initiate measures to mitigate the barriers women face in higher education STEM departments. Findings are made public as a requirement for these grants and have provided valuable and consistent information. However, these publications have not investigated common factors, influences, and experiences of women STEM full professors.

Review of Literature Related to the Study

The literature was divided into five primary subsections. The first subsection describes the perception of how a male-influenced climate and workplace impede women's progress in higher education STEM faculty positions. The second provides information on perceived barriers to women in higher education STEM fields regarding mentoring and workplace friendships. Also known as blended friendships, these workplace friendships that develop over time and extend beyond the workplace positively impact workplace productivity (Bridge & Baxter, 1992). The third subsection will focus on female faculty work-family conflict issues in higher education STEM positions, and the fourth subsection will include inequalities in workload. The final and possibly the most difficult to address will be the implicit bias women face in higher education institutions. Because these impact decisions and actions unconsciously and without intent, people do not realize they are making judgments based on gender, race, age, or appearance. Although they may impact decisions positively or negatively, they are a deep-seated part of a person's background, and these may be unrecognizable to the person as bias.

Male-Influenced Climate and Workplace

According to Laursen and Austin (2020), the climate at higher education institutions has "become masculinized, and women may be ignored, excluded, harassed or pressured to cover by denying aspects of their identity" (p. 13), and remains in academia (Britton, 2017). Masculine stereotypes include agentic traits, while women, perceived as deficient in these traits, are expected to be community-minded (Muhs et al., 2013). Women are expected to be more caring, are perceived as less capable of leadership, less competent, and less likely to succeed (Carnes et al., 2015). When women step outside those expectations, students and faculty alike may react with microaggressions (Carroll, 2017; Laursen & Austin, 2020; Pleck, 1990). In addition, a lack of respect may be prevalent in departments, conferences, and field camps (Avallone et al., 2013).

Workplace climate is directly related to job satisfaction, retention, and productivity (Archie et al., 2015), and although there may be policies at the institutional level, it is at the departmental level where the workplace climate is most impactful (Archie et al., 2015; Britton et al., 2012; McCoy et al., 2013). The faculty connections to the institution happen at the departmental level, where specific and intentional actions by the leadership and colleagues can make the most significant impact (Campbell & O'Meara, 2014), and efforts to demasculinize the workplace climate may be most effective (Archie et al., 2015; Britton, 2012).

The Role of Mentors for Women in STEM Fields

A shortage of female professors may result from the absence of mentors of the same demographic (Hsieh & Nguyen, 2019; Johnson, 2014, 2017; Mazerolle et al., 2018). When female STEM faculty have internal mentors of the same demographic, there is a reduction in

the number of departures from higher education (Mazerolle et al., 2018; Schmidt & Faber, 2016). The type of mentoring relationship is also essential. Junior faculty can benefit from internal mentors, who are expected to have the institutional knowledge to facilitate faculty growth, and external mentoring, often a doctoral advisor (Mazerolle et al., 2018). Both types of mentors are essential (Mazerolle et al., 2018).

Work-Life Balance Conflicts

The conflict between work and personal life strongly correlates with job satisfaction. When combined with a welcoming work environment, having a personal life and family are critical factors when female faculty decide whether to continue with their position or leave (Archie et al., 2015).

Having children early in one's career exemplifies the differing work-life balance impact on male and female faculty in higher education. According to Mason and Goulden (2004), men with children within the first five years of earning their doctorate in a STEM field are 20-24% more likely to make tenure than women. Female faculty with children have less available time for research impacting their advancement (Misra et al., 2012; Mitchell & Hesli, 2013).

Perceived as the breadwinner, men may get better assignments, promotions, and higher pay. They support the family and exceed expectations by taking on these responsibilities (Watanabe & Falci, 2017). As parents or caregivers, women are perceived as unorganized and not as devoted to their research (Falci & Watanabe, 2020; Watanabe & Falci, 2017).

Since more women have joined academia, the timetable for tenure and promotion developed from the masculinized model of the ideal worker has become problematic. The

tenure clock can be overwhelming when considering household duties, child or parental care, or other responsibilities (Williams, 2000). Females may have what Hoshschild (1989) called a second shift when they get home from work resulting in women taking longer to complete their education or even putting their goals on hold for family reasons. Although many institutions have policies for maternity leave and tenure clock extensions, there is a stigma attached to utilizing these policies and the resulting salary implications (Laursen & Austin, 2020; Reuben et al., 2014).

Inequities in Workload

Women are 10 percent less likely to achieve promotion to full professor even when factoring in productivity, race, and educational background due to "entrenched institutional practices" (Misra et al., 2012; Misra et al., 2011). These practices include the difference in service work performed by male and female associate faculty (Guarino & Borden, 2017). Inequities in teaching assignments and service loads may also contribute to women taking one to three and a half years longer to advance to full professor than their male counterparts (Guarino & Borden, 2017; Misra et al., 2011). A survey of 1400 faculty conducted by Mitchell and Hesli (2013) found that women spent more service hours advising and counseling students and served on more committees than men but are less likely to chair committees (Misra et al., 2011) or become department heads (Carnes et al., 2015).

Women teach more and contribute more service work, while men spend seven and one-half hours more per week on average on research. This disparity is not due to women faculty's preference for service work. According to Misra et al. (2011; 2012), women are offered and accept service work more because it is necessary to keep the university going, but they prefer to conduct research. Although evaluators may acknowledge uncompensated

service work when conducting yearly performance appraisals, it does not carry the weight of research or external service (Guarino & Borden, 2017).

Implicit Bias

The final barrier discussed in the literature review is implicit bias, the unconscious application of stereotypes and prejudices (Brownstein, 2019). Gender, race, sex, or age are some of the characteristics that may result in implicit bias. These biases are the "result of direct and indirect messages, starting early in childhood, from family, friends, schools, neighborhoods, the media, and other interactions" (Laursen & Austin, 2020, p. 9). Biases can also be cumulative, and identifying and intentionally making changes will allow individuals to alter personal inclinations.

An accumulation of small decisions biased against women faculty, such as letters of recommendation, tenure, and grant applications, is impacting the careers of female faculty in higher education (Laursen & Austin, 2020; Carnes et al., 2015; Carroll, 2017; DeWelde & Stepnick, 2015). Martel et al. (1996) conducted a computer simulation that determined a 1% bias against women at each evaluation stage, resulting in a 2:1 advantage for men after eight evaluation stages. Martel et al. (1996) stated that "a little bias hurts women a lot" (p. 158). Laursen and Austin (2020) found similar results in their research.

It is not only the job search where bias occurs; women can expect to have a series of inequitable decisions rendered against them throughout their careers. Women are less likely to win awards and fellowships and are often in out-of-the-way conference venues (Ford et al., 2018; Lincoln et al., 2012; Sheltzer, 2018). Identical conference proposals are ranked lower when submitted by names sounding feminine (Knobloch-Westerwick et al., 2013). This

preferential ranking changes when women are on the selection committee resulting in a more equitable mix of presenters (Casadevall & Handelsman, 2014; Sardelis & Drew, 2016).

Summary

The barriers to women promoting to full professor in higher education, including a lack of mentors, work-life conflicts, inequitable workloads, and implicit bias, have contributed to the shortage of female professors. While early-career matriculation was more common in the literature, advancement from associate to full professor was less studied (Van-Miegroet et al., 2018). What characteristics do these successful female professors have in common? A search of five databases resulted in two studies investigating positive factors impacting the promotion of women full professors in higher education. Dekelaita-Mullet et al. (2021) conducted a study in STEM research-focused institutions (R1). The work by Delelaita-Mullet revealed six common themes - shared traits, early STEM experiences, work-life balance, pathways, mentors, and institutional supports as revealed by a survey, analysis of the curriculum vita, and semi-structured interviews. A second study sought the motivating factors of women full professors in STEM higher education R1 institutions. This study examined the lived experiences of women full professors in Midwest professional degree-granting institutions (R3). By discovering the common positive influences of women full professors at R3 institutions, it may be possible to implement practices to promote gender equity for STEM faculty in other R3 higher education institutions.

Research Questions

The problem this study sought to investigate was that women in STEM are not advancing at the same rate as their male counterparts. The differences cannot be explained by demographic inertia (Laursen & Austin, 2020). The purpose of this study was to examine the

lived experiences of women in STEM who have advanced to full professor at professional degree-granting (R3) institutions. The overarching research question: What are the lived experiences of women full professors in STEM at professional doctorate degree-granting (R3) institutions?

1. For women, what experiences put them on the path to becoming full professors in STEM at R3 institutions?
2. What factors contributed most to the success of women full professors in STEM at R3 institutions?
3. What institutional supports do women full professors in STEM consider beneficial in the promotion process at R3 institutions?
4. In what ways, if any, does critical theory provide understanding of the path for women into full professorship in STEM at R3 institutions?

Methods

This study was qualitative and framed by critical theory using the phenomenological approach. “Quantitative methods typically produce a wealth of detailed information about a much smaller number of people and cases. This increases the depth of understanding of the cases and situations studies but reduces generalizability” (Patton, 2015, p. 14). The information may however be transferred to similar R3 universities. This study aimed to determine the shared lived experiences of women full professors in STEM through a series of interviews, a demographic survey, and an analysis of the participants' curriculum vitae in alignment with the overarching question. All of the participants were from similar institutions that have applied for or been awarded a National Science Foundation (NSF) ADVANCE grant. Selecting institutions interested in NSF ADVANCE was an important part

of the study as it demonstrated the university's commitment to gender equity. The NSF ADVANCE program aimed to expand the implementation of evidence-based systemic change strategies that promoted gender equity for STEM faculty in higher education. Findings will guide institutional leaders in developing policies and programs to increase women faculty and leadership in STEM disciplines.

This study utilized the phenomenological approach as it attempted to understand the lived experiences of women full professors in STEM and they made sense of their experiences in their journey to becoming full professors (Merriam & Tisdell, 2016). The phenomenological approach was appropriate as "qualitative methods typically produce a wealth of detailed information about a much smaller number of people and cases. This increases the depth of understanding of the cases and situations studies but reduces generalizability" (Patton, 2002, p. 14). Understanding their experiences is essential to developing solutions for future female professors (Misra, 2021; Laursen & Austin, 2020).

Setting

In this study, faculty from Midwest universities that met the Carnegie Classification of Institutions of High Education for doctoral/professional degree-offering institutions (R3) and were interested in NSF ADVANCE grants were interviewed. Four institutions met this criterion. Each institution has expressed the desire to improve gender equity in STEM professors, as evidenced by their ADVANCE grant application.

Participants

Participants were selected using the purposeful sampling method. Examinations of faculty websites for each of the selected R3 institutions revealed 129 women STEM full professors at the time of this writing. An email requesting their participation in the study was

sent to each professor who met the study criteria. The respondents agreed to participate in the study by returning the consent form, submitting a current curriculum vitae, and completing a short demographic survey. After the initial solicitation, five responses represented the four institutions that met the criteria. A second solicitation sent out two weeks later resulted in no additional responses. Participant data are reported in Tables 1-3.

Table 1 provides demographic data. It is worth noting that all the participants were married with children. Although persons of color were invited, none chose to participate. Consistent with the literature, a majority of the participants in the study have spouses that were also academics.

Table 1

Participant Demographic Data Derived from Curriculum Vitae and Survey

Participant	Age Range	Race	Marital Status	Discipline	Children	Spouse
I	55-65	White	Married	Math	Y	Professional
II	45-55	White	Married	Biology	Y	Academic
III	55-65	White	Married	Chemistry	Y	Academic
IV	45-55	White	Married	Chemistry	Y	Academic
V	45-55	White	Married	Biology	Y	Professional

Table 2 illustrates the academic timeline for each participant. This data was included as Laursen and Austin (2020) indicated that women take longer to attain professor than their male counterparts. The literature states the lack of women in leadership positions may be a contributing factor to the underrepresentation of women in STEM at the rank of full professor (Laursen & Austin, 2020). It is worth noting three of the five women in this study were in leadership positions.

Table 2

Participant Academic Timelines Derived from Curriculum Vitae and Survey

Participant	Years Post Doc	Ph.D. to Professor	Years as Asst	Years as Assoc	Leadership Positions
I	0	11	5	6	N
II	2	12	7	5	Y
III	3	16	5	6	Y
IV	3	18	6	7	N
V	0	14	7	5	Y

Table 3 provides a summary of the academic productivity of the participants in the study. All of the participants were all well published and first authors although one exceeds the productivity of the others. The women were all active in attaining grants and presenting at conferences. Note that women who publish with their spouse may be more productive, but it was also not necessarily the case with all participants.

Table 3

Academic Productivity Derived from Curriculum Vitae and Survey

Participant	Publications	First Author	Conference Presentations	Research Funding	Publish With Spouse
I	20	15	15	Yes, but $ Not Provided	N
II	31	4	>50	>$1,000,000	Y
III	75	40	35	>$1,000,000	Y
IV	11	6	>40	Yes, but $ Not Provided	Y
V	17	6	>12	>$250,000	N

Data Collection Tools and Procedures

Interviews and document analysis were utilized in the study. Semi-structured interviews allowed each participant to provide their perspective and personal history. Through the demographic survey and the curriculum vitae, there was the opportunity to establish a timeline and data regarding their academic career. This provided a means to review information from the interviews and verify the information. Participants were provided opportunities to review transcripts as a means to member check. Through triangulation of multiple data sets, interviews, curriculum vitae, and surveys, information was verified and cross-checked, strengthening the study (Patton, 2015).

Interviews

Participants from the selected universities were interviewed using a semi-structured interview protocol via Zoom to obtain the maximum number of interviews and reduce travel time and costs. They were provided a confidentiality statement and consent form a minimum of two weeks before the interview. In addition, consent was obtained verbally before the interview and recorded along with the interview.

Documents

Document analysis was used in this study to establish a timeline for each participant. Document analysis is a means of triangulation to provide verification of interview data (Creswell, 2013). Because each word the participant chooses is part of their understanding of the phenomenon, a recording was essential for the interview process (Seidman, 2019). Patton (2015) stated the importance of context and rich, thick descriptions when exploring participants' shared experiences using the phenomenological methodology. Interviews were

coded by the Roman numeral I - V so information could be traced to its original transcript location using the line number. Following each interview, the online transcription program Otter.ai produced verbatim documents that were line numbered to allow tracing data points to the original context. Transcripts were assigned a color, and names removed to protect participant identity.

Document Analysis

The survey provided demographic data, including marital status, gender identity, publications, grants, age range, and race. The curriculum vitae verified their publications, publication colleagues, grants, presentations, and a timeline of their undergraduate and graduate experience and their advancement through their academic careers. These data are provided in Tables 1 through 3.

Interview Analysis

After transcription, listening to the interview recording while reading the transcription allowed corrections and follow-up questions to be developed for future interviews using the constant comparative method (Krueger & Casey, 2015; Lincoln & Guba, 1985; Strauss & Corbin, 2014). Experiences were sorted and grouped thematically with a complete description following (Seidman, 2019; Meriam & Tisdell, 2016; Krueger & Casey, 2015). Horizontalization allowed for processing data giving equal weight to all experiences in the initial stages of analysis (Merriam & Tisdell, 2016). The phenomenological reduction, or bracketing, was employed during the second reading and set aside the researcher's perspective and focused instead on the meaning of each participant's experience (Merriam & Tisdell, 2016). Giving voice and equal weight to each participant's data were vital in the initial analysis. Eliminating data in the early stages of the interviews may have resulted in

missing trends and relationships (Krueger & Casey, 2015; Merriam & Tisdell, 2016). The analysis followed the process described by Seidman (2019, pp. 127-136). Themes were determined inductively without predetermined categories (Seidman, 2019). This process was repeated throughout the interview process using the constant comparative method. Through open coding, information was pared down to only the most relevant to the research.

Participant Narratives

To better understand each participant and develop the rich thick description a qualitative study requires, a narrative of each participant was completed before developing common threads. According to Patton (2002), this detailed information helps increase the understanding of the perceptions and situations of the participants.

Participant I. Alice

Alice is a math education professor and has always been involved in STEM-related activities. Her father was a STEM professional, her mother had a business degree, and they were encouraged to explore. “There was this humongous field across from us, so I grew up there…I have four brothers…so, you know, we were outside all the time.” They explored and investigated independently by “setting things on fire… with magnifying glasses and putting firecrackers down the storm drains.” She recalls these were all “small-scale pyrotechnics,” although she suspects one fire, which burned about six feet of the field, was set by her brother and a neighbor girl. She has fond memories of her time with the brothers and neighborhood explorations, but math was always her favorite. She loved “all the animals and spiders that we dealt with and the creatures,” but “I’m much more math than science.”

Alice’s mom was the accountant for the salon, and young Alice went with her mother each day to the salon. “My grandmother owned a beauty salon, and she had to balance the

books." "This was before computers," so all the types of haircuts and treatments had to be calculated and balanced each day. "Sometimes my mom would get behind… about (age) six or seven, my mom got me going on an … old type of adding machine that you punch in and the tape (came) out. I was always so happy when I balanced it!" She recalls that time at the beauty salon as an event that influenced her continued preference for math. "I loved doing it!"

Other influences in her childhood were her high school teachers. "I really loved my high school science teacher, and he was very innovative but got us involved. And we were doing lots of lab work." She took AP chemistry to "get as much chemistry as I could." Due in part to that high school teacher's influence, Alice started college as a chemistry major. She was two years into her chemistry program, however, "when organic chemistry got (me). But I was good at math; I was whipping through my math class. So, I decided to switch over to math education. The math and math ed were together" at her university. Alice felt the math "was pretty strong math background for that (math education)."

Since her degree was in math education, she taught high school math for eight years upon graduation. She realized she loved teaching math but not in high school. At this point, she decided to make a change and went back to graduate school. "I really didn't enjoy teaching high school too much…not hate it but didn't like it… decided I'll go back to school. I don't know what I am going to do, but I'll go back." One of her professors looked at her resume and "believed in me. Saw that I had a lot of potential and was a hard worker. She changed the trajectory of my life." This professor took a "real interest in me and knew I could do better." This professor felt confident enough in Alice to let her start teaching

master's classes while she was still in her master's program. "I wouldn't have done that for me, but she did."

When Alice was about to graduate from her master's program, her mentor asked her to coauthor a book chapter. More than two decades after Alice served as her mentor's teaching assistant, she "still incorporates me in a lot of her activities." After earning her master's degree, Alice realized she wanted to teach at a university and pursued her doctorate. "I loved teaching college!" Alice moved from one coast to another to begin working on her Ph.D. Her mentor in her graduate program influenced her decision to continue her education with her doctorate.

She relates how supportive the department was of its graduate students. "The professors in the department, the college, even the dean knew who I was and supported me, got me scholarships so I could finish my program." She saw that the other graduate students felt that way as well. The College of Sciences included the Math Department and Math Education. "Everyone was all in; we called it our college…I would say it was the whole climate. Just loved the environment." After graduation, Alice was hired at an R3 institution in the Midwest and has been there for nearly three decades. She took the position as she felt it was an excellent opportunity for a tenure track. As she wanted to continue teaching at the university level, she decided to pursue advancement to full professor. She also felt there was freedom to do the types of research and presentations she was interested in. Math education was valued. In the early days of her time at the university, Alice felt the environment wasn't always equitable for women. She was the only woman in the department. "You had to be pretty direct" to be heard.

Although she felt there were opportunities for advancement at the university she is at, Alice felt that "she always had to say yes to everything… to move forward and advance my career." Promoting was important to her, but she felt women were asked to do more service work. Although she understands that service work is important to the department, she felt she was asked to do service work instead of teaching more than male faculty. "So there were times where I was offered (release time) instead of teaching …No, I'd rather teach a class." Alice is at the university primarily because she loves teaching at the university level. Offering release time was not a reward to her. Although appreciative of the fact that the university was open to the research and presentations that Alice preferred, service work was not perceived as equitable to her. In addition, "in meetings, sometimes you have to be forceful to be heard." However, when promoted and tenured, she felt a measure of freedom. "I love my job 95% of the time; the other 5% I am grading."

Despite the inequitable service load and being talked over in meetings, Alice still felt her department was an excellent workplace due to her academic freedom. Since tenure and promotion, however, Alice stated, "I could pick and choose things that I wanted to work on, and I still can." However, the climate she perceived as good has changed in the last few years.

A new faculty member has received tenure and changed the department dynamic. "I really wanted to stay a few more years." This new faculty member has engaged in malicious gossip and unsubstantiated accusations. There has been a conflict between the new faculty member and the rest of the department. "She told us she could do what (the new faculty member) wanted now that she had tenure." Alice reflected, "Go ahead. I won't be here to watch." Although extra service work and some disrespect can be ignored, this blatant attempt

to dominate everyone in the department is too much for Alice. She is now considering other options. Teaching half-time, she believes, is just as much work, so she is considering tutoring online, or she "may just do sewing and alterations."

When discussing her institution's role in women's success, Alice said there is "not much institutional support." The only support she gets is $350 travel money. This travel money gets her conferences and presentations. There is a reflective teaching group that is "especially good for people who have never had education classes," but this hasn't been useful to Alice. Her math education degree has been helpful to her in teaching college, but she credits her values as well.

Alice describes herself as an organized person. "There's nothing better than being organized." She feels her straightforward approach to students is one of her strongest and best qualities. If "a student needs to correct something or I have to tell them something they don't want to hear, I can do that." It is not something she enjoys, however. She does it to help students improve. Her students will often tell her that "she knew they could do a better job and believed in them, pushed them to do better." She said this was "after they graduated, of course." She said, "you have to separate the student from the work." "The work," she explains, "might not be good, but you treat the student with kindness and respect."

Although she pushes them to do their best work, Alice feels it is important to "treat everyone with kindness." Something she taught her daughters as well. Contributing to the next generation of women scientists is something about which she feels strongly. "We started a program where we work with female undergraduate and graduate students, and we have a research week for them to present posters." She has remained involved in the research week throughout her career. "I feel like I am a mentor in terms of women in math and science."

Alice believes the micro-aggressions she was subject to are still happening but not as pervasive. Female students tell her they don't want to raise their hands in class because "they don't want to look stupid." She tells them not to be intimidated. "The guys don't know what is going on either." Alice understands that not everyone has the same background. "I work with a lot of students. Everyone can learn if they get the right background."

Participant II. Charlene

Charlene's love of science was fostered early in life. "My mom was one of 12 children, so there was always a ton (of cousins) around…we grew up in … in the delta. We were outside every day. They all enjoyed it (being outside) as much as I did." Charlene recalls that she was always surrounded by other kids who were not afraid of the outdoors. "I was a total tomboy. I never knew I was weird… it was normal." She remembers when "we spent the entire afternoon in that bayou playing and seeing, and we would get that crayfish, and I'm sure we horribly dissected it." She thought back about how "sketchy" some of their activities were given the alligators and snakes that were there. My mom did it." Charlene and her cousins took buckets and scooped up fish; "we would sit on the bank and pull up stuff and talk about it…that one sticks out to me quite a bit." However, her time with the cousins at the grandparent's house was not her only exposure to STEM.

"My mom was a 6th-grade science teacher. I remember looking at microscopes with pond water and bugs in my mom's class." With a mom that was a teacher, there was no going home when you were sick. "Back in the day, when you were a kid, and you were sick, your parents just took you to work with them if they could. We didn't think about pathogens and wearing masks and all that." She couldn't have been too sick as she participated in the classroom activities. But she was listening as she was engaged. "I always had her as a role

model," Charlene recalls when her mother returned to school for her master's degree. Her mother would have Charlene help her study. "I was little, and I'd be like, di D ox see? And she's like deoxyribonucleic acid, that's blah, blah, blah. And I was like, Oh my God! My mom is so smart!" However, she took a little hiatus from serious studies during high school. "I liked being outside and doing all those sorts of things until high school and boys." But that changed when she arrived at college.

Charlene decided she was going into medicine. "I was premed. Because that is what we know we (women) can do, right? You can be a doctor, or you can be a teacher." That changed when she walked into her biology professor's office in her sophomore year. She wanted a recommendation for a tutoring position. He asked a question that changed her career. "And he said, well, do you just want to teach or do you…really enjoy the science? And I said, well, both." That professor had funding for a position, and he hired me to hook fish and put them in a swim tunnel, basically a treadmill for fish." This was something Charlene was completely unfamiliar with. "I looked around and was like, wait, I can do science, and it doesn't have to be with people? I was hooked literally and figuratively at that point." She continued with that professor throughout her undergraduate career and published her research with him.

She met one of her closest collaborators while she was an undergraduate, her husband. Research with her professor was the "gateway to the rest of my career." Her research interest and that of her husband were a perfect match. "His interest is in big rivers, and mine is in small streams." She knew she wanted to continue to do research and teach. Continuing her education was the way to do that. She decided to continue through her doctorate.

Charlene feels incredibly lucky to have such great mentors in her graduate programs. "There are some pretty amazing women in the field that just sort of took me under their wings at times…they are always there." Not only did she participate in the research of her mentors and advisors, but she was also free to conduct her own research. Charlene's straightforward personality and love of networking were traits that she felt helped boost her educational opportunities in graduate school. "I was fortunate to have faculty that let me be that person. They let me go after things without telling me no."

Charlene had conducted research and wanted to attend a conference to present her data. Unfortunately, there was no funding. Her advisor encouraged her to ask the dean. "I just marched my happy butt over to the dean's office and made my case. We are a larger institution and need representation at the meetings to show…what we can do. I'm that person." She walked out with $1000 and the determination that she would be an advisor like that. One of the biggest things in her graduate program was that people didn't push her or tell her no. "They just sort of let me take off." Charlene remained self-motivated throughout her graduate program. There was no doubt that she wanted to continue research and teach. She also wanted a family. She began her family while still in graduate school.

Charlene had her first child while still in graduate school, even though some of her biggest influencers were women who chose not to have children because it would impact their careers. "I really didn't have any role models that I could pull on or people I could talk to in the field." Her first child arrived while she was in graduate school, and the second was when she was tenure track. "That's what we knew we wanted. It was a difficult decision. But it was unclear how it would impact my career."

When the time came to accept a tenure-track university position, she returned to her home region. She recalls her mentor's letter to the university that indicated, "don't interview her unless you intend to hire her!" Going home still had some challenges. "The old guard was still in charge. If you were a woman and you couldn't make the 4 o'clock curriculum committee meeting because you had to pick up your kid. Well, what do you expect? She's a woman." She states there was a dichotomy regarding how people perceived childcare based on sex. "If a male colleague had to go pick up their kid, it was, oh my God, look at how good a daddy he is." Having children was a difficult decision for her and her husband, who remains her biggest supporter.

Having her spouse in the department has been a positive for Charlene. They are both in the same discipline, working and publishing together. "When we're up here at work, we're collaborating on things…our brains work very differently. But we've worked out how to make that a positive collaborative relationship." Looking at some of her colleagues, she realizes they didn't have the support she had at home and work. "We (she and her husband) had two kids, but he was home with them as much as I was." When she transitioned from assistant to associate, she was offered the interim associate dean position, a position she held for four years before it became permanent. Her husband was very supportive even though she felt some pushback from colleagues, questioning if she was ready. "I had a couple of years to sort of show who I was and what I could do in that role before there was a search." She remained the associate dean for an additional six years. She was promoted to full professor in her second year as associate dean. She has since stepped down from the associate dean position to become program director in her department. Her primary focus throughout her academic career has been students.

Charlene explained that her mother had some trauma as a child. “She was pulled to the front of the class and given as an example of what you didn’t want to be.” That experience made her mom truly focus on students and was able to reach students that everyone else had given up on. Not coming from a privileged background, she feels she has beaten the odds and wants to help her students do the same. She feels many of her colleagues come from a background of privilege, and she did not; it gives her a broader understanding of the students. “So for me, family relationships, and how we interact with our students, that we’re meeting them where they’re at, not expecting them to be where we’re at.” She also states that negative experiences in academia could have easily derailed her if she had not had the proper support and personal strength.

Early in her academic career, she felt she was tasked with more service work than her male colleagues. She recalls going to “search committee meetings, teaching, and seminars “wearing” her two-week-old. Her administration told her it would be nice if she could also sit in on the other search committees. “They just wanted a woman so they could check that box.” Another time, a female colleague had to come in the day after giving birth. She once had a female student ask her, “where are the other women?” Conditions are improving, but it is taking time. “Some of those things just aren’t acceptable now…It is nice walking into a meeting and not being the only female.” Charlene recalls a scientific meeting where she was kneeling, talking to a seated colleague. “A well-known biologist looked over and said that’s just what I like, a woman on her knees. I didn’t feel I had any recourse. Young women today are not going to put up with it.” Although she did not feel like she could respond to such situations earlier in her career, some personal characteristics she feels benefited her.

She describes herself as energetic and unafraid to deal with challenging situations. She is a multitasker and feels women may be better at this. One of the things she sees as having a significant impact is her interaction with students. Remembering how her mother could reach students other teachers gave up on has inspired her. “I have an open-door policy with my students.” She recognizes that she bears more of the advising burden than her male colleagues. “I know from talking to them (male colleagues) I do think there is a difference for women.” She is unsure if it is the perception of a motherly figure or personality, but women bear more advising burden. Students tend to be more comfortable with women. “We’re teaching the entire student, right? Not just part of the student. It is an added workload; I don’t mean that negatively, but it is added time consumption that isn’t equitably distributed.” One of the reasons she chose her institution is that it is so student-centered.

Recognizing the impact of childhood experience on her career, she organizes experiences for young women to encourage their STEM ambitions. “I was given lots of opportunities as an undergrad, and she wants to give that back to her students. It is important for young girls and boys to see women as powerful and capable.” She is also excited to have some “kick-ass junior faculty in our department, women that I have no doubt are going to make it all the way through.” As for institutional support, Charlene indicated that there are no specific policies to support women. She says a “great group of men and women want to start working on that.” She is hopeful.

Participant III. Darla

Darla did not think of herself as privileged. “I had a wonderful childhood even though they were poor. I wouldn’t say we were wealthy at all growing up.” “We never had vacations except if we were going to one of my dad’s annual meetings. We would go camping at a state

park nearby his meetings." While her father would go to his meetings, the rest of the family would do kid stuff and explore. Darla also remembers the impact of her father's sabbaticals on her childhood. Her father was a STEM professor and took his family with him when he took sabbaticals to Seattle when Darla was in kindergarten and to Sydney, Australia, when she was in 8th grade. "At that point, I wasn't thinking professions, but it is something that affected my career and me taking sabbaticals with my family."

When Darla entered high school, a couple of chemistry instructors directed her toward a chemistry career. "My chemistry class in high school. It was co-taught by two dynamic women: a retired nun and an active Jewish lady. They ran a tight ship." She remembers that the instructors, who were so different but had a wonderful rapport, always ensured you understood the concepts and were always available for questions. "They made it fun. I think that's why I ended up in chemistry even though my father was more biology." The class was "even more than chemistry; it was sort of life lessons as well. Really, really, neat." When she graduated high school, it was understood that she would attend college. "We (she and her siblings) were ready for college. Parents made us take four years of English, math, and science in high school." She was fortunate to be accepted into a progressive undergraduate program that encouraged women in STEM.

In her undergraduate program, she met a female lab partner that would impact the rest of her career. "I think we were kind of a pair through our undergraduate program. Everyone knew us …supported each other, helping each other. We were tutors, TAs, and being responsible." Although they were in slightly different fields, they were together throughout their time as an undergraduate. "We liked to talk to each other, worked well together, and did our share of the work." Though her lab partner had always planned on continuing through her

doctorate, Darla had not really thought about it. “She completed a post-doc at Harvard and today is a dean. We still are in touch.” When graduating with her bachelor’s degree, her advisor recommended that she apply for graduate school. “I thought, well, okay, it puts off applying for a job!” Her advisor had just returned from a sabbatical at another university and thought she would be a good fit there. “It was the only place I applied, and I did get in, so I decided I would go. At that point, I sort of enjoyed my research, I was successful in research...even got a graduate research award. I just had a great time there.”

Darla continued working on her graduate degree for six years, bypassing the master’s degree and pursuing her doctorate. While working on her doctorate, she met and married her husband, a post-doc. “He was in a different group but in similar enough fields that our groups would interact.” Upon graduation, her husband accepted a position at a university in the Midwest. “I was the trailing spouse with a three-month-old, but he (her husband) encouraged me to work as well.” She considered staying home but then started thinking, “after going through graduate school, and doing all that training and doing all that work…maybe I did all that work for nothing.” Darla secured a position as a post-doc working for the USDA in town. “It was sort of an unusual post-doc for a physical chemist, but it was helpful in other ways.” Although the work was interesting, sometimes “finding what you don’t like is just as important as finding what you do like, and I didn’t like what I was doing there (at the USDA).” She decided she wanted to continue researching her chosen field and started applying for academic positions near her home. She was hired at a university about 45 minutes from her home. “I have really enjoyed it ever since. I like the physical chemistry aspects…the math…the physics…the chemistry. I like the teaching. I like the research. I love my job.” She loves to solve the math in chemistry. It is like a puzzle to her.

When Darla was hired, she stated that the university was moving toward more research." She was the second woman in the department and felt very supported. The college gave her teaching grants early in her career that helped get her started. She was provided time (release time) to teach her students to conduct research. "Teaching someone to cook is more time consuming than cooking yourself. You need to train people to do research and they (they university) gives you time to do it."

Just as her father had taken sabbaticals when she was a child, she applied for and was granted a sabbatical for her first promotion. She recalls her good experiences as a kid going on a sabbatical with her father. Her kids agree that it is one of the highlights of their childhood. "I spent one semester at the University of British Columbia. I could drop them (her two children) off at school, then catch the express bus to the university." She learned how to use a particular piece of equipment important to her research. "The sabbatical paid half my salary. I had also gotten an NSF grant that (provided) opportunities for women in research and education…the second six months of my sabbatical, I worked with my husband. We wanted to see if I could do my experiments on his equipment." The research her husband was doing she considered "drudge work." He welcomed the opportunity to work with Darla and liked her work better. They applied for an NSF grant, and although unsuccessful the first year, they have received funding every year since 2000. Their research has been very successful, with more than 75 publications. She says, "it is probably nice that we are at different universities, too. We already spend a lot of time together, so that some space can be helpful."

When describing her department, she says there has been a shift in expectations. "While she was able to promote to full professor, she is unsure that she and other faculty

could have made it with the changes in expectations. “When I was hired, it was fine for everyone to get an excellent for annual review. Now they rank more people as meritorious.” She states that the environment is “not as encouraging…not as much support for new hires… She says there has to be criteria. Still, the criteria are now “ridiculous.” She has started working more with women in chemistry through professional organizations and created a women’s chemists committee to help other women in STEM advance. Other than having to be “firm in your opinion to go against the stream”, Darla did not experience the bullying and harassment described by her peers in the climate surveys. “Those surprised me, I always felt supported.” Though the criteria for promotion and tenure may have changed, Darla’s core values have not wavered.

As important as research is to Darla, teaching and working with the students is a core value for her. The teaching grants early in her career were helpful. However, she feels teaching the whole student and involving them in her research is a big part of her reason for her job satisfaction. “I would say there is good in everybody. There is not really a good or bad. Everybody does bad things, and everybody does good things.” She perceives that there is still a lot of bias in the world. “Everyone has such different backgrounds. I didn’t think of myself as privileged, but I did have a safe family, a loving family.” She recognizes not everyone has that. “I was a white girl growing up in a progressive city, went to a progressive college, and was not discouraged from going into STEM.” She believes that people’s backgrounds have affected their success. “How do we find the parts (of STEM) that didn’t get taught? And how do we teach them?” Teaching labs is a favorite for her. “You have four hours to chat… sometimes you have to peel back the layers (in the student background) to find out where the problem or misconception is. If people have the right background, they

can be taught." Darla takes the time to get to know her students and encourage their research. The life skills she can pass on are just as critical to her as their STEM skills.

Participant IV. Betty

There was a local science center that was her home away from home throughout childhood. "There was a lot of STEM enrichment going on when I was a child. It (the science center) drew students from around the state for weekend programs and afterschool STEM programs." The center allowed students to do independent projects. Betty laughs when she relates "how awful some of my science projects really were." From elementary school on through high school, Betty was involved in open-inquiry STEM experimentation. "I would often pick very ambitious things that then would founder a little bit on my knowledge or lack of…worms that froze to the ice cubes, the computer program that didn't work the way I wanted, you know, things like that."

She was also able to explore in her school's gifted program that let her "do science and arts independent projects. They let us fail." When Betty was in middle school, she read a book that set her on her career path. "I read a book with short biographies of scientists. I thought a chemist sounded interesting." She picked her undergraduate degree because of the ACS certification (American Chemical Association). Since she went to a private school, once you paid your tuition," you could take as many credits as you could handle so I took other stuff that looked interesting."

Betty chose chemistry for her degree program but she chose a lot of random classes as well. She stayed as a chemistry major though she admits she wasn't a good chemistry

major. She did not feel particularly connected to her professors. In fact, “most of them left my undergraduate institution after I graduated.” She did not retain any relationships with her professors in her undergraduate program. Looking back, Betty can see that her professors were more interested in research. “Doing research was a requirement of my undergraduate degree. The professor I was researching for just forgot to turn in grades for the three of us.” The same professor was holding a group meeting of his advisees, and when Betty and another female student walked in, he told her that they were reading a paper that he had forgotten to send to them. Betty left and never went back. “So I was never really connected to the scientific enterprise.” One of the things that positively influenced her undergraduate experience was that she was awarded an NSF Research Experience for Undergraduates (REU) grant.

Her undergraduate institution offered a program allowing students to take a fifth year of classes tuition free. When she was finishing up her bachelor’s degree, she thought the “logical” thing to do was to go on to graduate school because that is what people seemed to do. She applied to several that looked interesting. Her advisor for her undergraduate program was not particularly helpful. “It was interesting because both of my parents had college degrees, but they were not science degrees. So they couldn’t help.” Her parents were not supportive of her continuing to graduate school. “When I told them I was thinking about graduate school, they asked if I could go part-time or could I work while I attended? When I explained that they (the university) would pay me to graduate school, they were more supportive.” The summer before beginning graduate school, Betty completed a summer internship at a private high school. It was a valuable experience for her, but teaching science

was not even on their (the private school's) radar." She considered teaching at that private school a valuable experience.

Betty also chose to forego the master's degree and work toward her doctorate. When she arrived at her chosen institution, Betty connected with a small research group and the program's professor. "One professor taught general chemistry in an unusual, Socratic style that included discussion groups. There were voluntary paid positions. You had to want to teach." She continued that position for a couple of years. As a result of that experience, she ended up in a research project that paired an English professor with a chemistry professor investigating how you prepare undergraduate chemistry majors to write essays on exams. It was at this point that she became interested in chemistry education. Betty asked, "Have you ever thought about measuring this or that? The professor said, you know, I have money for a post-doc, and you are about to finish… want to post-doc with me and ask some of those questions?" Betty considers her post-doc advisor as influential in her success. "He gave me a lot of freedom to explore questions, took me to conferences, and introduced me to people that he knew in the field." She spent eleven years at her graduate university and post-doc but knew she would never be hired for a tenure track position.

With her husband's support, she began to apply for positions. "I think I applied to 20 different schools, a number of which were looking for chem ed people." She applied to a wide range of schools because she wasn't fixed on any particular type of school. "I was open to anything from community college to Ph.D. granting. What made me decide on a professor position was …I enjoyed teaching, and I wanted to explore some of my own research ideas." She could have taken an industry position or worked for an educational company, but her research must focus on their priorities. "She was looking for a professional forever home."

Although moving to a new institution meant he had to restart his practice from scratch, her husband still supported the move. She feels she was fortunate to have had so many schools to choose from. When an institution told her, "I think you would really fit here," she knew she had found the right place.

Betty believes herself atypical in chemistry STEM because her research area is chemistry education research. "A lot of my work blurs the lines between my teaching and my scholarship." Her department is supportive of both. "When she was going through the assistant professor review, "people in her department stood up for her…they support chemistry education work." Though now housed in the chemistry department, her position was split between chemistry and the office of science and mathematics education when she was hired. "It was explicitly interdisciplinary, everyone had a primary home in their department, and the secondary home was in this group that focused on teacher preparation." The STEM resource center was where you could gather, try out new ideas, and create a sense of community. There was a tremendous amount of outreach, we ran science fairs and science camps. There were two staff that supported the office. Unfortunately, the office was closed just as Betty received tenure. "The university wanted to run the office at a higher level of the university. "I am still close and in contact with the people from that office."

The STEM resource center and her home department offer local support, but Betty also feels welcome and valued at chem ed conferences. One of the conferences that came to mind that impacted her career was the Gordon Research Conference. The internal funding offered by the university helps with travel expenses for conferences and funding for research. "It was just about when I was going on the market, and I was at the conference presenting a poster—one of the last speakers canceled. The organizers chose a few posters to present…I

still keep that on my CV." She also takes her students to conferences so they can present their research and meet other professionals in their field. She also appreciated the universities efforts of the university to support women in STEM.

In addition to the travel funding, the university holds social events, although these are pleasant but awkward. "I don't hang out in groups of all women." She understands the reasoning behind these gatherings, but they have had little substance. The university continues to explore ways to support women faculty and recently received an ADVANCE grant, so Betty hopes the climate will improve for the STEM departments across campus. Her desire for equity and respect extends to their students.

Betty believes in treating students with the love and respect they deserve. A core value for her is to separate the work from the student. "The work might not be good, but you still show kindness and respect." She is careful not to show preferential treatment to any of her students. "I don't offer something to a student that I wouldn't offer to all students." She will only take students that she can support their research.

Participant V. Emma

At the age of 5, Emma announced she would be a biologist. Though the type of biologist changed through the years, there was never any doubt in her mind that she was going to be a biologist. Her older brother may have had some influence with that decision. "We were both first-generation college students but just loved science. …fishing with him and catching fish…We would go to Houghton Lake every year." While there were experiences other than fishing, such as swimming, it was the time with her brother, who is now a veterinarian, that had the most influence. "He (her brother) ended up teaching me a lot of the things. I think that really drove me into want(ing) to be a fish biologist. But… I'd

always had this real interest in fish." She was the one who would clean the fish and look at the internal organs. "She was fascinated by them just because they lived in this totally different environment than we did."

While Emma knew she wanted to be a fish biologist, her high school background did not lay the groundwork for serious study in college. "I wasn't the best student (in high school), so I did have to go to a community college right after to get some decent grades, then go on to a four-year university." That time at community college was a positive experience for Emma. "The professors are incredibly positive (with) a lot of hands-on work that really resonated with me." The style of teaching at the community college suited her well. "I'm a field biologist, so I am constantly trying to get students involved and getting their hand on (research) and sharpening their skills."

However, not all her experiences in community college were positive. "Once in a while, you would get the (working) groups of men…talking amongst themselves…with my voice not being heard in the conversation." The professors would help her figure things out and how they worked. She just felt the professors were supportive of her. After a couple of years, Emma moved on to a four-year university and finished her biology degree. "Fisheries people, in general, are just a good group to be involved with. Everybody's looking to collect (fish). They're always willing to help me, and I'm always willing to help them." She still collects and conducts research at the field station she visited as an undergraduate and takes her graduate students there today.

When Emma graduated with her bachelor's degree, she knew she wanted to pursue a Ph.D. Her family was not so supportive of her choice. They wanted her to be a nurse or a K-12 teacher and get a job. "I knew I wanted a Ph.D., although I didn't know what I wanted to

do exactly after that. I had some really good (undergraduate) college professors. I really enjoyed that."

During her master's degree program, Emma felt she had an incredible amount of support as she had experienced in her undergraduate program. "But I certainly had friends in grad school that …just didn't have the same kind of investment from their advisors…and they had to struggle with…the things they were doing." Her master's program is also where Emma learned she had a strong desire to teach. "I had some experience in grad school … teaching, and I really enjoyed that." But it was her Ph.D. advisor that truly impacted her career.

"My advisor was a very hands-on, incredible person. He was very invested (in her success). Even though he is now retired, they still do research together. "He took me on in his lab. And I fell in love with the work he was doing. And it was very challenging throughout the whole time period, but challenging in a good way." He related his advising strategy to her one day, which she still follows. "When I mentor students, I try to bring out my feminine side," he stated. Her Ph.D. advisor said, "Every student is different; they all …need…empathy, an open mind, and compassion." "I try to use those lessons with my own students," stated Emma. At first, Emma had difficulty coming up with her own ideas for research, but "I could run with other people's ideas." She was the person who would plow through a problem and figure out how to solve it. "coming from a blue-collar background and being a hard worker helped her." Emma stated that "you don't have to be particularly bright to get a Ph.D., but you do have to be persistent. Persistence overcomes resistance."

Eventually, she transitioned into coming up with her own research ideas with help from her mentor. After graduation, Emma took a position with the United States Fish and

Wildlife Service for two years. “But I knew I wanted to get an academic position.” Again, there were some questions from her family. “How long is this going to take?” and “When are you going to get a real job?” were questions from Emma’s family. It was not long before she had a position at an R3 institution.

The department will have a dinner night or go to a hockey game and whoever can come shows up. “We have a really supportive department, and we all get along well.” Lunches or grabbing a drink after work are common. “Every two weeks during COVID, we would have a Zoom meeting just to talk.” Everyone in the department also has the same student mindset, which is best for the students. To provide support, the department had a mentor assigned when she arrived. “I didn’t have a lot in common with the mentor, so it was not a good pairing.”

The second year, she was assigned another mentor, and “that was very helpful. I was pregnant, and the mentor helped her navigate the childcare and other resources.” Although the second mentor was still not a good pairing, she could answer questions.” When she first arrived, few faculty members were female. “It is interesting that I never had a female mentor but happy to have I am happy to have female colleagues to talk to now. We recently discussed how female faculty are more likely to do more service.” The female faculty have to stop themselves from accepting more work. “We celebrate when one of us says no to more service work.” Emma cannot help but wonder if having an established female mentor earlier in her university career; she might have been more confident when going up for tenure.

Applying for tenure was stressful for Emma. “Going up for tenure was pretty important for me.” If you get tenure, you can explore questions that might take a long time to answer. She did not have to get all those publications out there. “People kept telling me that I

didn't have anything to worry about," but she is a worrier by nature. There is a plan, but it is not guaranteed. Emma worried, "am I good enough, am I not good enough?" After tenure, Emma was free to explore those options and felt a measure of freedom. It was very rewarding and "affirming to receive tenure."

After promotion to full professor, the administration wanted Emma to assume the role of department chair. She decided against taking on a leadership role but did fill in for a couple of years to help out. She knew she would not be happy in the role but thought to herself, "I should do this." Although Emma wanted others to feel they could rely on her, she knew it wasn't right for her. "After a couple of years where I had some chair duties, I thought, no, that's enough for me. It is not what fills my soul." She did offer to lead the departmental search for a new chair.

Emma would like to see a woman's discussion group at her university, a "female group of faculty, a community commons group. Meeting monthly is just a community to draw from when you have questions or have a fear about something." Not a set agenda but discussing issues that are somewhat unique to female faculty. For example, "there seems to be more service requirements or expectations (for women)." There are the student perceptions. "Students come in with the expectation that we're more compassionate…more likely to call us by our first names, there is all these different things that can be discussed." Student interactions is an important part of her core value and who she is.

Emma wants to pay it forward because she had a lot of support during her career. Her doctoral advisor involved her in his research and "really took an interest in me." She does the same thing with her students. "Whatever research I am doing, I involve the students. I do my research through them." She feels fortunate that her university has a lot of minority students,

and she does not want to leave them out. “I try to provide the same support I received in my undergraduate and graduate programs.” She wants to make sure that she can financially support any student she takes on and feels the university has been generous in that regard. “I’m not doing any paradigm-shifting science – the students are the main focus…my biggest contribution to science is what I can provide to them (her students) as a mentor.”

Connections

After grouping the data thematically, five themes emerged that answered Research Questions One and Two. These themes were Childhood STEM E3 (Empowerment, Exploration, Expectation), Communal Spirit, Alliances, Philanthropic Investment, and the Lily Hardy Effect. Research Question Three revealed that the participants could only identify limited institutional supports in the form of early internal funding and assigned guides, those who could help navigate the institutional policies. Research Question Four was addressed by the themes of Coerced to Comply, Bias Against Women, Heavier Service Loads, and challenging the Status Quo. Each of these themes are explored in the following section.

Childhood STEM E3

Childhood STEM influence came in three forms; Empowerment, Exploration, and Expectations. The one most prevalent for the participant group was outdoor experiences with family. Participant II, Betty, said that her mother was one of 12 children, so “a ton of cousins were always running around in the bayou. I was surrounded by other kids who were not afraid of the outdoors.” Participant I, Alice, had a similar experience. “I had four brothers and was outside all the time. All the animals and spiders, grass and everything else. But still much more math than science.” Although Alice says she was much more math, she and her

brother were not above practicing a bit of physics in the nearby field. “We had this humongous field across from us… we put firecrackers down the storm drain, magnifying glasses on daddy long-legs, and I suspect my brother ended up putting the field on fire.”

Alice and her brother also enjoyed just exploring the field. “I think I was inspired by some of that.” Like Alice, Participant V, Emma, feels she was inspired by her time outside exploring with her brother. Her brother, who was much older that her may have influenced Emma’s announcement at the young age of 5, that she was going to be a biologist when she grew up. She went to Houghton Lake every year and fished with her brother. She recalled that they “both really loved science.” She and her brother, who later became a veterinarian, played with the fish and looked at the insides. “They were interested in fish because they “live in a totally different environment.” Participant III, Darla, recalled that her outdoor memories came when her father, a molecular geneticist, was attending conferences. She related that her “vacations as a child were camping near where my father had a conference. We were poor but “had a wonderful childhood. Darla also was also influenced by the sabbaticals her father took.

When her father took a sabbatical to Sydney and Seattle, “he took us with him. These times have had an impact on my career path.” Darla said there was no doubt that she and her siblings would attend college, there was an expectation. “Our parents made us take four years of math, science, and English in high school. We were prepared for college.” Darla said she felt fortunate that she and her siblings were never discouraged from pursuing STEM careers. STEM interest.

Darla said one of her memories from elementary school was when she was sick at school, she wasn’t sent home. She was sent to her mother’s classroom. “I remember looking

at microscopes with pond water and looking at bugs in mom's classroom" during these sick days. She also recalled helping her mother studying for her master's degree. "I was little and I'd be like di D ox see? And she's like deoxyribonucleic acid, that's blah, blah, blah. And I would be like, Oh my God, my mom is so smart! I always had that role model." Another participant, Alice, had a similar experience with her role model mother.

An example of empowerment came from Alice. Her grandmother owned a beauty salon; Alice's mother was an accountant and kept the daily books. "This was back in the 70s before computers. My mom had to … add up how much money my grandmother made on different haircuts and beauty stuff." At times Alice's mother would get behind, so, at the age of six, she let Alice start adding up the receipts. "My mom got me going on an old type of adding machine that you punch in, and (the) tape came out. I was always so happy when it balanced! I absolutely loved doing it. I did it every day." For another participant, the STEM experiences provided by their parents were more structured.

Participant IV, Betty, didn't have the same outdoor experiences as the rest of the participant group but did have STEM experiences provided by her parents at the local science center. From elementary school up, Betty's parents took her to the science center at every opportunity. Betty was involved in STEM enrichment at the science center on weekends, in summer, and after school. "I would often pick very ambitious things that would founder a little bit on my lack of knowledge…worms that froze to the ice cubes and the computer program that didn't quite work." She feels the time invested at the science center definitely impacted her career path. Although her family had taken her to the science center and was supportive of her earning a biology degree, Betty's family was not supportive of her earning an advanced degree. They wanted her to get a teaching or nursing job. Betty was a first-

generation college graduate, and her family felt it was too expensive and really did not know what you could do with a master's degree. They asked, "Can you work and go part-time?"

Communal Spirit

Although data points, such as playing outside with the cousins in the bayou or the field across the street, could be listed under Childhood STEM E3, the number and depth of these entries warranted their own category. Each of the participants had a place where they were accepted, supported, and/or felt safe.

One of the more interesting data points identified in this theme was an event that Charlene directed that highlighted the contribution of women in science. A group of 60 to 70 volunteers helped put on the event each year, and Charlene said the support and comments from the participants were a big emotional support for her. It was one of the things that has "bolstered me over the last six or seven years. It has been a huge mental and emotional boost over the years." The girls participating in the one-day event comment, "I'm going to be a powerful woman in medicine," or "my power goal is to finish high school." Charlene smiled and stated, "we kind of kick-ass, right?"

Betty described herself as an atypical STEM professor. As a chemistry education faculty member, she "blurs the line between teaching and scholarship." When she first arrived at her university position, there was an interdisciplinary office for teacher education. She called this large open space a "community hearth." "There were two office staff members to support us. It was where all the outreach stuff was kept." Although everyone had offices in other buildings, this outreach center was "in the basement where a lot of people taught…they would come a few minutes early… they'd stop in and just kibitz." Other times, there were collaborations between the STEM education faculty where "people might pop

their head in, and you could ask what do you think about this? Do you think it would work? It just created a sense of community."

For Emma, the sense of belonging that began with her brother fishing at the lake continued into her professional career. "Fisheries people, in general are just a good group to be involved with" says Emma. At the biological station where she conducted research as a graduate student and now with her graduate students, Emma will "collaborate with many of the folks there and the research and writing we do. And they're always willing to help me and I'm always willing to help them." People from all over the U.S. come to the research station. They all research invasive species and gather at the station every summer. "It's been a great experience."

For Darla, her time as an undergraduate and her lab partner gave her a sense of belonging. Her undergraduate institution was "pretty supportive of women …even 40 years ago." The institution did not have a graduate program, so she and her female lab partner applied to tutor and act as teaching assistants, "(we) just always supported each other, helping (others) and being responsible for showing up for our TA positions." Although they would follow different career paths, Darla still keeps in touch with her lab partner. "I think we both helped in each other's lives… in positive ways." Darla truly feels her undergraduate institution and lab partner helped shape her career.

Alice's communal spirit can be traced to her graduate experience. "I would say it was the whole climate. All the professors, even the dean, knew who I was." Alice needed funding to finish her program, and the dean helped get her scholarships to complete her degree. "They had enough confidence in me that they allowed me to actually teach university master's level classes in math. I wouldn't have done that for me!" When she was graduating,

one of her professors asked if she was interested in co-authoring a book chapter. “Even though I graduated in 1996, I am still involved with her.”

Alliances

In addition to Alice’s reported experiences collaborating with her dean, document analysis was used to determine the number and longevity of the participants’ alliances. All of the participants had a strong, long-term collaborator. For Betty, Charlene, and Darla, those collaborators are spouses. In Alice’s interview, she talked about a professor from her graduate program that she still collaborates with today even though the professor is now retired. Emma still conducts research and publishes with her doctoral advisor. It is worth noting that when conducting the document analysis, some of the participants had partnerships in addition to collaborators. For example, Emma has had long-term collaborations with the Missouri Department of Conservation and the United States Fish and Wildlife Service.

Philanthropic Investment

The form of this investment was not funding; it was time, guidance, and support. Each participant in the study had a person who saw potential and supported them in their education and career paths. After a few years, Alice was a high school math teacher and decided that high school teaching was not for her. She loved teaching, just not at that age level. She went back to school for an advanced degree with the thought of teaching at the college level. “She [Alice’s College Advisor] believed in me and saw that I had a lot of potential and I was a hard worker. It really changed the trajectory of not just my career but personally.” Although no longer a student, Alice still keeps in touch with her mentor. Now in her 80s, her mentor, still active in research, involves Alice in her projects. “Whenever I get a publication, I still send it to her.”

An undergraduate advisor was the person who stood out to Charlene as an ally and encouraged her. Charlene was applying to tutor and asked her advisor for a letter of recommendation. This advisor recognized that she was doing well in her studies, she had gotten an A in his freshman class, and hard working. Her advisor asked her "do you just want to teach or do you really enjoy science?" She told him "both." Rather than recommend her for a tutoring position, he hired her as a research assistant. "I basically put fish in a swim tunnel. I loved it. I thought, wait, I can do science and it doesn't have to be with people?"

The support, encouragement, and investment from Charlene's advisors continued through her master's and doctoral program. There were also "some pretty amazing women in the field that took me under their wings." One of those women are now working with her son. Now a sophomore in college studying herpetology, the woman that played a big part in her life is now guiding Charlene's son. "It is a small world."

Charlene recalls a time when she had conducted research and wanted to present it at a conference. There was no funding set aside for graduate students to attend conferences in her college. Her undergraduate advisor encouraged her to go to the dean to get funding. "I marched my happy butt to the dean's office and explained why we (the college) needed representation at these conferences to show what we can do. I walked out with $1000." That is when she made the decision that she wanted to do research with undergraduate students someday.

Her undergraduate advisor also encouraged Darla to apply to a particular university where he had a colleague. "He really shaped my career… and supported me as an individual." Although she did not work under his colleague, Darla felt it was helpful to have someone there with whom she could talk and feel safe. She stayed at that university for six

years through to her doctorate degree. She really enjoyed doing the research and was encouraged to do so. “I was really good at research and won an award for it.”

Betty worked for her graduate advisor for 11 years through her doctorate and a post-doctorate position. “One professor was teaching introductory classes and had a more Socratic discussion style.” He was looking for graduate students to assist in teaching these classes. It was a voluntary paid position, so the university wanted graduate students who wanted to teach. “I ended up engaged in a research project between the chemistry professor and an English professor investigating how you prepare undergraduates to write essays on exams. It led to conversations and all sorts of questions.” Her graduate advisor invited her to conduct research as a post-doc to answer some of those questions. She went to English conferences and workshops and changed her research area to chemistry education as a result of this work. “Some of my colleagues … are more typical in their research. I blur the line between teaching and scholarship.”

Emma had some outstanding female college professors and mentors who helped her navigate the academy. It was a very challenging time for her, but her Ph.D. advisor was, but he was very supportive. He is retired, but they still do research together. She fell in love with the research her advisor was doing, and he took her on. Her advisor said he tried to bring out his feminine side when he advised students.

Lily Hardy Effect

The phrase “pay it forward” came up multiple times in the interviews, but it was more than that. The participants said they wanted to help students and always from a place of love. The quote is “You don’t pay love back, you pay it forward”(Lily Hardy, 1916). Each participant in this study stated they did not come from a privileged background and felt it

gave them a /broader perspective and understanding of their students. Darla pointed out that not everyone has the same opportunities and is in different places. “Someone taking remedial courses should not be ridiculed.”

On the other hand, they feel it is essential to ensure students know the expectations and push them to reach their potential. Students recognize this, appreciate it, and often tell her after graduation. The women in this study recognize how the support and encouragement they received early in their careers made a difference and now want to pay it forward. Each is actively involved in the success of their students.

In their opinion, these women’s most significant contribution to science is the support and mentorship they provide to their students. Whatever research they are doing, they involve the students. They all work hard to keep their lab equitable. They do not take on a graduate student that they cannot support financially nor anything that she would not offer to another of her students. Emma mentioned she felt fortunate to have so many students from underrepresented groups. She wants to ensure that “I … don’t leave them out.”

The participants felt, however, that it was important that the student learn from mistakes and have the opportunity to reflect and revise assignments after providing comments. Separating the work students do from the students is essential. Showing respect and kindness to each of them is a core value for each of these professors. When discussing their teaching philosophy, each professor used terms and phrases such as student-centered, core value, equitable opportunities, and primary focus. As Darla put it, “if people have the right background, they can be taught. “Sometimes you have to peel back a few layers to discover where misconceptions or missing content is.” To find the misconceptions students hold, professors must be available to students and willing to spend the time. That does not

mean coddling the students. The professors indicated that being direct and unafraid to tackle challenging situations was a strength. In short, these women see themselves as teaching life skills to students, preparing them for a future in science, and giving them the support and encouragement they need to be successful.

Institutional First Aid

Research Question Three addressed how the participants perceived institutional support. Although each participant's university had policies in place to support the advancement of women in STEM, the women found these measures had limited impact on their careers. Alice indicated she did not "hang out in groups of all women." Social events set up to be supportive were "pleasant but made her feel uncomfortable." The other participants had similar feelings about these events. Some of the policies enacted for all new faculty the women thought were especially helpful, including the early faculty grants and release time to mentor students in research. Darla felt strongly that "the teaching grants early in my career helped get her started." The participants felt it gave them a stable foundation from which to advance, although when analyzing their curriculum vitae, it was clear that gaining external funding was a strength for all of them. All had grants from a variety of sources and multi-year grants. Darla has had ongoing grants from NSF for research in collaboration with her husband for nearly two decades.

All participants mentioned that travel funding for conferences and internal funding supported their advancement. They felt it allowed them to start research earlier in their careers and took off some pressure to find outside funding. They all took advantage of these to advance their career, but Emma also indicated that it helped provide their students with

research opportunities. One policy that each participant institution had in place was mentoring.

All of the participants had an assigned mentor when they arrived, but the role these mentors played was more as an institutional guide rather than a mentor. These relationships did not come to fruition in the form of long-term collaborations. These mentors helped the new faculty with paperwork, policies, and institutional procedures. Darla and Emma indicated their first assigned mentor was not a good match as they did not have much in common. In the second year, Emma was assigned another mentor who was a better fit and helped her with maternity resources and childcare. Still was not a good pairing, but it "got (her) questions answered when needed."

Critical Theory

Research Question Four explored how critical theory provides understanding for women's path to full STEM professor at R3 institutions. Critical theory was appropriate for this study because it includes three important criteria: a minoritized population (women in this case), a power differential, and an effort to challenge the status quo. In its earliest days, higher education was exclusively the realm of men. Higher education was established to train men to be the decision-making body of society (Thelin, 2018). Although in some disciplines, such as education and the social sciences and even in biology to an extent, fields such as chemistry, engineering, geology, and physics remain male-dominated. Women in STEM are an under-represented group.

Coerced to Comply

The number of female professors is growing so slowly, but the positions of power, such as committee chairs, department heads, and deans, are still held mainly by men. This

power differential provides situations in which there may be coercive power of men over women. The departmental committees, chaired by men, may be making decisions on tenure applications, the topic and number of assigned classes, or leadership assignments.

. The women in this study reported being expected to make some difficult decisions in order to maintain their opportunities for advancement. For example, Charlene was on maternity leave and yet was assigned to serve on a hiring committee. She felt she had no choice but to come in even though her child was just two weeks old. Charlene's colleague had to come in the day after giving birth to her son. Because the other members of the hiring committee were the ones who would be making decisions about their career, both women felt they had to come in to work during their leave. Even after coming and serving on the hiring committee as asked, her department head said "we have two other search committees going. It would be nice if you could sit on those as well." This is just one example of how the power differential impacted the women in STEM in higher education in this study. Charlene was frustrated at times by the treatment but said "you just have to handle those things or be ostracized." Darla said there continues to be a double standard for men and women, but Charlene says that things are changing and that "the younger generation isn't going to put up with it."

Bias Against Women

As mentioned in the literature review, men tend to be perceived as the group that is more logical, more goal-driven, and in control (Laursen & Austin, 2020). Women are expected to be more community-minded, nurturing, and less capable of leadership (Carnes et al., 2015). As Darla said, "There is an unfairness in how women are treated, but you just have to shrug it off." Department and committee meetings are just an example of places that this

"unfairness" appeared. Alice indicated she will sometimes "just give up trying to talk" in meetings unless she feels strongly about the topic. On the occasions she feels strongly about a topic, she will draw attention to the fact that she is being left out by saying "I guess you don't want my opinion." She has removed herself from many of those committees because she "wasn't getting anywhere." She noted that when the men talked in meetings, the others were listening. When the women talked, there were side conversations. All the participants perceived that women's opinions do not seem to be valued as much as their male counterparts.

Heavier Service Loads

Charlene said in her interview that "you feel like you have to do more than men" to get the same level of respect or recognition. Emma believes "female faculty are more likely to be asked to do more service" than their male counterparts. She feels that "you have to stop yourself and "say no, I can't do another thing – we celebrate when one of us says no (to extra service work)." One area where this was evident from all the participants was in advising.

Emma indicated that female faculty have more student interactions than male faculty. "Not only do we have a larger advising load, but students come to us more often for advice even when we aren't their advisor." She also noted that the students were likelier to call them by their first name. "They respect our advice but don't respect our title."

Challenging the Status Quo

The third reason that the critical theory is a meaningful framework for this study because the status quo of men in positions of power is being challenged. The participants in this study all feel that their careers could have been derailed if they had not had such a strong support network, but all have noticed a change in the climate of STEM in higher education.

Darla said there is still a lot of work to do, but progress is being made. Charlene indicated slight shifts in the student workload for female faculty as well. More women are being promoted to positions of power, and this is needed not just for the next generation of women in STEM but also for men to see that women are capable. The women in this study all served in leadership positions not because they wanted to be in positions of power but because they felt it was their duty to do so. Another common thread is that all these women are involved in work supporting women in STEM, from hosting events for middle school girls and helping them develop power goals to hosting communities in common.

Discussion

Inequitable service loads are discussed throughout the research of women in academia (i.e., Guarino & Borden, 2017; Misra et al., 2011; Mitchell & Hesli, 2013). What was less discussed are possible solutions to this inequity that do not require additional recordkeeping and burden to the women faculty. This hidden workload was not considered in promotion and tenure policies, but providing extra weight in promotion and tenure decisions to these activities may improve the number of women who attain full professor.

Impacting work-life balance was the willingness of spouses to share in the responsibilities of home life. Three women shared research and publications with their spouses, but all five mentioned the shared duties at home. Spouses taking the children for the weekend when the participant needed to finish up a paper or children traveling with them when conducting research, conferences, and sabbaticals were mentioned by all participants in this study.

Both the long-term and internal mentors played a role in the success of these women. Participants were successful in securing their long-term mentors. Having a support person

that saw the potential and encouraged these women was beneficial. Although the internal mentors were perceived as most beneficial if they were from the same demographic group, the long-term mentors were not necessarily from the same demographic group but were seen as crucial to their success. Institutions could use a support system to encourage established faculty to take on younger faculty for long-term relationships. These long-term faculty mentors could be compensated in some manner, such as release time. Having an internal mentor of the same demographic group was another factor that may impact the successful promotion to full professor by women in STEM (Mazerolle et al., 2018; Schmidt & Faber, 2016). Having an assigned mentor within the department who does not have common interests was not seen as support.

Gender bias is more difficult to combat than providing mentors. Although anti-bias training is a requirement at many institutions, online training was seen as limited in its impact (Laursen & Austin, 2020; McClelland & Holland, 2015). Embedding anti-bias training into the hiring process (Fine et al., 2014; Laursen & Austin, 2020) and the promotion, tenure, and evaluation process may be the most impactful (Laursen & Austin, 2020).

Institutional support was limited to internal funding and this was perceived as helpful to get their careers off to a smoother and timely start. Again, this is a support provided to all faculty, but women saw these as impacting their careers. Policies that support all faculty may be a better strategy. Supports that address only a specific group can be seen as "fixing" that faculty segment and are ineffective over the long term (Laursen & Austin, 2020). Ensuring supportive places such as research stations and lab space were essential. Although the women's socials were hosted to support women, they were not perceived as beneficial by the women in this study. Conferences that offered "speed mentoring" where women could

explore possible collaborators were seen as alternatives to assist women in their research, future publications, and ultimately promotion and tenure.

The factor that may be the most critical for all women in both studies is early experiences in STEM. These experiences were more often but not exclusively with family. These women, as children, were allowed to explore, experiment, and fail and were encouraged by family or by strong women influences in their interests. They spent unstructured time outdoors during their developmental years. All the women in this study recognized the importance of this early experience, and today, each actively encourages young girls' interest in STEM careers. This may be the single most impactful strategy to increase the participation of women in STEM. Not only are the young women encouraged, they see highly successful women in academia in STEM fields. They can see the future for themselves.

Discussion

Findings derived from the participant interviews are consistent with the literature in some aspects. The masculinized workplace described by Laursen and Austin (2020) and Britton (2017) was experienced by the participants in this study from their undergraduate experiences to their promotion to full professor. The incident where the participant and her lab partner showed up to a meeting where only the male students were given the readings was just one example of the undergraduate experience. The lack of respect experienced by the participants in department meetings and conferences aligns with studies by Avallone et al. (2013). One participant said that her career could have been easily derailed without the support of their mentors and philanthropic investment from persons in positions of power. It is these departmental and specific actions by leaders that, as suggested by Archie et al.

(2015), Britton et al. (2012), and McCoy et al. (2013), have the most significant impact on careers.

Mentors played an essential role in the success of the women in this study. Although a shortage of female professors available to serve as mentors was suggested as a limiting factor for the promotion of women (Hsieh & Nguyen, 2019; Johnson, 2014, 2017; Mazerolle et al., 2018), only one of these women had a female mentor. None of these women developed long-term collaborations with the mentors assigned by their institutions. Each sought out and developed mentor-mentee relationships on their own. Three of the women developed long-term collaborations with their spouses. The mentors assigned by their institutions were perceived as somewhat helpful in navigating institutional policies, supporting research by Mazerolle et al. (2018) that internal and external mentors were essential for advancement.

Although three participants conducted research and published with their spouses, all were married and had children before tenure. The second shift, described by Hochschild (1989), did not have the same impact on these women as childcare and duties were shared by the participant’s spouses. The same cannot be said for the workplace. Women who were on maternity leave were coerced into retuning just a short time after giving birth to fulfill their obligations for search committees. All participants felt they had to do more service than men to gain the same respect. This supports the findings by Guarino and Borden (2017) and Misra et al. (2011). The reason the participants accepted the additional service work was consistent with Misra et al.'s (2011; 2012) finding. They felt that the work was important and necessary to keep the department and university going or to care for the academic community. Unlike Misra's studies, these women felt that giving back was an essential part of who they were as a person.

The findings by Misra (2011) that women are less likely to chair committees or become department heads (Carnes et al., 2015) were not present among the women in this study. All participants had served in leadership positions, including department head, hiring committees, and associate dean. Although they had leadership positions, they were not immune to gender bias, as described by Laursen and Austin (2020), Carnes et al. (2015), and DeWelde and Stepnick (2015). The women in this study were subject to sexual comments, over-talked at meetings, and ideas dismissed, although they felt they had it better than most. Their perception was that you just had to put up with it or be ostracized.

Limitations and Future Research

A limitation of this study is that all the participants were White and assigned females at birth. Although there were minoritized populations in the possible pool of participants, none chose to participate in the study after a second request. According to Wang and Degol (2017), women from all intersectionalities have similar obstacles. Intersectional identities should be explored, however, as these may combine to produce differing experiences and encounter different biases (Armstrong & Jovanovic, 2017; Cho et al., 2013).

Institutions that have applied for ADVANCE funding may have a different mindset toward women in STEM, and their faculty may have differing experiences. Diekman et al. (2015) suggested that STEM disciplines offer fewer opportunities for faculty to have a service-oriented career. The women in this study were active in service; although it cost them research time, they considered it a priority. Additional research should be conducted at R3 institutions outside the Midwest and those not applying for ADVANCE funding for comparison.

Maternal wall bias is the idea that women with children may be less committed to their position and research (Laursen & Austin, 2020; Luceno, 2006). The women in this study all had families, and the impact of having a family was not explicitly explored. Future research could include the effects of maternal wall bias and whether the bias increases with the number of children. Comparing maternal bias in R3 institutions on women and men could also be conducted.

Conclusion

When the U.S. was in its infancy, universities were created specifically for men to become leaders in the community. Women were relegated to learning to run a household and raise children. Since World War II and the entrance of women into the workforce, more and more women are earning college degrees and have now earned half of all doctorate degrees but do not have parity with their male counterparts in the higher ranks and leadership positions in colleges and universities. There has been less advancement of women in STEM fields that in other content areas. A large number of studies have attempted to determine the causes of this disparity, including comprehensive case studies by Laursen and Austin (2020) and a meta-analysis by Misra (2021). Although millions of dollars in NSF ADVANCE grant money has been spent to study and improve the ration of male and female full professors in STEM, the problem remains that women still do not promote to full professors at the same rate as men. This study attempted to glean the background of the successful promotion of women at R3 institutions in the Midwest to provide information to leadership that may benefit their attempts to diversify their faculty.

The women in this study identified strategies universities can use to improve the ratio of men to women STEM faculty in R3 institutions. One suggestion was to change the format

of the women's socials so that meaningful conversations regarding their current research interests are discussed. This may provide opportunities for collaboration across disciplines and offer the possibility of long-term collaboration. Another strategy identified that was somewhat helpful was the assigned mentor. Perhaps a better description would be a guide. Even this short-term mentor should have some commonalities with the mentee to be truly helpful. The long-term collaborators and partnerships that are successful were established by mutual agreement.

Another strategy that the women felt was helpful was the start-up funds and internal grants. Although this is provided to all junior faculty, the participants perceived the funding as a jumpstart to their careers. They could get started on their research interests without having to raise funds. This was also important as they could support their students, supporting what I called the Lily Hardy effect. They not only want to pay it forward, but they also do so from a place of love. The *Garden of Delight* by Lily Hardy (1916) is credited with the phrase but not the concept.

The philanthropic investment by persons in positions of power is not about funds but about investing time and scholarly support to undergraduate and graduate students. Institutions can encourage this by providing release time for senior faculty to work with junior faculty graduate or undergraduate students. The release time is necessary, but ensuring the work conducted as a mentor or advisor is included in annual evaluations, promotion, and tenure decisions is possibly more important. It will not be easy to achieve equity until such behavior is rewarded in an official capacity.

Finally, institutions can address Childhood E3, but it is a long-term solution. Families are scattered, and the very definition of family has changed. Single-parent households mean

that parents may not have time or resources to offer opportunities for STEM enrichment. Universities can partner with local schools, after-school organizations, and non-government organizations to offer enrichment. This investment will not pay off in the short term but will pay off. It would have to be institutionalized as an investment in the future of the university and community. Each of these women attested to the impact it had on them.

If we do nothing, progress will continue at its current slow pace. Making a difference means making a choice. We must choose to invest in the upcoming female STEM students and faculty. We will only achieve the critical mass of women in STEM if we are persistent and overcome the resistance.

Section VI. Scholarly Practitioner Reflection

Introduction to Scholarly Practitioner Reflection

The Educational Leadership and Policy Analysis (ELPA) program required analysis and reflection from the start. The program was arranged so that we analyzed first what was familiar; then, it quickly became more challenging, but guided by selected readings, we gradually became more skilled. The final phase of the doctoral journey, the dissertation, has influenced my practice through reinforcing my reliance data-driven decision-making and changing my perception of the types of data that I need. The dissertation has changed my scholarship in that I have changed from primarily content research to women in STEM. I feel blessed to be able to offer some information that may be of benefit to the administration for their consideration in their decision-making process.

Dissertation Influence on Practice

The process of writing the dissertation has influenced my practice by strengthening my reliance on data-driven decision-making and separating data from perception. When chatting with the participants for my study, they all indicated that they were lucky that they had not been subject to discrimination and bias as some of their colleagues had. However, as the interview progressed, issues that I would certainly describe as biased, derogatory, and demeaning came to light. The participants' perception was that they had not been subjected to discriminatory behaviors when they had. They could recognize discrimination when inflicted on another but did not classify the same actions as discrimination when directed at themselves. This has caused me to rethink the climate surveys colleges and universities regularly administer.

I understand that MSU will be administering another climate survey in the coming year. I appreciate the time, effort, and expense that goes into these surveys as the ADVANCE

committee on which I serve has been involved in adding questions to the survey to gather data for the efforts to improve gender equity on our campus. It is important for leaders to both gather good data and to act on that data to facilitate change (Zettelmeyer & Bolling, 2014). Although interviews and focus groups, such as the data gathered in our focus groups with STEM faculty on the MSU campus, are much more time-consuming and costly, I feel the data gathered is much more accurate. These surveys, administered to faculty, staff and students, is useful but if data is to be useful in solving real world problems, it needs to be the most best data possible and from multiple sources. I believe that the administration wants to make improvements in the climate at MSU and gathering data is a useful tool to achieve that goal (O'Leary, 2005). According to Manoharan et al. (2023), organizations who incorporate data-driven decision making outperform organizations who do not. Although this is a reference to the business world, I believe this applies to higher education and the issues that we are facing. This is just one example of how writing this dissertation has influenced how I consider data.

I try to be practical, looking at everything through a lens of return on investment, using data to guide my practice. Time is one of our most precious resources and a limiting factor in our accomplishments. As a schoolteacher, I have used data to make classroom and instructional decisions for nearly 30 years. I have to say; however, I am much more intentional and include not just scores and quantitative data. In my GRY240 Earth Science for Educators class, I am responsible for igniting, if not a love of science, at least an appreciation for science in addition to content. These students are going to be teachers in elementary or middle school. If they end up disconnected from science in my class, they will not be effective science educators, and I will have failed. Since I began the dissertation

process, I have started including discussion questions and making notes of student responses. It is a better use of time to ask a few questions and make changes to the learning experience than to continue learning activities that are not effective. The exams and labs tell me if they get the content, but their perception cannot be captured that way. This semester, I have required each student to come to talk with me as part of their final. I have taken notes and made changes to improve the learner experience in my class. Another way I have started collecting information and applying it to my class is by analyzing the Missouri Content Assessment (MoCA) scores, the certification test, for elementary and middle school science preservice educators.

Data are helpful in addressing real-world problems (O'Leary, 2005). A real-world problem for my students is passing their certification test. Some students do not see how they will use the information presented. While I am continually connecting science to real-world examples and how this information is assessed on the Missouri Assessment Program (MAP) test, they are convinced they will never teach science and do not need the information. Something they will all have to do is take the MoCA for certification. Going through the scores, I can look for areas of weakness and amend the learning activities to meet their goals better. I have started sharing these scores when we are doing the lecture and learning activities. I have even had the students look at their notebooks and labs to see which items might help them study for the exam better. In addition to the practices I have added in my GRY 240 class, I have changed some practices in how I conduct student-teacher observations.

When conducting observations, we are to observe the actions of the student-teachers and the students in detail and then assign a value. After each observation, I meet with the

student-teacher to discuss their perceptions of the lesson. One of the College of Education's objectives is to make sure our graduates are reflective practitioners. Once our students graduate, they will be alone in their classroom a majority of the time with only random, 5-minute observations from the principal. The student-teacher must be able to reflect on and evaluate each of their lessons. I spend much more time guiding the student through evaluating their own performance. Using the scoring guide, the student determines their score and together we formulate comments to be reported to the Department of Elementary and Secondary Education as well as SMART goals for their next observation. We also review assessments the student teacher has administered since the last observation. We review the evaluation items, student scores, and whether the items effectively evaluate the content. Together, we gather data and immediately put it to use, and in the process, we both improve.

The processes learned during the doctoral program, such as working in teams effectively, have proven very useful. Information on diversity I have put into use too many times to count, including successfully pointing out bias in a search committee. The program gave me the confidence to do that. It also got me interested in researching women in STEM. While in my current position, I have had the opportunity to participate in three NSF grants. Two of these sizable grants were related to women in STEM, and the third was to work with under-represented groups, including young women, and encourage their interest in STEM. While I find working on grants and conducting research rewarding, that is as a team, and has an ultimate purpose to make a difference for people. This process has confirmed that I do not want to move to a tenure track position and have the responsibility of publishing to keep my job. I much prefer working with students, doing the service work that so many articles discussing women in STEM say is inequitable, working on grants, working with teachers,

and recruiting/encouraging young people to explore their STEM side. Writing this dissertation has been stressful and frustrating, but the process I feel has encouraged me to include more qualitative information in my practice.

Dissertation Influence on Scholarship

My position at Missouri State does not require a research and publishing component. While the publishing still holds little interest, I am more interested in the research, particularly for girls and women in STEM. Like the women in my study, I had early experiences in STEM, early encouragement, mentors, and role models. Unfortunately, these early experiences are not available to everyone. This was the impetus for one of the NSF grants. The grant supports mentors from the same demographic group from the community, mentoring by graduate students from MSU, and the opportunity to do research at MSU under the supervision of a professor or graduate student from the same demographic group. Mentors from the same demographic group increase mentees' persistence and advancement (Mazerolle et al., 2018). The students who participate in the program will be recommended by their classroom teachers and those who might most benefit.

Another barrier for women in higher education, according to Misra (2021) and many others, is issues with work-life balance. Women are more likely the caregivers for children and possibly elderly parents leaving less time for research impacting promotion and salaries Ruben et al. (2014). Hochschild (1989) calls these extra duties at home a "second shift."

While MSU lists the child development center and Greenwood as amenities for faculty's children, the reality is that they are at capacity and often are not options for new faculty. Our NSF committee worked with the Chamber of Commerce and Human Resources

to get a list of available childcare resources and opportunities assembled and available on the Human Resources website.

Another issue with women in STEM is the two-body problem. With 54% of women in STEM having a trailing spouse who is also an academic (Laursen & Austin, 2020), women are sometimes forced to leave their position if their spouse is unsuccessful in securing employment. MSU has an unspoken policy that they will assist in finding a spouse a job, whether in the university system or in the greater community. This policy was on the website but well hidden. Asking the potential hire if they have a spouse is not permitted due to equal employment regulations. Interviewees do not often ask for fear it will potentially cost them the offer. We offered a solution of a person to guide the potential hire around the campus who was not part of the hiring committee. This person could direct them to resources and have those conversations that would be illegal for others in the department.

I plan to present this dissertation at the spring 2024 ARC Convening and the Association of Women Geologists conference in April 2024. I am working on a paper and poster with two colleagues regarding how the pandemic may have made Zoom interviews a more acceptable format for research. I felt an incredible sense of humility when I was asked to write a report on the focus groups a colleague and I conducted here on campus regarding the perceptions of women in STEM for the provost. I am encouraged that they are interested in the topic, but I understand that interest will only last as long as we keep the flow of information going.

I plan on continuing the work that started as this dissertation. In this study, I interviewed women from a limited number of professional degree-granting institutions. I want to interview a larger group to see what solutions can be found for the service load

inequity described by Misra (2021), Laursen and Austin (2020), and Gaurino and Borden (2017). Research into workload inequities is vital if the number of women full professors in STEM are to reach critical mass. I worked with a fellow instructor who serves on the faculty senate to develop a list of potential solutions to this invisible workload. We came up with a few answers that did not involve extra work for the women the policy was meant to help. This additional work is generally not considered for a promotion, but it is essential to keep the university running smoothly and serving our students (Guarino & Borden, 2017).

MSU is beginning a fairly involved implicit bias training for search committees and department heads. Research suggests online mandatory bias training may have a limited impact (Laursen & Austin, 2020). Because this training is interactive and requires responses that illicit thought, it will be interesting to see what if any, impact this has on hiring women and minoritized groups. Having a diverse workforce will make our institutions of higher learning more inviting to our diverse students. Since summer two and our project on the year-to-year retention of first-generation and minoritized groups, I have been trained as a proactive advisor and working with our at-risk advisees. Although I have not yet had the time to develop a project to track the students in our department, it is on my radar. One of my favorite quotes from the program is, “access without support is not opportunity” (Tinto, 2008). We owe it to our students to figure out how to support them. We need to have many conversations. Programs that help one student has been said to be fixing the student. The student does not need fixing. It is the system that needs an overhaul. I am excited about the programs Dr. Kelly Wood is initiating, and I am once again humbled to be asked to serve on the committee and cannot wait to do my part.

Conclusion

Our journey began with the Strengthquest© self-examination. That self-reflection and examination continue daily in my work. This program has challenged me to spend some time in introspection. Evaluation plays a more prominent role in my position than I had envisioned. Recently at a meeting with Dean Jahnke and others working on a few additional climate questions on the university-wide student, faculty, and staff survey. We had all attended a workshop on gathering meaningful data sponsored by AAAS. One of the committee members mentioned that they had held a social for the women in their college. Two of us immediately asked if he had collected evaluations. We were interested in how they were perceived since such events are sometimes awkward for the women who attend. I see data as a means to enact change. Data is expensive, and someone has to collect, organize, and house it but is so important to make meaningful change.

In short, writing this dissertation and reflection has taken me out of my comfort zone and yet made me feel empowered. Looking at myself through the same lens I have used in my dissertation, looking at my own shortcomings has been uncomfortable, but I feel I have grown from the experience. As Laursen and Austin (2020) state, we all have biases. We can never eliminate them, but we can examine them and mitigate them.

This program has given me some tools to facilitate change around me, although I need many more tools. It has given me the ability to look at the world and ask questions and the tools to start figuring out at least part of it. My research interests are grounded in making a difference. As a result of the ELPA program, the research I have begun and writing this dissertation, I am asked to be part of discussions and projects for which I would not have

previously been considered. It has provided an incredible opportunity for which I will always be grateful to the faculty of the program.

"Sometimes *you can't* see what *you're learning until you* come out the other side." Gal Gadot (Wonder Woman 1984). Now that I am on the other side, I can see how much further I have to go on my learning journey.

References

Alase, A. (2017). The interpretative phenomenological analysis (IPA): A guide to a good qualitative research approach. *International Journal of Education and Literacy Studies, 5*(2), 9-19.

Alexander, K., & Eckland, B. (1974). Sex differences in the educational attainment process. *American Sociological Review, 39*(5), 668-682. https://doi:10.2307/2094313

American Mathematical Society (AMS). (2019). *Annual survey of mathematical sciences: Demographics in the mathematical sciences.* https://www.ams.org/profession/data/annual-survey/demographics

Archie, T., Kogan, M. & Laursen, S. L. (2015). Do labmates matter? The relative importance of workplace climate and work-life satisfaction in women scientists' job satisfaction. *International Journal of Gender, Science, and Technology, 7*(3), 373-397.

Armstrong, M. A., & Jovanovic, J. (2017). The intersectional matrix: Rethinking institutional change for URM women in STEM. *Journal of Diversity in Higher Education, 10*(3), 2016-231.

Austin, A. E., Sorcinelli, M. D., & McDaniels, M. (2007). Making tenure viable: Listening to early-career faculty. *American Behavioral Scientist, 41*(5), 736-754.

Avallone, L., Hallar, A., Thiry, H., & Edwards, L. (2013). Supporting the retention and advancement of women in the atmospheric sciences: What women are saying. *Bulletin of the American Meteorological Society, 94*(9), 1313-1316. https://www.jstor.org/stable/26218701

Bell, D. (1980). Brown v. Board of Education and the interest-convergence dilemma. *Harvard Law Review, 93*(3), 518-533. https://doi:10.2307/1340546

Bentley, J. T., & Adamson, R. (2003). Gender differences in the careers of academic scientists and engineers: A literature review: Special report. National Science Foundation. http://www.nsf.gov/sbe/srs/nsf03322/pdf/nsf03322.pdf.

Bertrand, M. (2018). Coase lecture: The glass ceiling. *Economica, 85*(338), 205-231. https://doi.org:10.1080/10570319209374414

Bettinger, E. P., & Long, B. T. (2005). Do faculty serve as role models? The impact of instructor gender on female students. *Understanding Teacher Quality, 95*(2), 152-157.

Bohman, J., (2001, Spring). "Critical Theory," *The Stanford Encyclopedia of Philosophy* In E. N. Zalta (ed.). https://plato.stanford.edu/archives/spr2021/entries/critical-theory/

Bolman, L., & Deal, T. (2021). *Reframing organizations: Artistry, choice, and leadership* (7th ed.). Jossey-Bass.

Bowman, J. S. (2010). The success of failure: The paradox of performance pay. *Review of Public Personnel Administration, 30*(1), 70–88. https://doi.org/10.1177/0734371X09351824

Bowman, N. A. (2011). Promoting participation in a diverse democracy: A meta-analysis of college diversity experiences and civic engagement. *Review of Educational Research, 81*(1), 29–68. https://doi.org/10.3102/0034654310383047

Branch, E, H. (2016). *Pathways, potholes, and the persistence of women in science: Reconsidering the pipeline.* Lexington.

Bridge, K. & Baxter, L. A. (1992). Blended relationships: Friends as work associates. *Western Journal of Communication, 56*(3), 200-225. doi:10.1080/10570319209374414

Britton, D. M. (2017). Beyond the chilly climate: The salience of gender in women's academic careers. *Gender and Society, 31*(1), 5-27.

Brownstein, M. (2019). Implicit Bias, *The Stanford Encyclopedia of Philosophy* (Fall Edition), Edward N. Zalta (ed.). https://plato.stanford.edu/archives/fall2019/entries/implicit-bias/

Campbell, C.M., & O'Meara, K. (2014). Faculty agency: Departmental contexts that matter in faculty careers. *Research in High Education* 55, 49–74. https://doi.org/10.1007/s11162-013-9303-x

Carnegie Classification of Institutions of Higher Learning (2021). *Institution look-up.* https://carnegieclassifications.iu.edu/

Carnes, M., Bartels, C., Kaatz, A., & Kolehmaninen, C. (2015). Why is John more likely to become department chair than Jennifer? *Transactions of the American Clinical and Climatological Association,* 126, 197-214.

Carroll, D. (2017) A faculty Woman of Color and micro-invalidations at a White research institution: A case of intersectionality and institutional betrayal. *Administrative Issues Journal: Connecting Education, Practice, and Research*, 7(1), 39-50. http://doi:10.5929/2017.7.1.2

Casadevall, A. & Handelsman, J. (2014). The presence of female conveners correlates with a higher proportion of female speakers at scientific symposia. *American Society for Microbiology,* 5(1), eoo846-13. https://doi.org/10.1128/mBio.00846-13

Castilla, E. 2008. Gender, race, and meritocracy in organizational careers. *American Journal of Sociology 113,* 1479–526.

Catalyst.org. (2004). Bottom line: Connecting corporate performance and gender diversity. Catalyst. https://www.catalyst.org/research/the-bottom-line-connecting-corporate-performance-and-gender-diversity/

Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological Science in the Public Interest, 15*(3), 75–141. https://doi.org/10.1177/1529100614541236

Cho, S., Crenshaw, K. W., & McCall, L. (20130. Toward a field of intersectionality studies: Theory, applications, and praxis. *Signs, 38*(4), 785-810.

Jesse, D. (2023, May 31). Most new presidents at top research universities are now women. The Chronicle of Higher Education. https://www.chronicle.com/article/most-new-presidents-at-top-research-universities-are-now-women

Columbia College. (1999). About Columbia College: History and background. https://www.columbia.edu/content/history

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Sage. doi.org/10.4135/9781452230153

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3rd ed.). Sage.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Sage.

Davis, P. C. (1989, June). Law as microaggressions. *Yale Law Journal*, *98*(8), 1559-1577.

Delelaita-Mullet, D., Rinn, A. N., & Kettler, T. (2021). Catalysts of women's success on academic STEM: A feminist poststructural discourse analysis. *Journal of International Women's Studies, 22*(1), 83-103.

Denzin, N. K. (1970). *The research act; A theoretical introduction to sociological methods.* Aldine.

DeWelde, K., & Stepnick, A. (2015). From people to policies: Enduring inequalities and inequities from women in academics. In K. De Welde & A. Stepnick (Eds.), *Disrupting the culture of silence: Confronting gender inequality and making change in higher education* (pp. 1-28). Stylus.

Downey, J. (2001). Guest editor's introduction: Academic leadership and organizational change. *Innovative Higher Education, 25*, 235–238.

Duffin, E. (2019a). Number of doctoral degrees earned in the United States from 1949/50 to 2018/19, by gender. https://www.statista.com/statistics/185167/number-of-doctoral-degrees-by-gender-since-1950/

Dutt, K., Pfaff, D. L., Bernstein, A. F., Dillard, J. S., & Block, C. J (2016). Gender differences in recommendation letters for postdoctoral fellowships in geoscience. *Nature Geoscience,* 9**,** 805–808. https://doi.org/10.1038/ngeo2819

Eisenmann, L. (1997, Winter). Rediscovering a Classic: Assessing the history of women's higher education a dozen years after Barbara Solomon. *Harvard Educational Review, 67,* 689-717.

Ellemers, N., de Gilder, D., & Haslam, S. A. (2004). Motivating individuals and groups at work: A social identity perspective on leadership and group performance. *The Academy of Management Review, 29*(3), 459–478. https://doi.org/10.2307/20159054

Ely, R. J., & Thomas, D. A. (2001). Cultural diversity at work: The effects of diversity perspectives on workgroup processes and outcomes. *Administrative Science Quarterly, 46*(2), 229–273. https://doi.org/10.2307/2667087

Equal Employment Opportunity Act. (1972). https://www.dol.gov/sites/dolgov/files/ofccp/regs/compliance/posters/pdf/eeopost.pdf

Falci, C. D., & Watanabe, M. (2020). Network marginalization of women in the workplace: A case in academia. *Journal of Women and Minorities in Science and Engineering*, *26*(2), 155–175. https://doi.org/10.1615/JWomenMinorScienEng.2020029186

Farnham, C. A. (1994). *The education of the southern belle: Higher education and student socialization in the antebellum South.* New York University Press.

Fine, E., Sheridan, J., Carnes, M., Handelsman, J., Pribbenow, C., Savoy, J., & Wendt, A. (2014). Minimizing the influence of gender bias on the faculty search process. *Advances in Gender Research*, 19, 267–289. https://doi.org/10.1108/S1529-212620140000019012

Flaherty, C. (2020, April 21). No room of one's own. *Inside HigherEd.* https://www.insidehighered.com/news/2020/04/21/early-journal-submission-data-suggest-covid-19-tanking-womens-research-productivity

Frehill, L. M., Abrue, A., & Zippel, K. (2015). Gender, science, and occupational sex segregation. In Pearson, L. M. Frehill, & C. L. McNeeley (Eds.), *Advancing women in science* (pp.51-92). Springer.

Ford, H. L., Brick, C., Azmitia, M., Blaufuss, K., & Dekens, P. (2019). Women from some under-represented minorities are giving too few talks at world's largest Earth-science conference. *Nature*, 576, 32-35. https://doi.org/10.1038/d41586-019-03688-w

Forsyth, D. R. (2018). *Group dynamics.* Cengage Learning.

Greenwald, A. G., & Krieger, L. H. (2006). Implicit bias: Scientific foundations. *California Law Review*, *94*(4), 945-967. https://doi:10.2307/20439056

Grogan, Kathleen. (2018). How the entire scientific community can confront gender bias in the workplace. *Nature Ecology & Evolution, 3*(10). doi:1038/s41559-018-0747-4

Grunert, M. L. (2010). Women's career choices in chemistry: Motivations, perceptions, and a conceptual model (Doctoral dissertation, Purdue University).

Guarino, C., & Borden, V. (2017). Faculty service loads and service: Are women taking care of the academic family? *Research in Higher Education, 58*(6), 672-694. https://doi.org/10.1007/s11162-017-9454-2

Hall, R. M., & Sandler, B. R. (1982). *The classroom climate: A chilly one for women?* Association of American Colleges and Universities. https://www.semanticscholar.org/paper/The-Classroom-Climate%3A-A-Chilly-One-for-Women.-Hall-Sandler/96a6ae5e304da857f5ee360bdcf72b7cb81a358f

Hardy, L (1916). *In the garden of delight*. Alpha Edition.

Helitzer, D. L., Newbill, S. L., Cardinali, G., Morahan, P. S., Chang, S., & Magrane, D. (2017). Changing the Culture of Academic Medicine: Critical Mass or Critical Actors? *Journal of Women's Health, 26*(5), 540–548. https://doi.org/10.1089/jwh.2016.6019

Hengel, E. (2017). Publishing while female: Are women held to higher standards? Evidence from peer review Cambridge Working Paper in Economics 1753. https://www.repository.com.ac.uk/handle/1810/270621

Hofhuis, J., van der Rijt, P. G., & Vlug, M. (2016). Diversity climate enhances work outcomes through trust and openness in workgroup communication. *SpringerPlus*, *5*(1), 714. https://doi.org/10.1186/s40064-016-2499-4

Holman, L, Stuart-Fox, D., & Hauser, C.E. (2018). The gender gap in science: How long until women are equally represented? *PLoS Biology, 16*(4), e2004956. https://doi.org/10.1371/journal.pbio.2004956

Hoshschild, A. R. (1989). *The second shift: Working parents and the revolution at home.* Avon.

Husserl, E. (1913/1962). *Ideas: General introduction to pure phenomenology* (W. R. B. Gibson, Trans.). Collier Books.

Hsieh, B., & Nguyen, H. T. (2019). Identify-informed mentoring to support acculturation of female faculty of color in higher education: An Asian American female mentoring relationship case study. *The Journal of Diversity in Higher Education*, *13*(2), 169-180.

Johnson, I. (2017). Female faculty role models, self-efficacy, and student achievement. *College Student Journal*, *51*(1), 151–172.

Johnson, I. (2014). Female faculty role models and student outcomes: A caveat about aggregation. *Research in Higher Education*, *55*(7), 686-709. https://www.jstor.org/stable/24571809

Johnson, A. (2018). *Privilege, power, and difference* (3rd ed.). McGraw-Hill.

Johnson-Bailey, J. (2004). Enjoining positionality and power in narrative work: Balancing contentious and modulating forces, In K. Demarrais & S. Lapan (Eds.), *Foundations for research: Methods of inquiry in education and the social sciences* (pp. 123-138).

Keister, L. A. 2000. *Wealth in America: Trends in wealth inequality.* Cambridge University Press.

Kincheloe, J. L., Mclaren, P., & Steinberg, S. R. (2011). Critical pedagogy and qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Sage handbook of qualitative research* (4th ed., pp. 163-177). Sage.

Knobloch-Westerwick, S., Glynn, C. J., & Huge, M. (2013). The Matilda effect in science communication: An experiment on gender bias in publication quality perceptions and collaboration interest. *Science Communication*, 35(5), 603-625.

Kosoko-Lasaki, O., Sonnino, R. E., & Voytko, M. L. (2006). Mentoring for women and underrepresented minority faculty and students: Experience at two institutions of higher education. *Journal of the National Medical Association, 98*(9), 1449–1459.

Krueger, R. A. & Casey, M. A. (2015). *Focus groups: A practical guide for applied research* (5th ed.). Sage.

Laursen, S., & Austin, A. E. (2020). *Building gender equity in the academy: Institutional strategies for change.* John Hopkins University Press.

Lee, C. J., Sugimoto, C. R., Zhang, G., & Cronin, B. (2013). Bias in peer review. *Journal of the Association for Information Science and Technology, 64*(1), 2-17. doi.org/10.1002/asi.22784

Lempert, R. (2010). A personal odyssey toward a theme: Race and equality in the United States: 1948–2009. *Law and Society Review, 44*(3-4), 431-462. https://doi.org/10.1111/j.1540-5893.2010.00409.x

Lerback, J., & Hanson, B. (2017). Journals invite too few women to referee. *Nature, 541*, 455-457.

Levi, D. J. (2017). *Group dynamics for teams* (5th ed.). Sage.

Lencioni, P. (2002). *The five dysfunctions of a team.* Jossey-Bass.

Lincoln, A. E., Pincus, S., Koster, J. B., & Leboy, P. S. (2012). The Matilda Effect in science: Awards and prizes in the U.S., 1990s, and 2000s. *Social Studies of Science, 42*(2), 307–320. https://doi.org/10.1177/0306312711435830

Lincoln, Y., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Luceno, C. D. (2006). Maternal wall discrimination: Evidence required for litigation and cost-effective solutions for a flexible workspace. *Hastings Business Law Journal, 3*(1), 157-179.

Madera, J. M., Hebl, M. R., & Martin, R. C. (2009). Gender and letters of recommendation for academia: Agentic and communal differences. *Journal of Applied Psychology, 94*(6), 1591-1599.

Manoharan, S. G. S., Subramaniam, R., & Mohapatra, S. (2023). *Enabling Strategic Decision-Making in Organizations Through Dataplex*. Emerald Publishing Limited.

Marschke, R., Laursen, S., McCarl-Nielsen, J., & Rankin, P., (2007). Demographic inertia revisited: An immodest proposal to achieve equitable gender representation among faculty in higher education. *Journal of Higher Education, 78*(1), 1-26.

Martel, R. F., Lane, D. M., & Emrich, C. (1996). Male-female differences: A computer simulation. *American Psychologist, 51*, 157-158.

Maslow, A.H. (1943) A Theory of Human Motivation. Psychological Review, 50, 370-396. http://dx.doi.org/10.1037/h0054346

Mason, M. A., & Goulden, M. (2002). Do babies matter? The effect of family formation on the lifelong careers of academic men and women. *Academe, 88*(6), 21-27.

Mason, M. A., & Goulden, M. (2004). Do babies matter? Part II: Closing the baby gap. *Academe, 90*(6), 10-15.

Mason, M. A., Wolfinger, N. H., & Goulden, M. (2013). *Do babies matter? Gender and family in the ivory tower.* Rutgers University Press.

Massey, D. S. (2008). *Categorically unequal: The American stratification system.* Russell Sage Foundation Publications

Maxwell, J. A. (2013. *Qualitative research design: An interactive approach* (3rd ed.). Sage.

Mazerolle, S. M., Nottingham, S. L., & Coleman, K. A. (2018). Faculty mentorship in higher education: The value of institutional and professional mentors. *Athletic Training Education Journal*, *13*(3), 259–267. https://doi.org/10.4085/1303259

McCarthy, N. (2021). Doctoral degrees: U.S. women earned more PhDs than men last year. *Statista.com*. https://www.statista.com/chart/15685/doctoral-degrees-awarded-by-broad-field-and-gender-in-the-us/

McCoy, S. K., Newell, E. E., & Gardner, S. K. (2013). Seeking balance: The importance of environmental conditions in men and women faculty's well-being. *Innovative Higher Education, 38*(4), 309-322.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). Jossey-Bass.

Merriam-Webster. (n.d.). Equitable. In *Merriam-Webster.com dictionary*. https://www.merriam-webster.com/dictionary/equitable

Milner, H. R., & Pearman, F. A., & McGee, E. O. (2013). Critical race theory, interest convergence, and teacher education. In M. Lynn & A.D. Dixson (Eds.), *The handbook of critical race theory in education*, (pp. 39-354). Routledge Press.

Missouri State University (2021a). Mission, Vision, and Values. https://www.missouristate.edu/about/mission-statement.htm

Missouri State University. (2021b). College of Natural and Applied Sciences Faculty Websites.

Missouri State University. (2019). Missouri State University 2018-2019 Fact Book. https://www.missouristate.edu/Assets/oir/Factbook-FINAL-18-19.pdf

Misra, J., (2021). Women's leadership in higher education. *ARC Network.*

Misra, J., Lundquist, J. H., Holmes, E., & Agiomavritis, S. (2011). The ivory ceiling of service work. *Academe, 97*(1), 22-26. https://www.aaup.org/article/ivory-ceiling-service-work?wbc_purpose=basic&WBCMODE=presentationunpublished#.X5hx84hKjIU

Misra, J., Lundquist, J. H., & Templer, A. (2012). Gender, work time, and care responsibilities among faculty. *Sociological Forum*, 27(2), 300-323.

Mitchell, S., & Hesli, V. (2013). Women don't ask? Women don't say no? Bargaining, and service in the political science profession. *PS: Political Science & Politics, 46*(2), 355-369. https://doi:10.1017/S1049096513000073

Morris, L.V. (2016). Management and Leadership in Colleges and Universities. *Innovation High Education, 41*, 1–3. https://doi.org/10.1007/s10755-015-9352-5

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences of the United States of America, 109,* (41), 16474-16479. https://doi.org/10.1073/pnas.1211286109

Muhs, G. G., Harris, A. P., González, C. G., & Niemann, Y. F. (2013). *Presumed incompetent: The intersections of race and class for women in academia*. University Press of Colorado.

National Center for Science and Engineering Statistics. (2019). *Science and Engineering Indicators.* https://www.nsf.gov/statistics/2018/nsb20181/

National Science Foundation. (2018). *ADVANCE portfolio overview.* https://www.nsf.gov/crssprgm/advance/awards.jsp

National Science Foundation, National Center for Science and Engineering Statistics. (2019a). *Women, minorities, and persons with disabilities in science and engineering: 2019*. Special Report NSF 19-304. https://www.nsf.gov/statistics/wmpd.

National Science Foundation, National Center for Science and Engineering Statistics. (2019b). *Doctorate recipients from U.S. universities: 2017.* https://www.nsf.gov/statistics/doctorates/

Nielsen, S., & Huse, M. (2010). Women directors' contribution to board decision-making and strategic involvement: The role of equality perception. *European Management Review, 7*, 16-29. https://doi.org/10.1057/emr.2009.27

Noble, H., & Smith, J. (2015) Issues of validity and reliability in qualitative research. *Evidence-Based Nursing,* 18(2), 34-35.

Northouse, P. G. (2019). *Leadership theory and practice* (8th ed.). Sage.

Notgrass, D. (2014). The relationship between followers' perceived quality of relationship and preferred leadership style. *Leadership and Organizational Development Journal, 35*(7), 605-621. http://doi:10.1108/LODJ-08-2021-0096

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). The Belmont report: Ethical principles and guidelines for the protection of human subjects of research. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/index.html

O'Leary, Z. (2009). *Researching real-world problems: A guide to methods of inquiry*. Sage.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). Sage.

Pierson, G. W. (1976). *Yale: A Short History*. Publications on Yale History. https://elischolar.library.yale.edu/yale_history_pubs/11

Pleck, E. (1990). The unfulfilled promise: Women and academe. *Sociological Forum, 5*, 517-524.

Ponjuan, L., Conley, V. M., & Trower, C. (2011). Career state differences in pre-tenure track faculty perceptions of professional and personal relationships and colleagues. *The Journal of Higher Education,* 82, 319-346. http://dx.doi.org/10.1353/jhe.2011.0015

Rasmussen, D. (2012). Critical theory: Then and now. *The Journal of Speculative Philosophy*, *26*(2), 291-298. https://doi:10.5325/jspecphil.26.2.0291

Reuben, E., Sapienza, P., & Zingales, L. (2014). How stereotypes impair women's careers in science. *Proceedings of the National Academy of Sciences, 111*(12), 4403-4408.

Rice, R. E., Sorcinelli, M. D., & Austin, A. E. (2000). *Heeding new voices: Academic career for a new generation.* American Association of Higher Education.

Rossiter, M. W. (1982). *Women scientists in America: Struggles and Strategies to 1940.* Johns Hopkins University Press.

Rosser, V. J. (2004). Faculty members' intentions to leave: A national study on their worklife and satisfaction. *Research in Higher Education, 45***,** 285–309. https://doi.org/10.1023/B:RIHE.0000019591.74425.f1

Sandler, B. R., & Hall, R. M. (1982). *The classroom climate: A chilly one for women*. American Association of Higher Education.

Sardelis, S., & Drew, J. A. (2016). Not "pulling up the ladder": Women who organize conference symposia provide greater opportunities for women to speak at conservation conferences. *PLOS One, 11*(7), eo160015. https://pubmed.ncbi.nlm.nih.gov/27467580/

Schiebinger, L., Davies Henderson, A., & Gilmartin, S. K. (2012). *Dual career academic couples: What universities need to know*. CA: Michelle R. Clayman Institute for Gender Research, Stanford University. https://gender.sites.stanford.edu/sites/g/files/sbiybj5961/f/publications/dualcareerfinal_o.pdf.

Schmidt, E. K., & Faber, S. T. (2016). Benefits of peer mentoring to mentors, female mentees, and higher education institutions. *Mentoring and Tutoring: Partnership in Learning*, *24*(2), 137–157. https://doi.org/10.1080/13611267.2016.1170560

Seidman, I. (2019). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (5th ed.). Teachers College Press.

Shaw, A. K., & Stanton, D. E. (2012). Leaks in the pipeline: Separating demographic inertia from ongoing gender differences in academia. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1743), 3736-3741.

Sheltzer, J. M. (2018). Gender disparities among independent fellows in biomedical research. *Nature Biotechnology*, *36*(10), 1018-1021.

Smith, D., & Johnson, B. (2020). 3 ways to advance gender equity as we return to the office. *Harvard Business Review*. https://hbr.org/2020/06/3-ways-to-advance-gender-equity-as-we-return-to-the-office

Strauss, A., & Corbin, J. (2014). *Basics of qualitative research techniques and procedures for developing grounded theory* (4th.). Sage.

Taylor, F. W. (2005). The principles of scientific management. In J. M. Shafritz, J. S. Ott, Y. S. Jang (Eds.). *Classics of organizational theory* (6th ed., pp. 61-72). Wadsworth. Reprinted from Bulletin of the Taylor Society, 1916.

Thelin, J. R. (2018). *A history of American higher education*. John Hopkins Press.

Thomas, N. R., Poole, D. J., & Herbers, J. M. (2015). Gender in the sciences and engineering faculties: Demographic inertia revisited. *PLOS One, 10*(10), eo139767. https://doi.org/10.1371/journal.pone.0139767

Tinto, V. (2008, June 9). *Access without support is not opportunity*. Inside Higher Ed. https://www.insidehighered.com/views/2008/06/09/access-without-support-not-opportunity#.ZCxVHoej62o.link

Trix, F., & Psenka, C. (2003). Exploring the color of glass: Letter of recommendation for female and male medical faculty. *Discourse and Society, 14*(2), 191-220.

Tsang, C. W., & Dietz, T. L. (2001). The unrelenting significance of minority statuses: Gender, ethnicity, and economic attainment since affirmative action. *Sociological Spectrum 21*, 61-80.

Umbach, P. D. (2007). Gender equity in the academic labor market: An analysis of academic disciplines. *Research in Higher Education, 48*(2), 169-192.

U.S. Department of Education, National Center for Education Statistics. (2019).

U. S. Department of Labor (1964). Civil Rights Act of 1964. https://www.dol.gov/agencies/oasam/civil-rights-center/statutes/civil-rights-act-of-1964

University of California. (2017). *Smart goals: A how-to guide.* https://www.ucop.edu/local-human-resources/_files/performance-appraisal/How%20to%20write%20SMART%20Goals%20v2.pdf

van Dijk, H., Kooij, D., Karanika-Murray, M., De Vos, A., & Meyer, B. (2020). Meritocracy a myth? A multilevel perspective of how social inequality accumulates through work. *Organizational Psychology Review, 10*(3–4), 240–269. https://doi.org/10.1177/2041386620930063

Vicars, M. (2012). Toward a rhizomatic methodology: How queer! In S. Sternberg & G. Cannella (Eds.), *Critical qualitative research reader* (pp. 468-478).

Valian, V. (1999). *Why so slow? The advancement of women*. MA: MIT Press.

Walker, J. (2021, March). *Female professors in STEM reflect on experiences in their fields: Women in STEM on navigating male-dominated fields in academia.* Brown Daily Harold. https://www.browndailyherald.com/article/2021/03/female-professors-in-stem-reflect-on-experiences-in-their-fields

Wang, M. T., & Degol, J. L. (2017, March 1). Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educational Psychology Review*. https://doi.org/10.1007/s10648-015-9355-x

Watanabe, M., & Falci, C. (2017). Workplace Faculty Friendships and Work-Family Culture. *Innovative Higher Education, 42*(2), 113–125. https://doi.org/10.1007/s10755-016-9373-8

Williams, J. C. (2000). *Unbending gender: Why family and work conflict and what to do about it.* Oxford University Press.

Zettlemeyer, F., & Bolling, M. (2014). *Big Data Doesn't Make Decisions, Leaders Do The six steps to build organizational muscle in analytics*. www.kellogg.northwestern.edu/~/media/files/general/2014/bigdata-white-paper-r9(2).ashx

Appendices

Appendix A Request for Participation

[Full Professor]

[R3 Institution]

[Address]

[City, State Zip]

Dear: [Dr.]

I am a doctoral candidate in the Educational Leadership and Policy Analysis program at the University of Missouri-Columbia. In addition, I am an Instructor in the College of Natural and Applied Sciences at Missouri State University. My dissertation, entitled "Persistence Overcomes Resistance: The Journey of Women in STEM to Full Professor," focuses on documenting the common factors of women full professors in STEM at Professional Degree-Granting (R3) institutions. Since 1977, the NSF Advance grant program has supported research into the barriers faced by women in STEM. These studies have been well-documented by Austin and Laursen (2020) and Misra (2021), to name a few.

For this study, women STEM full professors at R3 institutions have been asked to participate. Participants will be asked to complete a short demographic survey of fewer than 5 minutes, provide their curriculum vitae to establish a career timeline, and participate in an interview that will last approximately one hour.

I understand the demands your busy schedule places on you, but I hope you will consider participating in further research. If you have any questions or need further clarification regarding my study, don't hesitate to contact me at 417-224-5219 or MCardenJessen@MissouriState.edu. Otherwise, I look forward to hearing from you and appreciate your sincere consideration.

Respectfully,

Melanie Carden-Jessen

Higher Education Doctoral Student

Missouri State University

Adapted from Jensen, S. (2019). Women in STEM: Strategies and recommendations for academic women and institutional leaders. Theses and dissertations. https://scholarworks.uark.edu/etd/3473

Appendix B Consent to Participate in Doctoral Dissertation Research

Invitation to Participate

You have been asked to participate in a research study about women's lived experiences in higher education who have advanced to STEM full professor. Institutions with a Carnegie Classification of Professional Doctorate-granting status (R-3) are the focus of this study.

What You Should Know About the Research Study

Who is the Principal Investigator?

Melanie Carden-Jessen

MCardenJessen@Missouristate.edu

What is the purpose of this research study?

This research study aims to understand the common factors of women full professors in STEM at R-3 institutions and how these factors have impacted their advancement. This interview aims to get your feedback on factors that may have positively impacted advancing the careers of women in STEM disciplines.

Who will participate in this study?

This study's target number of participants is ten female STEM full professors from Professional Doctorate-granting institutions in the Midwest United States.

What are the participants being asked to do?

Participants are asked to complete a short demographic survey, provide an updated curriculum vitae, and participate in an approximately one-hour Zoom interview. Interviews will be recorded and then transcribed with all identifiers removed. There will be an opportunity to review interview transcripts as a member check.

What are the possible risks or discomforts?

There are no expected risks or discomforts for any participant.

What are the benefits of this study?

This study will expand the knowledge base on successful STEM women and increase the number of full professors in higher education.

How long will the study last?

The study will take place over a two- or three-month period, but each participant's involvement will be limited to the one-hour interview and possible member checking.

Will there be any compensation for the participants?

There will be no compensation to the participants in this study.

Will the participants have to pay for anything?

There are no costs to the participant for the study.

What are the options if a participant does not want to participate?

Participation is entirely voluntary. In addition, the participants may choose to terminate participation in the study at any time.

How will my participation be kept confidential?

Confidentiality will be kept to the extent allowed by State and Federal laws. Transcripts will be reviewed, and identifiers removed. The interviews will be recorded on a separate hard drive and housed in the researcher's office. In the report, Roman numerals will be used to protect participant identity.

How will the information gathered be used?

Data collected will be reported in a dissertation in partial fulfillment of an EdD in Educational Leadership and Policy Analysis at the University of Missouri-Columbia. In

addition, data may also be used in future publications while still maintaining the anonymity and confidentiality of the participants.

Contact Information

Melanie Carden-Jessen:
Office: 417 224-5219
e-mail: MCardenJessen@MissouriState.edu

I understand this information and agree to participate fully under the abovementioned conditions. You may type your name as your electronic signature.

Name of Participant:

_____

Signature: _____ Date: _____

Appendix C Demographic Survey

Name:

E-mail:

Year of birth:

Gender assigned at birth: Male / Female / Other / Decline to answer

Gender: Masculine / Feminine / Androgynous / Transgender / Fluid / Other /

Decline to answer

Race/ethnicity: White / Black / Chicana or Latina / Native American / Asian or Pacific

Islander / More than one ethnicity (please describe) / Decline to answer

_____

Discipline: Physics / Chemistry / Technology / Computing / Engineering / Mathematics /

Other

If other, specify:

_____

Relationship status: Married / Committed partner / Single / Other / Decline to answer

Approximately how many times have you been published in scholarly, peer-reviewed

journals?

_____

How often have you been a principal investigator (first author) on published research?

_____

How many times have you presented research findings at national conferences or meetings?

_____

Have you ever received an award for original scientific research? If yes, how many? Please list.

_____

How much have you received in internal or external funding for your research?

_____

Before college, did you ever participate in a STEM enrichment program such as a science or math summer camp? Yes / No

Adapted from Delelaita-Mullet, D., Rinn, A. N., & Kettler, T. (2021). Catalysts of women's success on academic STEM: A feminist poststructural discourse analysis. *Journal of International Women's Studies, 22*(1), 83-103.

Appendix D Interview Questions

1. Tell me about your journey to becoming a STEM professor.
    a. Follow-up questions:
        i. What influenced your choice?
        ii. When did you first realize that you wanted to pursue a STEM career?
        iii. How did people around you respond to your choice?
2. Describe a specific event in your education or career that you found supportive or positive.
    a. Follow-up questions: Describe your memory: setting, people, impressions, and feelings.
3. Think of someone who influenced your success. How has that person been involved in your success?
    a. Follow-ups:
        i. What are the circumstances of your relationship?
        ii. What has been the person's impact on your career?
        iii. What are your feelings about the person?
4. Describe a positive or supportive place that is or was part of your work life.
5. Think back to an important transition in your career that marked advancement or recognition. Describe the transition.
    a. Follow-ups:
        i. What were the events leading up to the transition?
        ii. Who were the people involved?
        iii. What were your thoughts and feelings during the transition?

6. Can you describe a childhood STEM memory in as much detail as possible?
    a. Follow-ups:
        i. Who were the people?
        ii. Is there a specific place or event associated with this memory?
7. Tell me about your personal qualities or characteristics that you have found helpful throughout your academic life.
8. Tell me about a difficult decision you had to make at some point along your career path.
    a. Follow-ups:
        i. Discuss the decision,
        ii. What were your options?
        iii. What were your thoughts and feelings throughout the process?
9. What self-care regimens have supported your well-being or mental health?
10. What institutional policies have been in place to support your advancement?
11. Tell me about your fundamental beliefs or values if you're comfortable doing so. What role do they play in your academic life?
12. Is there anything else you would like to share?

Questions adapted from:

Delelaita-Mullet, D., Rinn, A. N., & Kettler, T. (2021). Catalysts of women's success on academic STEM: A feminist poststructural discourse analysis. *Journal of International Women's Studies, 22*(1), 83-103.

Appendix E IRB Approval

Institutional Review Board
University of Missouri-Columbia
FWA Number: 00002876
IRB Registration Numbers: 00000731, 00009014

310 Jesse Hall
Columbia, MO 65211
573-882-3181
irb@missouri.edu

June 14, 2022

Principal Investigator: Melanie Carden-Jessen (MU-Student)
Department: Educational Leadership-EDD

Your IRB Application to project entitled Women Full Professors in STEM: Overcoming the Leaky Pipeline was reviewed and approved by the MU Institutional Review Board according to the terms and conditions described below:

IRB Project Number	2091291
IRB Review Number	376941
Initial Application Approval Date	June 03, 2022
IRB Expiration Date	June 03, 2023
Level of Review	Expedited
Application Status	Approved
Project Status	Active - Open to Enrollment
Expedited Categories	45 CFR 46.110.a(f)(6) 45 CFR 46.110.a(f)(7)
Risk Level	Minimal Risk
Type of Consent	Written Consent Consent with Waiver of Documentation
HIPAA Category	No HIPAA
Approved Documents	Informed Consent & Assent - Consent with Waiver of Documentation: #596316 Informed Consent & Assent - Written Consent Form: #596322 - Electronic signature approved Other Study Documents - Instruments (i.e. surveys): #593753 Other Study Documents - Interview Questions: #593752 Protocol & Investigator's Brochure - Protocol: #596315 Recruitment Materials - Recruitment E-Mail: #595891 Recruitment Materials - Recruitment E-Mail: #595895

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
2. All unanticipated problems must be reported to the IRB on the Event Report within 5 business days of becoming aware of the problem. Unanticipated problems are defined as

events that are unexpected, related or possibly related to the research, and suggests the research places subjects or others at a greater risk of harm than was previously known or recognized. If the unanticipated problem was a death, this is reportable to the IRB within 24 hours on the Death Report.

3. On-site deaths that are not unanticipated problems must be reported within 5 days of awareness on the Death Report, unless the study is such that you have no way of knowing a death has occurred, or an individual dies more than 30 days after s/he has stopped or completed all study procedures/interventions and required follow-up.
4. Major noncompliance must be reported to the MU IRB on the Event Report within 5 business days of the research team becoming aware of the deviation. Major noncompliance are deviations resulting from investigators' failure to comply with the IRB approved protocol when these deviations caused harm or have the potential to cause harm to research subjects or others, and may have affected subject's rights, safety, and/or welfare. It also includes subjects' failure to comply with the protocol when these deviations caused harm. Minor noncompliance include deviations that had no harm to a research subject or others. Minor noncompliance should be reported at the time of continuing review. Please refer to the MU IRB Noncompliance policy for additional details.
5. All changes must be IRB approved prior to implementation unless they are intended to reduce immediate risk. All changes must be submitted on the Amendment Form.
6. All recruitment materials and methods must be approved by the IRB prior to being used.
7. The project-generated annual report must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date. If the study is complete, the Completion/ Withdrawal Form may be submitted in lieu of the annual report.
8. Securely maintain all research records for a period of seven years from the project completion date or longer depending on the sponsor's record keeping requirements.
9. Utilize the IRB stamped consent documents and other approved research documents located within the document storage section of eCompliance. These documents are highlighted green.

If you have any questions, please contact the IRB Office at 573-882-3181 or muresearchirb@missouri.edu.

Thank you,
MU Institutional Review Board

VITA

Melanie Carden-Jessen is a doctoral candidate in the Doctor of Educational Leadership and Policy Analysis program at the University of Missouri. The statewide doctorate is in partnership with Missouri State University. Melanie is currently the Secondary Science Education Program Coordinator and an Instructor for the Department of Geography, Geology, and Planning. Her duties include preparing teacher candidates for entering the field. She lives in Springfield, Missouri with her dog Frodo.