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Sense of Belonging of Underrepresented Students: Role of Faculty Inclusiveness and Online Versus Campus Learning

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This is to certify that the doctoral dissertation by

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Abstract

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BSc (Honors), The University of Sheffield, 2010

Dissertation Submitted in Partial Fulfillment

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Abstract

Underrepresented female doctoral students (UFDS) face challenges in science, technology, engineering, and mathematics (STEM) education, particularly concerning a low sense of belonging (SoB). Little is known about the impact of learning settings (online or on-campus) and the inclusive leadership qualities of research supervisors on the SoB of women in STEM doctoral programs. This quantitative nonexperimental comparative study aimed to address this research gap, comparing the SoB of UFDS in online versus campus university settings and examining the relationship between perceived faculty inclusive leadership qualities (PFILQ) and SoB. Rooted in Fiske's core social motives, particularly sense of belonging, the study utilized an independent samples *t* test and regression analysis to analyze survey data from 638 participants, with 191 meeting analysis criteria. The key findings indicated no significant SoB differences between online and on-campus settings. PFILQ emerged as a significant predictor of UFDS's SoB, while university setting had no predictive value. Further refinement introduced percentage online involvement (POI), revealing no significant differences in SoB scores across campus, hybrid, and online POI categories. Notably, PFILQ and POI, specifically comparing campus and hybrid involvement, were identified as significant predictors for UFDS's SoB. The results may catalyze positive social change by providing guidance to educational institutions in cultivating a culture that not only welcomes diversity but also fosters a more inclusive and collaborative research environment for underrepresented women in STEM. This, in turn, may enhance the collective intelligence and innovation within these fields.

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Dedication

To Laurens and Isoldi, my ever-supportive husband and daughter: Your love and laughter have been my guiding light. You make the journey worthwhile, even during the late-night writing sessions. Rose, my dear late mother, your hidden note in that first psychology book touched my soul, inspiring me to persevere. Your memory lives on in every page.

Nefeli and Iokasti, my inquisitive nieces, your endless questions kept me on my toes, reminding me to explore new avenues. Your curiosity fuels my passion for knowledge and discovery.

I extend my sincere thanks to Dr. Medha Talpade, my first chair, and Dr. Matthew Howen, my second committee member, for their steadfast belief, support, and guidance, crucial in overcoming moments of self-doubt and shaping this academic milestone.

In pursuit of “hysterofimia,” I aspire to make even a tiny speckle of difference in this world.

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Chapter 1: Introduction to the Study

Introduction

This aim of this study was to investigate the relationship between the sense of belonging (SoB) of underrepresented female doctoral students (UFDS) in science, technology, engineering, and mathematics (STEM) and the role of inclusive leadership qualities of faculty in both online and on-campus settings. Female underrepresentation in STEM, particularly among doctoral students, is a significant issue that needs to be addressed, and a low SoB is a known issue for women in STEM (Blaney & Barrett, 2021; European Commission & Directorate-General for Research and Innovation [EC&DGRI], 2021; Kahu et al., 2020; Sax et al., 2018; Singh, 2018). Additionally, little research has been done comparing the best learning setting (traditional or online) to promote the SoB for female doctoral students in STEM, and there is a lack of research on the impact of inclusive leadership qualities of faculty in promoting the SoB among UFDS in STEM (Aboramadan et al., 2021; Ashikali et al., 2021; Fisher et al., 2019; Gopalan & Brady, 2020; Kahu & Nelson, 2018; Kirby & Thomas, 2021; Martin et al., 2020; Muenks et al., 2020; O'Meara et al., 2017; Pascale, 2018; Quayson, 2019; Sax et al., 2018; Singh, 2018; Van Rooij et al., 2021; Widdicks et al., 2021). This study is significant because it is one of the first that compares the SoB of UFDS in STEM on campus versus virtual higher education institutions and investigates the relationship between UFDS's perceived faculty inclusive leadership qualities (PFILQ) and SoB. More importantly, positive social change implications include providing valuable information for program coordinators, educators, psychologists, and researchers seeking to improve UFDS's academic progress and success and promote gender diversity and equality in research, innovation, and STEM.

First, a brief background will be provided on the underrepresentation of women in STEM doctoral programs and the related gaps in the literature that this study was conducted to address. Subsequently, the problem statement will be presented, clarifying what is still unknown in the relationship between the variables under investigation. A reiteration of the existing gap in the literature with regard to the underrepresentation of women in STEM doctoral programs within university settings and the role of faculty as inclusive leaders will follow this. Furthermore, the study's purpose, research question, theoretical framework, and nature will be explicated. In addition, definitions of variables, covariates, and other related terms will be provided. Finally, limitations and significance will be discussed, and the section will conclude with a summary that will transition into Chapter 2.

Background

Despite an increase in female graduates, gender gaps still exist in research, innovation, and STEM fields in the EU-27 and associated countries (EC&DGRI, 2021). This highlights the need to address the underrepresentation of women in STEM programs, particularly among UFDS. The European Commission's SHE Figures handbook provides statistical data on gender equality in European research and innovation. The handbook focuses on achieving gender parity among doctoral graduates as one of the missions of the EU (EC&DGRI, 2021). Interestingly, studies have shown that SoB is linked to academic success, academic persistence, and well-being among students, but women in science fields tend to have a lower SoB than men (Rainey et al., 2018; Sax et al., 2018; Stachl & Baranger, 2020; Suhlmann et al., 2018; Wilson & VanAntwerp, 2021). While there have been studies examining the SoB of female doctoral students in traditional and online university settings, little research has focused on identifying the best learning setting to promote SoB for underrepresented female students in STEM fields (Fisher et al., 2019; Gopalan & Brady, 2020; Kahu & Nelson, 2018; Martin et al., 2020, O'Meara et al., 2017; Sax et al., 2018; Singh, 2018). This creates a gap in the literature comparing the SoB between online and campus learning for UFDS in STEM fields.

Moreover, Fiske (2018) argued that social interaction is crucial for human success, and humans have developed psychological motivations, including the SoB, to navigate social experiences. SoB involves creating strong and balanced relationships with others, and people's behavior is guided by affiliating with groups to maintain positive interactions and secure long-lasting bonds, which benefits them psychologically and physically. Furthermore, the literature suggests that SoB underlies all social core motives for sustaining group memberships, including enhancing oneself, controlling one’s environment, trusting one’s environment and others, and understanding the social world. The notion of sustaining group memberships, particularly for PhD researchers in research and innovation, explains the role of a SoB (Chiu et al., 2016; Fisher et al., 2019; Sax et al., 2018; Stachl & Baranger, 2020). Moreover, the dynamics of relationships within a group (i.e., intragroup relations), particularly the impact of the group leader or faculty, are essential factors influencing the members' SoB. Studies suggest that the group leader's relationship and interaction with group members affect their SoB (Barreto & Hogg, 2017; Qyason, 2019). Therefore, this paper explores the connection between faculty as leaders and their interaction with female PhD researchers in STEM and how it affects their SoB.

On that note, the faculty–student relationship is a significant factor affecting a student's SoB, which is important for academic and personal success (Sax et al., 2018; Van Rooij et al., 2021). Studies have shown that supportive faculty with positive interactions strengthen students' SoB, while negative or no interactions have the opposite effect. Recent studies have also highlighted the role of inclusive faculty in promoting SoB among students, but there is a lack of research on the impact of inclusive leadership qualities of faculty on UFDS in STEM (Cortina et al., 2017; Freeman et al., 2007; Hoffman et al., 2002; Johnson et al., 2007; Maestas et al., 2007; Martin et al., 2020; Singh, 2018). Overall, this points out the gap in the literature concerning the role of inclusive leadership qualities of faculty on UFDS, and given the recent data on the decreased numbers of women attaining doctoral degrees in STEM (EC&DGRI, 2021), it is crucial to fill this gap in the literature.

Furthermore, efforts to support equity and inclusion are crucial to address the lack of UFDS in STEM fields. Students' SoB is influenced by multiple factors, including faculty relationships and interactions (Sax et al., 2018; Van Rooij et al., 2021). Positive interactions with faculty members with inclusive behaviors increase students' SoB, while negative interactions decrease it (Sax et al., 2018; Van Rooij et al., 2021). However, there is a gap in the literature regarding the effects of faculty inclusiveness on UFDS's SoB, particularly in online and campus learning settings. Additionally, there is a lack of research comparing the differences in SoB between these two settings for UFDS in STEM (Budash & Shaw, 2017; Fisher et al., 2019; Gopalan & Brady, 2020; Kahu & Nelson, 2018; O'Meara et al., 2017; Sax et al., 2018; Singh, 2018). Therefore, further investigation into the SoB of underrepresented students and the role of inclusive leadership qualities of faculty is necessary to promote gender diversity and equality in research and STEM professions.

Problem Statement

The specific research problem that was addressed in this study was the lack of knowledge concerning the relationship between the SoB of UFDS in STEM in online and on-campus settings and the role of the inclusive leadership qualities of faculty. The problem of female underrepresentation in STEM, especially among doctoral students, is a current and significant issue that needs to be addressed (EC&DGRI, 2021). Studies have shown that a SoB is essential for academic success, persistence, and well-being among students, and women in STEM tend to have a lower SoB than men (Rainey et al., 2018; Sax et al., 2018; Stachl & Baranger, 2020; Suhlmann et al., 2018; Wilson & VanAntwerp, 2021). Additionally, little research has focused on identifying the best learning setting to promote SoB for female doctoral students in STEM (Fisher et al., 2019; Gopalan & Brady, 2020; Kahu & Nelson, 2018; Martin et al., 2020; O'Meara et al., 2017; Sax et al., 2018; Singh, 2018), which has created a gap in the literature on the comparison of SoB between online and campus learning for UFDS in STEM. Furthermore, the faculty–student relationship is a crucial factor influencing a student's SoB, and recent studies have highlighted the role of faculty members with inclusive behavioral qualities in promoting SoB among students (e.g., Aboramadan et al., 2021; Ashikali et al., 2021; Kirby & Thomas, 2021; Martin et al., 2020; Muenks et al., 2020; Pascale, 2018; Quayson, 2019; Van Rooij et al., 2021; Widdicks et al., 2021). However, there is a lack of research investigating the impact and role of inclusive leadership qualities of faculty in promoting a SoB among UFDS in STEM, leading to a gap in the current research.

Purpose of the Study

The purpose of this quantitative nonexperimental comparative study was to compare the SoB of UFDS in STEM between online and campus university settings and to examine the relationship between the UFDS's PFILQ and SoB.

Research Questions and Hypotheses

RQ1: Are there differences in the SoB as measured by the Social Fit Scale of UFDS in STEM as a function of their university setting (online vs. campus)?

H_0: There are no statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

H_a: There are statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

RQ2: Is PFILQ as measured by the Inclusive Leadership Scale and/or university setting (campus/online) a predictor for SoB of UFDS in STEM?

H_0: PFILQ and/or university setting is not a significant predictor of SoB scores of UFDS in STEM.

H_a: PFILQ and/or university setting is a significant predictor of SoB scores of UFDS in STEM.

Theoretical Framework for the Study

The theoretical foundation of the current study was rooted in Fiske's (2018) core social motives, particularly the SoB. Fiske's theory posits that humans possess psychological incentives that assist them in managing social encounters, leading to the development of five primary social motives: trusting, understanding, controlling, self-enhancement, and belonging. Among these social motives, the SoB is deemed the most vital as it underpins the other four motives. The SoB concept pertains to the human desire to cultivate meaningful and balanced relationships with others. This research focused on investigating the SoB of UFDS in STEM. Thus, the theoretical framework can be utilized to answer the research questions of this study and to examine how university settings and PFILQ can impact the SoB of UFDS in STEM. All in all, this framework enabled me to address the research questions and objectives of the study comprehensively. In Chapter 2 of this study, I extensively explain the theoretical foundation, including its relevance and applicability to current research.

Nature of the Study

In order to address the research questions in this quantitative study, the research included a survey design, specifically a nonexperimental comparative and predictive design (Frankfort-Nachmias & Guerrero, 2018). This design was suitable for comparing and predicting differences in the dependent variable across two categorical groups based on the independent variable. Additionally, a survey design was appropriate because such a design allows researchers to collect data from many participants in a short period. This design was also suitable because the study did not involve manipulating any variables. An independent samples *t* test was conducted for RQ1 with subjective scores for UFDS's SoB compared between campus and online university settings. The independent variable was the university setting with a categorical level of measurement with two groups (campus versus online). The dependent variable was the SoB, with a continuous level of measurement, a minimum score of 1.0, and a maximum of 5.0.

Moreover, the specific research design included a regression analysis (Frankfort-Nachmias & Guerrero, 2018; Warner, 2013) for RQ2 with subjective scores of UFDS's PFILQ and university setting (campus/online) as predictors of the UDFS's SoB. The research analysis included a multiple linear regression analysis with one continuous variable (PFILQ) and one dichotomous dummy variable (university setting) to predict the UFDS's SoB. The first independent variable was the PFILQ with a continuous level of measurement, the second independent variable was the university setting with a categorical level of measurement with two groups (campus vs. online), and the dependent variable was SoB with a continuous level of measurement. The target population for this study was UFDS in STEM, specifically those who had pursued but failed, were currently pursuing, or had attained a doctoral degree in STEM. In order to reach this population, I planned to collect samples by administering online surveys through social media platforms. Finally, the data collected were analyzed using IBM SPSS Statistics (Version 28.0; IBM Corp., 2021).

Definitions

University setting: Face-to-face learning refers to a synchronous physical learning environment where physical interaction is at the forefront and students and teachers meet concurrently (Asarta & Schmidt, 2015; Müller & Mildenberger, 2021).

Online learning: A form of distance learning; refers to learning occurring asynchronously without a common physical space where teachers and students meet, with various technological tools used for learning. Teacher–student and student–student interaction happens virtually (Asarta & Schmidt, 2015; Müller & Mildenberger, 2021; Prasetyo et al., 2021).

Hybrid/blended learning: Essentially a combination of face-to-face and online learning. Learning can happen synchronously or asynchronously, may occur in a physical environment or virtually, or may be delivered through recorded lectures (Asarta & Schmidt, 2015; Müller & Mildenberger, 2021; Prasetyo et al., 2021; Singh et al., 2021).

Sex/gender: The current study focused solely on women or cisgender women (with *woman* referring to a person who identifies as female or feminine). Sex refers solely to biological and physiological traits. Because gender is a complex and sensitive topic, the question about the participants' gender was not binary and included a list of all recognized gender identities (woman, man, nonbinary, genderqueer, genderfluid, agender, two-spirit, androgynous, transgender, cisgender) in which the inclusion criteria were for participants who identified as women (American Psychological Association, 2015).

Faculty: In this study, the term *faculty* pertains to an individual who holds the position of a primary research supervisor, PhD supervisor, primary advisor, dissertation advisor, supervisor, thesis advisor, doctoral advisor, research supervisor, doctoral mentor, principal investigator, dissertation committee chair, dissertation chair, or doctoral faculty advisor. This individual serves as the leader of a student's PhD development and holds the right to assess the product of the student's research (Bryant, 2004).

Perceived faculty inclusive leadership qualities (PFILQ): Refers to a student’s perception of how their primary faculty demonstrate inclusive leadership behaviors towards them. Faculty inclusive leadership qualities are coined from a branch of the relational leadership theory called *inclusive leadership*. Consequently, it is logical to connect the faculty to leadership in this study because the faculty are perceived as leaders of PhD candidates (Carmeli et al., 2010; Komives et al., 2015; Uhl-Bien, 2006).

Relational and inclusive leadership: Refers to purposeful, empowering, ethical, and process-oriented relationships between leaders and subordinates. Inclusive leadership is a mode of relational leadership that ascertains that leaders who show openness, accessibility, and availability to their subordinates are considered inclusive (Carmeli et al., 2010; Komives et al., 2015; Uhl-Bien, 2006).

Sense of belonging (SoB): A SoB is a core social motive that underlies the other four motives (understanding, controlling, enhancing oneself, and trusting). It refers to the idea that humans strive to create potent and balanced relationships with others and strive to belong to groups that accommodate these needs (Fiske, 2018).

Assumptions

This study was based on several underlying assumptions. The first assumption was that Fiske's (2018) core social motives, specifically the SoB, provided a suitable theoretical framework for explaining the research questions posed in this study. Second, it was assumed that the survey method employed in this study effectively captured the variables of interest, including PFILQ, university setting, and SoB, in a truthful and accurate manner. Last, it was assumed that a significant relationship existed between the variables under investigation in this study.

Scope and Delimitations

To address the research problem of the SoB among UFDS in STEM and the relationship between their SoB, PFILQ, and university setting, I conducted this study to fill the knowledge gap regarding the experiences of UFDS in STEM. In order to address the issue of internal validity, extraneous variables that might have had an impact on the results, such as the characteristics of the doctoral program, were controlled for. Specifically, participants were asked to indicate whether their doctorate was self-funded or traditional. This was important because self-funding can be a potential source of internal invalidity, referred to as history, which can be addressed through a survey question to enable statistical control.

Moreover, the study's scope was limited to UFDS in STEM who had pursued but failed/were currently pursuing or attained a doctoral degree in STEM, excluding male students and students in other fields. The delimitations of the study included the use of a survey, nonexperimental comparative, and predictive design. Additionally, the study focused on UFDS in STEM at a particular point in time and did not account for any changes or fluctuations in their experiences over time. Regarding external validity, the study's generalizability is limited to UFDS in STEM who have pursued but failed/are currently pursuing or have attained a doctoral degree in STEM, and the results cannot be generalized to other student populations or other fields of study. To increase the generalizability of the results, an estimated sample size of 230 was used.

Limitations

Recruiting a sufficient number of participants and addressing the possibility of response bias represented two significant limitations (Groves et al., 2009). Despite the potential of social media recruitment to attract interested and engaged participants, incomplete responses might have still occurred, leading to nonresponse bias. Furthermore, because the study relied on self-reported surveys, it was vulnerable to the drawbacks of self-reports, such as response biases and inaccurate representation of participants' SoB and PFILQ (Groves et al., 2009). Extreme responses, for instance, might have jeopardized the effectiveness of the survey. In order to prevent response biases and improve recruitment, data outliers were identified and removed during the analysis stage, and the participant recruitment platform SurveyMonkey was utilized.

Another limitation was the assumption that certain doctoral degrees included more than one supervisor. As a result, participants were asked to provide answers to the survey relating to the PFILQ based on their relationship with their primary supervisor.

Additionally, doctoral degrees could take two forms: a paid position where the topic was already provided and sponsored or a self-funded PhD where the candidate chose the topic. Having the freedom to choose their research topic might have influenced participants' commitment to completing the research, and the isolation associated with self-funding a PhD could potentially have affected motivation (Mogaji et al., 2021). While the type of PhD might have impacted motivation, there was insufficient research to substantiate this claim. Consequently, in the recommendation for future studies section in Chapter 5, it is proposed to address this research gap through a more comprehensive review. Importantly, no ethical issues were found connected with completing the survey.

Significance

The potential contributions of this study to advance knowledge in the disciplines of psychology, social psychology, education, and STEM include addressing the research gap regarding the effects of inclusive leadership qualities of faculty on UFDS's SoB, particularly in online and on-campus learning settings. Previous studies have examined the impact of online, hybrid, or campus higher education on underrepresented minority students' SoB individually (Besser et al., 2020; Farrell & Brunton, 2020; Jackson, 2016; Martin et al., 2020; Pedler et al., 2022; Thomas et al., 2014). However, there is a notable gap in the literature when it comes to directly comparing the effects of different university settings on underrepresented female students' SoB. This study addressed the scarcity of research comparing the university setting and students' SoB. By comparing the SoB of UFDS in STEM between on-campus and virtual higher education institutions, there is potential for a nuanced solution to the problem of female underrepresentation in STEM.

Additionally, gender parity among PhD graduates is one of the aims of the European Union, and despite progress, significant gender gaps persist in research and innovation, particularly in STEM. This underscores the importance of balancing the representation of women in research and innovation (EC & DGRI, 2021). Women pursuing doctoral degrees in STEM face stereotype threats and stigmatization related to their academic capability, which can hinder their SoB (Blaney & Barrett, 2021; Kahu et al., 2020; Sax et al., 2018; Singh, 2018). The feeling of belonging is crucial for diversity and inclusion initiatives in STEM, and it is a strong predictor of college performance, especially in STEM fields (Palid et al., 2023).

Furthermore, inclusive leadership qualities of faculty were anticipated to indirectly influence students' SoB (Ibrahim & Zaatari, 2020; Kahu & Nelson, 2018; Martin et al., 2020; van Rooij et al., 2021; Sax et al., 2018). Therefore, it was necessary to investigate the extent to which UFDS's PFILQ affected their SoB. This was because there is a potential to offer valuable insights and assist educational institutions in establishing a more supportive learning environment for women in STEM, resulting in increased retention rates, enhanced inclusivity, and greater encouragement for women to pursue STEM education and careers. Ultimately, this can contribute to a broader range of diverse ideas and innovations within the field.

All in all, the findings of this study can contribute to positive social change by promoting and encouraging diversity and inclusion through scholar-practitioner approaches addressing persistent social inequities that hinder women from pursuing and completing PhD degrees, particularly in STEM disciplines. By mitigating female doctoral underrepresentation in STEM, this study can support the promotion of gender diversity and equality in research, innovation, and STEM, thereby strengthening the collective intelligence of research and increasing the overall number of research and STEM professionals.

Summary

Chapter 1 addressed the underrepresentation of female doctoral students in STEM and emphasized the importance of a SoB for this population. Gaps in the literature were identified, particularly regarding the inclusive leadership qualities of faculty, specifically faculty and their influence on the SoB of female doctoral students. The aim of the study was presented, that is, to compare SoB in different university settings (online or campus), investigate the role of inclusive leadership qualities of faculty, and contribute to program improvement and gender diversity in research and STEM. Last, the significance of investigating inclusive leadership qualities, university settings, and promoting diversity and inclusion in STEM was emphasized. Chapter 2 provides a comprehensive review of the theoretical foundation, key variables, and existing literature related to SoB in various contexts, including female doctoral degree underrepresentation in STEM, sustaining group memberships, academic retention, undergraduate and graduate women in STEM, university settings, faculty interaction, and the role of inclusive leadership in SoB.

Chapter 2: Literature Review

Introduction

SHE Figures is a European commission handbook that focuses on statistical data relating to gender equality in research and innovation across Europe (EC&DGRI, 2021). According to the EC and DGRI (2021), despite a general increase in the proportion of female graduates across the EU-27 and associated countries, women are still underrepresented in STEM. Current research has demonstrated that female doctoral students in STEM experience a low SoB, which decreases their motivation and persistence, which in turn negatively affects their academic success (Rainey et al., 2018; Sax et al., 2018; Stachl & Baranger, 2020; Suhlmann et al., 2018; Wilson & VanAntwerp, 2021). Additionally, there have been studies that have examined the SoB of female doctoral students in traditional and online university settings (e.g., Fisher et al., 2019; Kahu & Nelson, 2018; Martin et al., 2020) and other studies measuring the SoB on campus for the general student population and other underrepresented ethnic minority students (e.g., Gopalan & Brady, 2020; O'Meara et al., 2017; Sax et al., 2018; Singh, 2018). Nevertheless, little research has focused on examining the best type of learning setting (campus vs. online) for students who are underrepresented in order to promote their SoB. Furthermore, other studies have shown that an inclusive leadership style (part of the relational leadership model [Komives et al., 2015]) positively affects group members' SoB (Freeman et al., 2007; Hoffman et al., 2002; Johnson et al., 2007; Maestas et al., 2007). This is important because the faculty supervising the students' doctoral research have a leadership role as part of the doctoral group affiliation and therefore play a role in affecting the students' SoB (Barreto & Hogg, 2017; Chiu et al., 2016; Fisher et al., 2019; Sax et al., 2018; Stachl & Baranger, 2020). Consequently, the purpose of this quantitative nonexperimental comparative study was to compare the SoB of UFDS in STEM between online and campus university settings and to examine the relationship between the UFDS's PFILQ and SoB.

In this literature review, the students' SoB in higher education and the role of a university setting (online or campus based) and inclusive leadership are discussed. Further on, the underrepresentation of women, specifically in doctoral degree attainment in STEM, will be reviewed. The literature review will report on four main topics: female doctoral underrepresentation in STEM, SoB (in higher education, for underrepresented populations, specifically women in STEM, university setting [campus and online], and faculty interaction), inclusive leadership, and faculty supporting doctoral women in STEM. The emphasis of this chapter is to gain a deeper comprehension of the importance of the SoB in tertiary education relating to retention and student well-being for an underrepresented student population in STEM and more specifically women. The beginning of this chapter contains information relating to the methods of finding information for the literature review, followed by an explication of the theoretical foundation. Chapter 2 concludes with a summary of the major themes of a SoB in tertiary education, university setting, and inclusive leadership and a description of how the study fills specific gaps in the literature.

Literature Search Strategy

The studies used for this literature review related to the underrepresentation of female doctoral students in STEM, their SoB across online and campus learning, and the role of inclusive leadership qualities from faculty as a predictor of their SoB. The databases searched included Academic Search Complete, JSTOR, ERIC, Sociological Abstracts, PsycINFO, Project Muse, PsycARTICLES, Scopus, Sage Journals, Frontiers in Psychology, Web of Science and ERIC Database (Educational Psychology), and Sociological Abstracts (Social Psychology). Moreover, Google was used as a search engine, and to check whether a journal was peer-reviewed, Ulrich's Periodicals Directory was utilized. The keywords searched included *student engagement*, *student motivation*, *core social motives, sense of belonging, sense of fit, group identification, academic success, e-learning and sense of belonging, attrition and online learning, women in science female doctoral students in STEM*, *attrition of female doctoral students*, *sense of belonging in online studies*, *sense of belonging in campus, comparing campus and online students' sense of belonging, engagement*, *virtual classroom, women/gender and belonging and STEM, group identity*, *social identities*, and *women in STEM***.** Moreover, the literature review on a SoB relating to inclusive leadership qualities from faculty, university settings, and other extraneous variables spanned between 2014 and 2023. Finally, the theoretical foundation of this research was substantiated with seminal research spanning between 2008 and 2018.

Theoretical Foundation: Core Social Motive of a Sense of Belonging

The theories and/or concepts that grounded this study included Fiske's (2018) core social motives related to the SoB. According to Fiske, human beings need the companionship of others to survive. Consequently, humans evolved psychological incentives to assist them in surviving social encounters, reinforcing people's fundamental thoughts, emotions, and behaviors. These core motives also explain why people join and leave groups, choose to join one group over another, and engage in intragroup relations (Fiske, 2018).

The specific social core motives defined by Fiske (2018) are *trusting, understanding, controlling, self-enhancement*, and *belonging*. More explicitly, understanding refers to people's tendency to interpret the world around them and make sense of events and other people's behaviors and their own. This motivator fosters the discussion of belonging as an extension of self-identity. The motive of understanding exists to assist people in predicting situations in case of uncertain times and in understanding potential outcomes. It is important to note that with understanding comes controlling, as gaining understanding provides a sense of control over one's environment (Fiske et al., 2018).

Controlling relates to people's need for personal effectiveness in their social environment, which is often contingent upon their actions and the outcomes of those actions (Fiske, 2018). The need to control develops quite early in a person's life, even in infancy. For example, some infants discover that their parents react immediately to them when they cry or smile, which is an early example of social control and effectiveness.

Self-enhancement involves a person's self-esteem and self-improvement. Gaining positive feedback from others via group associations enhances a person's self-image and, therefore, their self-esteem, leading them to be motivated towards group memberships. Finally, trusting refers to the confidence people have in others that they will not act in ways that would inevitably hurt them physically and/or mentally (Fiske, 2018).

As mentioned earlier, five core social motives affect joining, sustaining, and leaving group memberships (Fiske, 2018). The SoB motive is considered an essential social core motive and the one that underlies the other four motives (Fiske, 2018; Kashima et al., 2022). This particular motive (SoB) was chosen to support this study's research problem, purpose, and nature. More explicitly, SoB refers to the idea that humans strive to create potent and balanced relationships with others (Fiske, 2018). Indeed, people tend to form social connections easily to create a SoB. For example, research has shown that proximity alone can foster social connections and loyalty (Liberman & Shaw, 2019). Therefore, UFDS in STEM are likely to strive to form close relationships with members of their research group or research department, which will influence their SoB. Additionally, close connections have been shown to affect people's subjective well-being; a threat to an individual’s SoB, either by being ostracized or feeling underrepresented, affects the individual's mood, health, and stress levels (Fiske, 2018; Siedlecki et al., 2014). For example, a female doctoral student in STEM who feels underrepresented, alone, and ostracized is likely to have a poorer mood, poorer health, and increased stress, which could lower their persistence to complete their degree (Roland et al., 2018). Therefore, being part of an underrepresented population such as

UFDS in STEM creates psychological and academic barriers when this underrepresentation exists within a group affiliation (Fiske, 2018).

Accordingly, research has indicated that diversity in groups poses certain threats and benefits to the members of the group (Fiske, 2018). Additionally, cohesive and high membership identification groups tend to be homogenous. Consequently, diversity (such as diverse ethnic backgrounds, gender, age, etc.) within groups could undercut cohesion, inadvertently affecting the SoB of individual members (Fiske, 2018). For example, although STEM research groups are diverse in regard to ethnicity and other nonobservable attributes (e.g., skills), there is a lack of parity between genders in that most members of these groups are men (EC & DGRI, 2021). Based on the aforementioned, one could then assume that women entering the STEM research group might feel disconnected from the group because they inadvertently play a role in decreasing cohesion, which affects their SoB. In a similar line, people tend to highly identify with groups and their members who share similar attributes, which influences their SoB within the group (Fiske, 2018). Consequently, if the STEM research group does not fulfill certain characteristics that make UDFS feel that they are similar to its members, it is likely that their SoB might suffer. This is why it is pertinent to increase gender balance within the STEM field to allow future female members to enter the group without threats to their SoB. This is a logical connection to the research problem of UFDS in STEM and their SoB.

Additionally, a basic tenet in social psychology is the power the situation has over individual behavior, cognition, and affection (Fiske, 2018). Fiske (2018) posited that the power of the context or situation will place a positive or negative valence on a certain goal and subsequently on motives that relate to the goal. In the context of this study, one can consider the university setting as a situation that influences the person's experience and the valence they may place on the motive (SoB). For example, a student's experience in an online university and at a traditional campus university might differ due to the context of the university setting; an online setting might negatively (or positively) affect the valence of the social motive based on the person in the situation principle. Unfortunately, there is a gap in the literature comparing these contexts in order to examine the differences in the SoB among university students and specifically UFDS. Thus, it is important to measure the motive of belonging in different contexts in order to examine the contextual differences in the UFDS SoB. Similarly, faculty inclusiveness can be seen as a context that influences the valence of the UFDS's SoB. Studies have shown that faculty relationships/interactions significantly influence students' SoB (Freeman et al., 2007; Hoffman et al., 2002; Johnson et al., 2007; Maestas et al., 2007). Moreover, supportive faculty with inclusive behaviors and positive interactions with students strengthened the students' SoB. Therefore, UFDS in STEM joining an environment that includes inclusive leadership qualities from faculty will benefit their SoB, and this provides a logical connection between the framework presented and the purpose of this study.

Furthermore, the nature of this study was quantitative, and quantitative measures such as surveys relating to social fit (SoB) and inclusive leadership (PFILQ) were used to assess how much UFDS felt like they belonged within the STEM department and how much they felt their faculty demonstrated inclusive behaviors towards them (Carmeli et al., 2010; Walton & Cohen, 2007; Walton et al., 2012). The survey utilized to measure the SoB was created based on the tenets of social psychological constructs relating to the core motive of belonging and group memberships (Fiske, 2018; Walton & Cohen, 2007; Walton et al., 2012). Additionally, the survey utilized to measure how much UFDS feel their faculty demonstrate inclusive behaviors towards them was based on the notion that inclusive leadership involves inclusive, accessible, interactive, and open communication towards team members. Finally, PFILQ relate to the theoretical framework of belonging because intragroup relations (i.e., relations within a group membership, amid group members) play an important role in one's SoB within the group; this provides a logical connection between the framework presented and the nature of this study (Chiu et al., 2016; Fisher et al., 2019; Sax et al., 2018; Stachl & Baranger, 2020).

Literature Review Related to Key Variables

Female Doctoral Degree Underrepresentation in Science, Technology, Engineering, and Mathematics

Women have increasingly gained doctorate degrees over the last decade, especially in health and social sciences. For example, in the European Union and associated countries (EU-27), women represent 48.1% of European doctoral graduates (EC&DGRI, 2021). According to the National Science Foundation ([NSF], 2021), in the United States, women gained over 49% of doctorate degrees in fields such as psychology, humanities, education, and other fields unrelated to STEM. Moreover, the Organization for Economic Cooperation and Development's (OECD, 2021a) data on doctoral degree attainment in 2019 across 46 countries, including the United States, indicated an exponential increase in women earning doctoral degrees. For example, in Australia, Belgium, Canada, and Korea, women gained over 71.9%, 71%, 72.3%, and 70% of doctorate degrees in the education field, respectively (OECD, 2021a). Across the world, women have consistently grown in the number of doctoral degrees attained in other STEM-unrelated fields compared to men. For example, 71% of those attaining a doctoral degree in the arts and humanities were women, whereas men accounted for 29% (the percentages are the sum of averages of all countries—OECD average). More explicitly, Table 1 demonstrates the OECD average of doctoral degree attainment between men and women in the remaining non-STEM-related fields (OECD, 2021a).

Table 1

OECD Average of Doctoral Degree Attainment of Men and Women in Non-STEM Fields (2019)

Field	Men	Women
Generic programs and qualifications	23.9%	76.1%
Education	29.2%	70.8%
Arts and humanities	46.2%	53.8%
Social sciences, journalism, and information	43.1%	56.9%
Business, administration, and law	53.4%	46.6%
Agriculture, forestry, fisheries, and veterinary	44.9%	55.1%
Health and welfare	39.8%	60.2%
Services	55.5%	44.5%

Regardless of the increase in female doctoral degree attainment and parity between men and women across the globe, significant gender gaps persist in the field of STEM (EC&DGRI, 2021; Miller & Wai, 2015; NSF, 2021; OECD, 2021a, 2021b). Based on the latest OECD data on the total number of doctoral degree graduates in 2019, the percentage of women attaining doctoral degrees in STEM fields is exponentially lower than for men (OECD, 2021a). For example, in engineering, manufacturing, and construction, women accounted for 29% of doctoral degrees, whereas men accounted for 70%. A positive note is the parity between men and women in doctoral degree attainment in the natural sciences, mathematics, and statistics, as demonstrated in Table 2. Nevertheless, further data on doctoral degree attainment of men and women in information and communication technologies suggest that a gender gap remains, as shown in Table 2 (OECD, 2021a).

Moreover, in certain countries, the gap in doctoral degree attainment between men and women is exceedingly high. For example, in Saudi Arabia, between 2013 and 2019, 2.8% of women doctoral graduates were in engineering, manufacturing, and construction. In Germany, women accounted for 19.5% of doctoral degree attainment in engineering, manufacturing, and construction**.** Tables 3 and 4 show the percentages of some countries with female doctoral degree attainment in information and communication technologies and engineering, manufacturing, and construction below 20% between 2013 and 2019, respectively (OECD, 2021a). The data suggest the social problem of female underrepresentation in doctoral degree attainment in STEM. Consequently, there is a significant gender gap in doctoral STEM degree attainment.

Table 2

OECD Average of Doctoral Degree Attainment of Men and Women in STEM Fields (2019)

Field	Men	Women
Natural sciences, mathematics, and statistics	54.2%	45.7%
Information and communication technologies	81%	**19%**
Engineering, manufacturing, and construction	70.3%	**29.6**%

Table 3

Percentages of Countries With Female Doctoral Degree Attainment in Engineering, Manufacturing, and Construction Below 20% Between 2013 and 2019

Engineering, manufacturing, and construction	
Country	%
Colombia	17.7
Costa Rica	0.0
Germany	19.4
Iceland	14.3
India	19.8
Japan	16.3
Korea	13.7
Luxembourg	6.7
Saudi Arabia	2.8
South Africa	17.2

Table 4

Percentages of Countries With Female Doctoral Degree Attainment in Information and Communication Technologies Below 24% Between 2013 and 2019

Information and communication technologies					
Country	%	Country	%	Country	%
Argentina	7.2	Switzerland	15.3	Lithuania	8.1
Austria	16.6	Germany	15.1	Luxembourg	11.8
Belgium	6.3	Greece	14.5	Netherlands	16.0
Chile	5.6	Hungary	13.8	Norway	10.9
Colombia	13.9	Iceland	0.0	Poland	11.2
Costa Rica	0.0	Ireland	16.5	Slovak Republic	10.1
Czech Republic	10.2	Israel	13.2	Slovenia	6.0
Estonia	8.5	Italy	16.9	Sweden	19.9
Finland	18.3	Korea	13.8	USA	23

Despite the plethora of data and information on global degree attainment from sources such as the EC&DGRI (2021), NSF (2021), and OECD (2021a), the data were not without limitations. Namely, data from the SHE Figures European commission handbook focused on statistical data relating to gender equality in research and innovation across Europe (EC&DGRI, 2021). While I evaluated the data I used from the handbook for accuracy and ensured I utilized quality databases (e.g., European Commission Databases such as Eurostat or other national statistical offices), it was not possible to ensure that all agencies with statistical data had undergone quality reviews from statistical authorities (EC&DGRI, 2021). Consequently, this implied a margin of errors within the data, although the accuracy of the collection methods was acceptable (EC&DGRI, 2021).

Another limitation concerned gathering gender-specific data. For example, the data from the SHE Figures European commission handbook (EC&DGRI, 2021), NSF (2021), and OECD (2021a) focused on the collection of binary gender data, thus only for the classification of females and males. Nonbinary regards gender identities that do not necessarily fall into the category of male and female and include terms such as Lesbian, Gay, Bisexual, Transgender, Transsexual, Two-spirit, Queer, Questioning, Intersex, Asexual, Ally, A-gender, Bi-gender, Gender Queer, Pansexual, Pangender, and Gender Variant (the short abbreviation is known as LGBTQIA+ and constantly evolving). Consequently, future data that includes nonbinary gender identities might provide more accurate and high-quality data (EC&DGRI, 2021; NSF, 2021; OECD, 2021a). A final limitation related to the variable used to demonstrate the underrepresentation of female doctoral attainment in STEM by the OECD (2021a). Namely, the variable *OECD average* was used for the global education statistics comparisons. It is important to note that not all countries were homogenous (OECD, 2021b). Nevertheless, the variable *OECD average* was an overall calculation of the unweighted means of all countries that provided data and remained an accurate and high-quality pool of data (OECD, 2021b).

All in all, the data indicated that women are considerably underrepresented in doctoral degree attainment in STEM (EC&DGRI, 2021; NSF, 2021; OECD, 2021a). Many reasons could be attributed to the exponentially low number of female doctoral degree attainment in STEM. Difficulties with work and life balance, a low number of other women in science acting as role models, problems with belonging, and feeling excluded are a few (Charlesworth & Banaji, 2019). Further in this review, I will focus on women's problems with belonging to STEM fields. Namely, academic success and retention studies have shown that students' SoB was associated with academic success, persistence, and well-being (Sax et al., 2018; Suhlmann et al., 2018). Interestingly, there was a lower SoB for women who pursue a doctoral degree in STEM compared to men (e.g., Fisher et al., 2019; Kahu & Nelson, 2018; Martin et al., 2020). Therefore, SoB and its role in degree attainment for women in STEM, the underrepresented minorities, was an important factor to review.

Sense of Belonging and Sustaining Group Memberships

According to Fiske (2018), human beings require the company of others to succeed in life. For this cause, humans have developed psychological motivations to help them live through social experiences. A SoB refers to the idea that human beings strive to create potent, long-lasting, and balanced relationships with others and, therefore, place a high value on group identification (e.g., being a member of a math club or belonging to a research association). Interestingly, because people value identifying with groups through social contact, their behavior is guided towards affiliating with said groups to maintain positive interactions and secure long-lasting bonds, which is psychologically and physically beneficial (Fiske, 2018). Finally, Fiske explains that a SoB underlies all social core motives (i.e., other core motives are trusting, enhancing oneself, controlling, and understanding) for sustaining group memberships. Therefore, the notion of sustaining group memberships, such as continuing one's membership within the group of Ph.D. researchers in research and innovation, explains the critical role SoB plays in this review. Finally, it is essential to reiterate that Fiske explains that identifying with groups fulfills the need to belong (i.e., satisfies one's SoB). Consequently, a SoB and identification are not considered separate concepts but are intertwined and synonymous (Raman, 2014).

From a behaviorist perspective, seeking pleasure and avoiding pain is what motivates human behavior (Skinner, 1963). Namely, if a situation results in pleasure, people will seek to replicate the situation and sustain the pleasure or avoid it if it results in pain. In essence, when favorable consequences follow actions or situations, humans will strive to remain in the situation to replicate the positive feeling (Skinner, 1963). In that sense, when belonging to a group results in positive reinforcement such as positive well-being and life satisfaction (Maitland et al., 2021; Sønderlund et al., 2017; Wakefield et al., 2017; Ysseldyk et al., 2019), people will likely strive to sustain their membership in order to replicate or sustain the positive outcomes. Consequently, based on this fundamental notion, I investigated how a SoB is a critical core motive for sustaining memberships in a group.

For example, Sønderlund et al. (2017) conducted a quantitative correlational survey that explored the relationship between belonging to multiple social groups and well-being. The preliminary study results indicated a strong association between belonging to social groups and well-being. However, they noted that only identifying with groups of perceived high value and visibility (e.g., identifying with being part of a prestigious educational group such as doctoral researchers in STEM) positively shaped well-being. In contrast, well-being was negatively shaped for people who identified with groups they considered devalued and with high visibility, such as stigma related to a group (e.g., gender biases in STEM; Roper, 2019; Sønderlund et al.,2017).

With support from Sønderlund et al.'s (2017) study, I can argue that a SoB provides positive rewards, especially to groups considered of value. Therefore, people are more likely to sustain their memberships within the groups they value, as their SoB is positively correlated to their well-being, which is positive reinforcement. While Sønderlund et al. strongly argued the relationship between belonging to groups and well-being, certain limitations confine generalization and causation. For example, as the methodology used was correlational, causal implications are impossible. Additionally, the sample size was small, which might have created issues with interpretation. Nevertheless, despite the limitations and the tentative results of the study, it was an essential contribution to the literature on the benefits of belonging. In addition, it allowed for further empirical research and provided a strong standing for supporting that a SoB is an important factor to evaluate (Sønderlund et al., 2017).

Ysseldyk et al. (2019) conducted mixed-method research to understand further what issues might impact postdoctoral women's mental health. In addition, they examined potential correlations between belonging to groups (i.e., having a SoB within their discipline), perceived control, and psychological well-being. In their second quantitative study, the researchers examined the self-reports of postdoctoral women on belonging, control, and mental health. They found that highly identifying with one's discipline (i.e., having a high SoB) was positively correlated with a positive mental health state.

Consequently, the findings suggested that a high SoB in one's discipline (e.g., female doctoral students in STEM) protected the psychological well-being of postdoctoral women, which mitigated their academic attrition (Ysseldyk et al., 2019).

While the research of Ysseldyk et al. (2019) had certain limitations, it generated results from data relevant to the current literature review. For example, one limitation concerned the equality of variance of the data on the gender, discipline, and country of the participants (Ysseldyk et al., 2019). Namely, while the data collected included men, 74% were female, 80% of the participants belonged to natural and STEM disciplines, and the survey responses did not include a vast array of nationalities. Nevertheless, as the current literature review concerns female doctoral students in STEM, the limitations of Ysseldyk et al.'s research worked as an advantage. Altogether, the study's conclusions were essential to this literature review as they demonstrated the importance of a SoB in sustaining group memberships. Indeed, based on the notion that people strive to replicate positive rewards (Skinner, 1963), they are more likely to sustain their group memberships in postdoctoral studies if their high SoB or identification results in elevated psychological well-being. In short, I have demonstrated that a SoB is an important factor when considering group memberships and specifically retention within memberships (Maitland et al., 2021; Sønderlund et al., 2017; Wakefield et al., 2017; Ysseldyk et al., 2019). The crucial function SoB plays in this review is explained by the idea of maintaining group memberships, such as maintaining one's membership as a woman within the group of PhD researchers in STEM.

Sense of Belonging and Academic Retention

In higher tertiary education, SoB has long been highlighted as a critical factor for predicting student retention and attrition (e.g., through drop-out intention and second-year registrations; Davis et al., 2019; Edwards et al., 2022; Fink et al., 2020; Hausmann et al., 2009; Hoffman et al., 2002; O'Meara et al., 2017; Pedler et al., 2022; Salusky et al., 2022; Shah & Cheng, 2019; Soria et al., 2019; Stachl & Baranger, 2020; Suhlmann et al., 2018). For example, Pedler et al. (2022) conducted a mixed methods study to investigate the SoB of 578 university students, the factors that affect their SoB, and the association of a SoB with study satisfaction and motivation. The results indicated that students who had thought of leaving the university without completing their degree had a considerably lower SoB compared to those who never considered leaving the university or considered leaving only once. Pedler et al. also found significant positive correlations between a SoB, study satisfaction, and motivation. These additional findings indicated that students with a higher SoB had increased study satisfaction and motivation compared to students who reported a low SoB (Pedler et al., 2022).

Other studies also promoted the importance of SoB related to academic performance and retention. Namely, Edwards et al. (2022) found that students' SoB in a chemistry course was significantly tied to their academic performance, which inadvertently affected their attrition rates. A high SoB was associated with better academic performance and lower attrition rates. In another study, investigators examined the benefits of a new and extended student welcome orientation for first-year university students (Soria et al., 2019). The purpose of the new student orientation was to help promote a university identity and help first-year students develop a stronger SoB. Consequently, results demonstrated that participation in an extended student welcome orientation positively influenced the students' SoB, academic performance, and retention for the second year of their studies. In another recent study, investigators focused on first-year university students’ belonging to create a retention prediction model (Davis et al., 2019). The results suggested that the level of belonging was a strong predictor of academic persistence and attrition (Davis et al., 2019). Interestingly, Ahn and Davis (2020) conducted a quantitative study to examine the fundamental features of a SoB, social and academic engagement, and withdrawal thoughts and included demographic characteristics. The data from 380 university student participants revealed that retention and SoB were significantly correlated ($r = -0.365$, $p > 0.01$). More importantly, they were independently and significantly influenced by social and academic engagement (i.e., relationships and interactions with academic, administrative, and support staff and fellow students; Ahn & Davis, 2020). These results were important to the current study as academic/faculty interactions were one of the variables (PFILQ) examined and considered a critical factor influencing a SoB.

Sense of Belonging and Underrepresented Student Populations

The literature on students' SoB in higher education revealed that it played a critical role in academic retention (Davis et al., 2019; Edwards et al., 2022; Hoffman et al., 2002; Pedler et al., 2022; Salusky et al., 2022; Shah & Cheng, 2019; Soria et al., 2019; Stachl & Baranger, 2020; Suhlmann et al., 2018). Additionally, studies showed that a high SoB in higher education has many significant and positive effects on student's academic progress and well-being (Ahn & Davis, 2020; Freeman et al., 2007; Hoffman et al., 2002; Kahu et al., 2020; Korpershoek et al., 2020; Strayhorn, 2020; Suhlmann et al., 2018; Ul Hasan, 2021; van Rooij et al., 2021). Conversely, several studies demonstrated the adverse effects of a low SoB in university students and that low levels of a SoB were more prominent amongst underrepresented student populations (e.g., ethnic minorities; Fan et al., 2020; Gopalan & Brady, 2020; Gopalan et al., 2022; Johnson et al., 2007).

More explicitly, Gopalan and Brady (2020) used national data to investigate the SoB levels of first-year college students based on first-generation, underrepresented minority, and sex status. The data was taken from a longitudinal study (Beginning Postsecondary Students) with a two-year follow-up. The results indicated that, on average, students "somewhat agreed" to having a SoB to their college; however, the levels significantly differed across student statuses. For example, underrepresented students reported a lower SoB than other students. Their results were similar to a more recent study concerning college students' SoB and mental health during the COVID-19 pandemic (Gopalan et al., 2022). That is, underrepresented students' SoB was exponentially lower than their peers. Fan et al. (2020) used a quantitative survey to measure the satisfaction and SoB of 2,791 university students. Their results similarly revealed low levels of SoB in underrepresented student groups (e.g., ethnic minorities, LGBTQIA++) compared to their peers who did not identify as a minority or felt underrepresented (Fan et al., 2020).

The literature on students' SoB in higher education highlighted its critical impact on academic retention and overall well-being (Fan et al., 2020; Gopalan & Brady, 2020;

Gopalan et al., 2022; Johnson et al., 2007). Additionally, the literature demonstrated that students with a high SoB experience positive outcomes in terms of academic progress and well-being, while those with low levels of belonging face adverse effects, particularly among underrepresented student populations like ethnic minorities (Fan et al., 2020; Gopalan & Brady, 2020; Gopalan et al., 2022; Johnson et al., 2007). Despite the significance of a SoB, the literature remains limited in its exploration of female doctoral students in the STEM population and their relationship to factors such as SoB, university setting (campus and online), and PFILQ (i.e., the students' perceived inclusive leadership qualities of their primary supervisors). The existing research seeks to address this literature gap.

Sense of Belonging and Undergraduate Women in Science, Technology, Engineering, and Mathematics

A plethora of research has demonstrated that underrepresented female university students in STEM had a significantly lower SoB compared to male students and other minority student groups (e.g., ethnic, religious minorities, etc.; Blaney & Stout, 2017; Cheryan et al., 2017; Holanda et al., 2021; Lewis et al., 2016, 2017; Maries et al., 2022; McPherson et al., 2018; Moudgalya et al., 2021; Pietri et al., 2019; Rainey et al., 2018; Sax et al., 2018; Stout & Blaney, 2017; Veldman et al., 2021; Wilkins-Yel et al., 2022; Wilson & VanAntwerp, 2021; Xu & Lastrapes, 2021). Furthermore, the literature suggested that women, from a young age, enter STEM fields with a decreased SoB (Master et al., 2016). Unsurprisingly, a SoB for women in STEM remains a constant challenge during their studies. For example, Blaney and Barrett (2021) conducted a quantitative study to examine predictors of a SoB in computing students, focusing on unique predictors for upward transfers in STEM and, more specifically, in computing for women. Their results revealed that peer support was a strong predictor of belonging for all students. More importantly, they found that while for men, their SoB increased over time, for women, it decreased (Blaney & Barrett, 2021).

Maries et al. (2022) investigated the academic retention disparity between 18,319 women and men pursuing STEM degrees in a quantitative study. In detail, the authors measured the differences in switching out of a STEM major and academic persistence between binary genders (men and women). Additionally, the authors measured the student's grade point averages of those who persisted and switched their majors. Students who dropped from their majors generally had lower grade point averages than those who did not. Remarkably, women who dropped out of their majors had a higher-grade point average than men who persisted. Consequently, in their review, Maries et al. surmised that the results could be due to the disparities within the learning environment, particularly a deficiency in women's self-efficacy and SoB. In another qualitative study, Rainey et al. (2018) interviewed 201 ethnic minority senior university students. The students had either dropped out of their STEM program or were studying at the moment of the interview. In addition, the focus of the study was to explore the students' SoB in relation to their race and gender. Accordingly, the results demonstrated a lower SoB in women of color as compared to men who were not part of a minority group (Rainey et al., 2018). Moreover, it was found that students who persisted in their degrees had a higher SoB compared to those who did not persist. Consequently, this further supported the notion that a SoB played a critical role in student retention and that gendered minorities might suffer more from a lower SoB than nongendered minorities (Rainey et al., 2018).

Women's underrepresentation in STEM is a phenomenon that invades their psychological and academic well-being (EC&DGRI, 2021; NSF, 2021). Moreover, the adverse effects of their underrepresentation in STEM, such as a low SoB, can be seen in Sax et al. (2018). More explicitly, Sax et al.'s study was focused on examining the SoB of undergraduate female and racial/ethnic underrepresented minority students in an introductory computing class. Their findings suggested significant differences in the SoB between women, racial/ethnic underrepresented minority, and majority students. Interestingly, the levels of women's SoB starting the introductory computing course were significantly lower compared to men. Additionally, women who identified as part of an ethnic or racial minority had a significantly lower SoB compared to their male counterparts. Notably, in general, the SoB of all students seemed to have decreased towards the end of the computing course, and while gender differences in the SoB were prominent, women's SoB significantly declined over time compared to men (Sax et al., 2018). The findings were important as they demonstrated that women's SoB in STEM started low and decreased overtime. Overall, the literature review indicated the need to understand the factors influencing the SoB in STEM for women, as well as for women who identified as racial/ethnic underrepresented minorities, in order to find ways to mitigate their effects.

In another study, Wilson and VanAntwerp (2021) completed a review of 36 articles on the SoB of women in engineering. Their goals were to understand the SoB in education and the workplace for women as compared to men. The authors found that in most studies, underrepresented ethnic minority students had a significantly lower SoB than their peers. Interestingly, the results were unclear among female graduate and postdoctoral scholars. This ambiguity was significant because most literature on university students' SoB focused on undergraduate and master's students. On the contrary, the SoB in graduate populations in STEM is significantly low (Stachl & Baranger, 2020). Consequently, this supports the research problem of this study, which is to further understand the SoB of UFDS in STEM and other external factors affecting it (e.g., university setting, faculty support/interactions as primary research supervisors).

Sense of Belonging and Graduate Women in Science, Technology, Engineering, and Mathematics

Female graduate students in STEM have proven their capabilities in their subjects from their previous educational attainments (e.g., Bachelor's and Master's). Therefore, their capabilities have already been established to compete for admission within a doctoral STEM program (Cabay et al., 2018). In addition, they are dedicated individuals with an understanding of the financially, emotionally, and academically difficult path they have chosen to follow. However, despite their dedication, understanding, and capabilities, significant gender gaps exist in attaining doctoral degrees in STEM, with women attaining significantly fewer doctoral degrees than men (EC&DGRI, 2021; NSF, 2021; OECD, 2021a). Moreover, studies showed that female students and underrepresented students pursuing doctoral degrees in STEM were subject to more emotional, psychological, and academic distress compared to male students who do not identify as underrepresented (Fisher et al., 2019; Ross et al., 2022; Stockard et al., 2021). More importantly, studies have demonstrated that a SoB was critical for the well-being, academic persistence, and degree attainment of graduate and postdoctoral students in STEM (Howe et al., 2022; Pascale, 2018; Ross et al., 2022; Ysseldyk et al., 2019). All in all, the literature revealed that graduate women in STEM faced exponentially complex barriers such as stereotype threat, gender bias, and academic demotivation during their studies. However, a low SoB was a recurring theme in the literature on factors affecting graduate students' well-being and academic success. More alarmingly, graduate female students in STEM tended to fall out of the norm with a significantly lower SoB compared to their counterparts (Blackburn, 2017; Charlesworth & Banaji, 2019; Fassiotto et al., 2016; Hill et al., 2010; O'Connell & McKinnon, 2021; Okahana et al., 2018; O'Meara et al., 2017).

Accordingly, Wilkins-Yel et al. (2022) conducted 12 interviews with graduate women in STEM (including ethnic and racial minorities) who dropped out of their studies or persisted in their degrees. They found that a recurring theme for the doctoral STEM degree was a highly stressful experience for most women. Additionally, most women reported experiences and feelings of self-isolation, burnout, a significantly low SoB, and, in some instances, a complete lack of belonging, which negatively impacted their well-being and academic persistence (Wilkins-Yel et al., 2022). These results were consistent with another study in which the investigators found that female graduates following the faculty path in chemistry had a substantially low SoB and extreme feelings of depression, which is relevant to the current research topic, as the focus is on all female graduate students not only those pursuing the faculty path (Howe et al., 2022). Furthermore, Stachl and Baranger (2020) conducted a quantitative visual narrative survey to measure the SoB in graduates, postdoctoral students, and faculty in STEM. The researchers identified aspects of the culture in academia that affected the graduates' SoB and examined the most noticeable factors influencing the SoB of graduate students, postdoctoral researchers, and faculty. The results showed that one noticeable aspect of a SoB in graduate students and postdoctoral researchers was feeling like an imposter in the field (e.g., the impostor phenomenon; Stachl & Baranger, 2020).

Additionally, it was revealed that graduate students and postdoctoral researchers were least likely to feel that they belonged, whereas faculty had the highest SoB. More importantly, they found that the participants who identified as underrepresented had the lowest SoB compared to their peers (Stachl & Baranger, 2020). It is important to note that the study did not focus solely on examining and comparing the SoB of graduate students, postdoctoral researchers, and faculty based on gender. Instead, the factor of gender was incorporated within the participants who identified as underrepresented, and this is why the current research topic is important because it fills the gap of focusing on the examination of female underrepresented graduate students. Nevertheless, this study was one of the few that developed a nuanced quantitative understanding of the SoB within the graduate community (Stachl & Baranger, 2020). Consequently, the literature points to the notion that there is a need to develop our understanding of the nuanced aspects of a SoB in women in the graduate community in STEM further.

Further on, Casad et al. (2021) investigated graduate female underrepresentation in STEM. They found that in STEM environments, gender bias was prominent. Additionally, it was revealed that there was a conspicuous association between female underrepresentation in STEM academic environments and low to no SoB. More alarmingly, in a qualitative study, Cabay et al. (2018) discovered that women dropped from their doctoral studies more often than men in STEM, even though a considerable number still earned higher grades than male students who did not drop their studies. Additionally, several women reported having a very low SoB due to collegial microaggression and exclusion. For example, one female graduate student reported that her colleagues often switched to speaking their home language, which she could not understand whenever their supervisor was absent. Another example was when some women would win specific competitive scholarships, and their success would be attributed to the quota that needed to be filled for minorities in STEM. All these experiences contributed to their high attrition due to their significantly decreased SoB (Cabay et al., 2018). In summary, the discernible role of a SoB emerged as crucial in fostering the retention of students overall and, notably, for women pursuing graduate studies in STEM disciplines. However, notwithstanding their prior academic achievements, women encountered persistent extraneous challenges that frequently impeded the pursuit of their educational objectives and professional trajectories (Cabay et al., 2018; Casad et al., 2021).

All in all, the literature demonstrated that female graduate students in STEM have low to no SoB. Additionally, their drop-out rates are higher than males in the same field but more alarmingly for females who have higher grades than men**.** It is important to note that within these studies, the female graduate students in STEM and their SoB were examined only in a campus setting. The researchers did not compare the populations' SoB between a campus and an online university setting. Also, researchers did not consider the role of the supervisor even though some participants mentioned how the education environment became unwelcoming the moment the supervisor was not present (e.g., Cabay et al., 2018). Consequently, the current research assessed the impact of the university setting and the role of the supervisor as an inclusive leader on the SoB among female graduate students, as elaborated in subsequent chapters.

Campus and Online University Setting in Relation to Sense of Belonging and Underrepresented Female Doctoral Students in Science, Technology, Engineering, and Mathematics

Researchers have explored the factors affecting the SoB of students who study online throughout the years (e.g., Peacock & Cowan, 2019; Pedler et al., 2022; Shah & Cheng, 2019; Stephens & Morse, 2022; Thomas et al., 2014). This is because several studies revealed that social interaction was a crucial factor affecting the strength of a student's SoB to their degree (Freeman et al., 2007; Hoffman et al., 2002; Johnson et al., 2007; Kirby & Thomas, 2021; Patterson et al., 2012). In particular, some studies suggested that due to the lack of a physical presence and a preconception that online higher education lacked social interaction, students' SOB was exceedingly low online

(Besser et al., 2020; Gedera et al., 2015). More importantly, there were studies separately measuring the effects of online, hybrid, or campus higher education on underrepresented students' SoB (Besser et al., 2020; Farrell & Brunton, 2020; Jackson, 2016; Martin et al., 2020; Pedler et al., 2022; Thomas et al., 2014), however, there were no studies directly comparing the effects the university setting might have on underrepresented students' SoB. Hence, there is a research gap in understanding the SoB of UFDS in STEM or other programs across various university settings. Consequently, this reflects the gap in the literature that supports the importance of the current topic, which is examining the effects of the university setting on the SoB of UFDS in STEM and the role of PFILQ.

Faculty Interaction, Sense of Belonging, and the Role of Inclusive Leadership

The majority of recent literature demonstrated that SoB plays a pivotal role in maintaining group memberships (Fiske, 2018; Hoffman et al., 2002; Suhlmann et al., 2018; van Rooij et al., 2021). Additionally, research indicated significantly low SoB (Fassiotto et al., 2016; Fisher et al., 2019; Howe et al., 2022; McGee et al., 2022; O'Meara et al., 2017; Pascale, 2018; Stachl & Baranger, 2020) and significantly low academic retention for female doctoral students in STEM who were underrepresented (Blackburn, 2017; Cabay et al., 2018; Corbett, 2015; Hill et al., 2010; Hughes et al., 2017; Okahana et al., 2018). For this reason, investigating factors affecting the SoB of UFDS in STEM is important. For example, one important factor that has been repeatedly investigated is the role the interaction between the members of a group (e.g., a Ph.D. group or a group from a mathematics department) plays on their SoB. Verily, a number of studies demonstrated that adequate and positive interactions with faculty (i.e., PhD researchers' interactions with their primary research supervisor) had a significantly positive effect on students' SoB (e.g., Barreto & Hogg, 2017; Cole et al. 2020; Cortina et al., 2017; Izumi et al., 2015; Kirby & Thomas, 2021; Muenks et al., 2020; O'Meara et al., 2017; Pascale, 2018; Pyhältö et al., 2015; Rattan et al., 2018; Strayhorn, 2020; van Rooij et al., 2021; Widdicks et al., 2021) and that faculty interaction was a strong predictor of students' SoB (Cortina et al., 2017; Singh, 2018)

For example, van Rooij et al. (2021) conducted a study with 839 PhD candidates at a Dutch university. The results showed that important factors raising Ph.D. completion rates and satisfaction were the nature of the supervisor-PhD candidate relationship, SoB, degree of project freedom, and alignment of the project with the supervisor's research. These factors were all positively related to satisfaction and negatively related to intentions of quitting (van Rooij et al., 2021). In another study, Kirby and Thomas (2021) investigated the association between teacher relationships and undergraduate students' SoB. The results demonstrated that positive experiences with faculty (i.e., manifested through positive, caring, and supportive behaviors of faculty towards students) predicted high SoB in students (Kirby & Thomas, 2021). Despite the indication that faculty interaction is a critical factor in determining a student's SoB, the existing literature has not extensively explored the immediate correlation between faculty and PhD candidates' interaction and SoB. The current study is important as it aims to address the lack of research directly linking the faculty relationship to the SoB of PhD candidates. The SoB has been recognized as a critical factor in determining the satisfaction and completion rates of students. Despite several studies that have explored the SoB and its influencing factors, including faculty interaction, the majority of these studies have been limited to the undergraduate student population and have not specifically focused on the direct relationship between the SoB and faculty interaction among female doctoral candidates in STEM fields. The present study endeavors to fill this gap in the literature.

The Role of Inclusive Leadership in Sense of Belonging

The literature on intragroup relations points out the importance of the interaction of members within a group on their SoB (e.g., SoB of university students and the role of faculty interaction; Barreto & Hogg, 2017; Chiu et al., 2016; Fiske, 2018; Sax et al., 2018; Stachl & Baranger, 2020). Moreover, the role of the leader on the SoB of group members has been regularly highlighted in research as an influential factor (e.g., Aboramadan et al., 2021; Pressentin & Harris, 2022; Rosado & Toya, 2015). For example, research has explored the indirect influence of affective commitment (Briggs et al., 2022), organizational learning (Aboramadan et al., 2021), collective voice behavior of employees (Chen et al., 2023), and psychological safety (Carmeli et al., 2010) on the SoB of group members. Additionally, an indirect influence on group members' SoB was implied through the combination of implementing servant and inclusive leadership styles on group members (Pressentin & Harris, 2022). Nevertheless, the literature was not focused on the inclusive leadership style based on the concepts of Relational Leadership (Carmeli et al., 2010; Komives et al., 2015; Nembhard & Edmondson, 2006) on which the current thesis is based, and this is an important gap to fill. Moreover, the literature was focused on the general inclusiveness and diversity leadership style (e.g., Jian, 2022) that was based on conceptual frameworks that partially incorporated parts of the foundational arches of the inclusive leadership qualities within the Relational Leadership Model (Aboramadan et al., 2021; Ashikali et al., 2021; Canlas & Williams, 2022; Carmeli et al., 2010; Javed et al., 2019; Pressentin & Harris, 2022; Ramamoorthi et al., 2021). More importantly, there is scarce recent research on the effects of inclusive leadership on the SoB in education and even more so in doctoral studies of women in STEM.

In this research, I assume that inclusive leadership plays a significant role in the SoB of doctoral women in STEM. This is supported through research connecting faculty interaction with inclusive leadership and inclusive leadership (role of the primary research supervisor) with the SoB of underrepresented doctoral women in STEM. The faculty (e. g., primary research supervisor) in the context of a group of Ph.D. researchers in STEM is considered the leader of the group. Despite the importance of the role of the faculty as a leader in shaping the SoB of group members, there is a lack of research exploring the impact of inclusive leadership qualities from faculty on the SoB of UFDS in STEM. Moreover, the systematic review by Martin et al. (2020) found that the instructor role was the least researched subject in the field of teaching and learning between 2009 and 2018. Consequently, this gap signifies the importance of investigating the role of the faculty (leader of the group) in influencing the SoB of UFDS in STEM.

Overall, the relationship between intragroup relations and SoB has been widely explored in literature. Studies have established that the leader's behavior significantly affects the SoB of group members, with research investigating the indirect influence of leadership on various factors such as affective commitment, organizational learning, and psychological safety. However, there is a lack of research specifically focused on the impact of inclusive leadership style on the SoB of group members. The impact of inclusive leadership on the SoB in education, particularly among female doctoral students in STEM, is an understudied area. This research assumes the importance of inclusive leadership in shaping the SoB of female doctoral students in STEM, with the faculty (e.g., primary research supervisor) being considered the leader of the group and having a crucial role in influencing the SoB of group members. Consequently, the significance of addressing this deficiency is highlighted by the current study, which aimed to examine the influence of the university environment on the SoB of UFDS in STEM and the contribution of PFILQ.

Summary and Conclusions

Belonging in higher education has been found to significantly impact student retention and academic performance in previous literature (Ahn & Davis, 2020; Hoffman et al., 2002; Suhlmann et al., 2018; van Rooij et al., 2021, etc.). However, underrepresented groups like ethnic minorities and female undergraduate, graduate, and doctoral students in STEM fields have been shown to have a lower SoB compared to their peers (Blaney & Stout, 2017; Gopalan & Brady, 2020; Gopalan et al., 2022; O'Meara et al., 2017; Stachl & Baranger, 2020, etc.). Despite this, the literature has limited exploration of the SoB among female doctoral students in STEM in relation to the influence of the university setting (campus or online) and PFILQ on their SoB.

The aim of the current study was to address this gap in the literature and examine the influence of inclusive leadership on the SoB of UFDS in STEM fields. In particular, the aim was to investigate the impact of inclusive leadership style on the SoB of group members, which has been an understudied area. Additionally, the effect of the university setting and PFILQ on the SoB of these students was investigated, filling the gap in the literature that focused on this relationship. Finally, the study assumed the importance of the university setting and inclusive leadership, particularly in the context of the primary research supervisor as the leader of the group, in shaping the SoB of female doctoral students in STEM (Gopalan & Brady, 2020; Gopalan et al., 2022; O'Meara et al., 2017).

The purpose of this study was to examine the influence of inclusive leadership on the SoB of UFDS in STEM fields. Additionally, the study aimed to explore the effect of the university setting and PFILQ on their SoB. In order to achieve this, a suitable quantitative nonexperimental method was used, with a survey design as the data collection method. Finally, details about the nature of the study, methodology, and measures are discussed in the next chapter.

Chapter 3: Research Method

Introduction

The purpose of this quantitative nonexperimental comparative study was to compare the SoB of UFDS in STEM between online and campus university settings and to examine the relationship between the UFDS's PFILQ and SoB. The upcoming chapter provides a detailed account of the current study's research design and methodology. The first section outlines the study's variables, research design, target population, sampling, and data collection procedures. Then, in the remaining sections, the data analysis plan, threats to validity, and ethical considerations are explained. Finally, the chapter ends with a summary section providing an overview of the design and methodology of the study.

Research Design and Rationale

In order to address the research questions in this quantitative study, the research design included a survey design, specifically a nonexperimental comparative and predictive design (Frankfort-Nachmias & Guerrero, 2018; Warner, 2013). A qualitative design was not appropriate because researchers in qualitative studies explore and describe phenomena, which was not the intention of this design. Therefore, a quantitative research design was found to be most appropriate for the current study as it aligned with the way the variables from the research questions would be examined. The first research question (RQ1) was used to investigate whether there are differences in the SoB of UFDS in STEM as a function of the university setting (online vs. campus), which involved conducting an independent samples *t* test. The second research question (RQ2) was used to determine whether PFILQ and/or university setting (campus/online) were predictors of the SoB of UFDS in STEM, which involved conducting a multiple linear regression analysis.

Moreover, the independent variable for the first research question was the university setting (online vs. campus), while the dependent variable was the SoB of UFDS in STEM. For the second research question, the independent variables were PFILQ and university setting (online vs. campus), and the dependent variable was the UFDS's SoB in STEM. To conclude, the selected research design was most appropriate for this study because quantitative research designs offer objective and exact ways of measuring the relationships between variables, testing hypotheses, and deepening knowledge concerning the variables examined (Frankfort-Nachmias & Guerrero, 2018; Warner, 2013). Additionally, the design allowed for the collection of numerical data, which was suitable for statistical analyses to draw conclusions about variables. Moreover, a nonexperimental design meant that the participants were not influenced by the research process because no variable was manipulated. Finally, comparative and predictive analyses using a survey design allowed for the hypotheses to be tested in order to arrive at a conclusion regarding the relationships among the variables (Frankfort-Nachmias & Guerrero, 2018; Warner, 2013).

Furthermore, there were certain time and resource constraints relating to a nonexperimental comparative and predictive survey design that were taken into consideration, as they might have constricted the feasibility and scope of the current study. These time and resource constraints included data collection for UFDS in STEM (sampling, recruiting, administrating, collecting, and cleaning data) and access to participants (e.g., securing an adequate response rate and finding sufficient participants who met specific criteria such as those who had failed, had graduated, or were currently working on their PhD; Jones et al., 2013; Maymone et al., 2018; Misro et al., 2014). Regardless of the time and resource constraints relating to the specific research design, it remained the best choice of design that could advance knowledge in the discipline of social psychology, education, and leadership. The reason for this was that it permitted the collection and analysis of numerical data that were utilized for the assessment of hypotheses, predictions, descriptions of data, and understanding of the phenomena investigated in a precise way. Moreover, the design was consistent with research design to advance knowledge as it was used to investigate in a natural way the relationships between variables (e.g., the relationship between UFDS SoB and university setting and/or perceived faculty inclusiveness; Frankfort-Nachmias & Guerrero, 2018; Jones et al., 2013; Maymone et al., 2018; Misro et al., 2014; Warner, 2013).

Methodology

Population

The target population for this study was UFDS in STEM, with a specific focus on women who had pursued but failed/were currently pursuing or attaining a doctoral degree in STEM. UFDS are individuals who face significant barriers to entering and thriving in STEM fields due to systemic inequities related to their gender, race, ethnicity, socioeconomic status, or other marginalized identities (EC&DGRI, 2021; Miller & Wai, 2015; NSF, 2021; OECD, 2021a, 2021b). This group has been historically underrepresented in STEM fields, and I aspired in this study to shed light on their experiences and perspectives to inform interventions that promote equity, diversity, and inclusion in STEM. The general estimation for the sample size was 230 in order to assume generalizability.

Sampling and Sampling Procedures

The type of sampling in the study was probability sampling, as research suggested that it was the most suitable type of sampling that enhances representativeness (Andrade, 2021). Moreover, to reach UFDS in STEM, samples were gathered through the administration of online surveys via social media platforms such as Instagram, Facebook, Twitter, and TikTok, as well as professional networks such as LinkedIn and organizations that support women in STEM, such as Finding Ada, The White House Office of Science and Technology Policy/White House Council on Women and Girls, Association for Women in Science, Girls Who Code, Society of Women Engineers, Latinas in STEM, National Girls Collaborative Project, Women in Shipping (WiSh), and so forth. The aforementioned organizations promote gender diversity and equality in STEM. Some offer educational mentorships and networking opportunities and promote policies for supporting women in STEM. By utilizing diverse channels, I sought to access a broad and representative sample of UFDS in STEM, enabling the collection of comprehensive data to inform the research. Finally, the inclusion criteria involved female doctoral students in STEM fields who were active students, were enrolled in the past but did not attain their degree, enrolled in the past and attained their degree, self-identified as a woman, and were available to participate in the study during the data collection period. The study included both online and campus students. The exclusion criteria applied to male doctoral students in STEM fields, non-STEM-field doctoral students, those who did not self-identify as women, and those who could not participate or were not willing to provide informed consent.

Sample Size Calculation

To calculate the sample size for the *t* test for RQ1, G*Power software was used (Faul et al., 2009). The inputs for the calculation were a conservative Cohen's *d* effect size of .30 and power of .80 (a = .05). The sample size calculation method used was "a priori: Compute required sample size—two groups (two tails)." Based on these inputs, the recommended sample size was 138 participants (69 per group). In order to calculate the recommended sample size for the multiple regression for RQ2, G*Power software was used. The inputs for the calculation were a power of .80 and with a medium effect size of f^2 = .15, a = .05. The sample size calculation method used was "a priori: Compute required sample size—multiple regression." Based on these inputs, the recommended sample size was 171 participants (Faul et al., 2009). All in all, the total number of required participants was 230, which was approximately 30% more than the minimum number of participants calculated through G*Power to account for incomplete responses. Finally, Cohen's *d* effect size of .30 was considered most appropriate as it was considered to be a small to medium effect size (Cohen, 1994). A conservative effect size of .30 was suitable as there was limited research on the relationship between UFDS’s SoB and university setting and/or PFILQ. Additionally, the conservative effect size could empower the detection of any effect that may have existed in the study, improve reliability, and reduce the risk of a type II error (Brydges, 2019; Cohen, 1994; Maher et al., 2013).

Procedures for Recruitment, Participation, and Data Collection

The recruitment process was conducted via email, social media platforms, and educational and professional networks using an online survey tool (see Appendix A for the study invitation). The demographic information and presurvey questions included age, race/ethnicity, gender identity, university setting (campus, hybrid, and online), geographic location of the university, STEM specialization, education status (currently enrolled, failed or stopped, and attained degree) and percentage of online involvement (POI) (see Appendix B). The online survey included an informed consent section before the start of the survey. The informed consent included an explanation of the purpose, procedure, risks, and benefits of the study, in addition to information about the participants' rights. Once consent was given, participants were thanked and directed to start the survey. When consent was not given, participants were thanked, and the survey ended. Finally, the survey included my contact information; participants could reach out to me if they had any questions or concerns regarding the study.

Instrumentation and Operationalization of Constructs

Perceived Faculty Inclusive Leadership Qualities (PFILQ) Scale

In order to measure PFILQ, a nine-item scale, Inclusive Leadership from Carmeli et al. (2010) was used. This was an appropriate scale because it was originally used to assess the inclusive leadership of the deans who supervise academic staff, which closely related to the relationship between a Ph.D. candidate and the supervisor. An example of an item in the scale is “The manager is available for consultation on problems,” the adapted version of which would be “The supervisor is available for consultation on problems.” The aim of the scale was to assess openness, availability, and accessibility, which encompass the three dimensions of inclusive leaders (Carmeli et al., 2010). The scale was rated on a 5-point Likert scale with the following range of scores: 1 = *not at all*, 2 = *to a small extent*, 3 = *to some extent*, 4 = *to a moderate extent*, and 5 = *to a large extent*. On the scale, the participants were asked to score the extent to which they felt that their supervisors were open, available, and accessible during the course of their PhD studies. Moreover, to calculate the final score for each participant, the average rating of the items was taken. This was done by adding the participants’ answers to each item and dividing this sum by the total number of items (nine; [(Number of total scale points) ÷(Respondent’s answer)]). The factor analyses generated a one-factor solution with an eigenvalue of 6.18, which accounted for 68.74% of the variance. The scale's factor loadings ranged from .51 to .82, and Cronbach’s alpha was .94 (Carmeli et al., 2010).

Other studies have also utilized the Inclusive Leadership (IL) scale developed by Carmeli et al. (2010). For example, Fang et al. (2019) conducted a study to examine the effects of inclusive leadership styles on innovative employee behaviors. Confirmatory factor analysis and reliability tests were performed on Carmeli et al.’s IL scale, and Fang et al. confirmed that the scales had a good level of reliability with a Cronbach's alpha coefficient of 0.93 and that the confirmatory factor analysis demonstrated that the IL scale was a good fit for the data. Another example can be found in Marri et al.'s (2021) study on the role of inclusive leadership in project success. The authors confirmed the scale's Cronbach alpha was .94 and utilized the scale for 302 construction workers. The researchers assessed the validity and reliability of the IL scale and found that the estimates of the composite reliability (CR) were greater than 0.9, which demonstrated outstanding internal consistency. Finally, there was no evidence of convergent validity issues; therefore, discriminant validity was established (Marri et al., 2021).

Sense of Belonging Scale

To measure SoB, the Sense of Social Fit Scale was used. This is a 17-item scale that measures how much university students feel they belong in their academic department (Walton & Cohen, 2007; Walton et al., 2012). A few example questions are as follows: "People at my department accept me," "People at my department are a lot like me," and "I do not know what I would need to do to make my department's professors like me." This measure is rated on a 5-point Likert scale with the following range of scores: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, and 5 = *strongly agree*. Moreover, to calculate the final score for each participant, the average rating of the items was taken. This was done by adding the participants' answers to each item and dividing this sum by the total number of items (17), taking into consideration the calculation of reversed items within the scale (Q2, Q3, Q5, Q6, and Q13 with this formula: [((Number of scale points) + 1) - (Respondent's answer)]). Cronbach's alpha for the 17-item inventory assessing participants' sense of social fit was 0.89. Finally, other studies have also utilized the Sense of Social Fit Scale developed by Walton and Cohen (2007). For example, Fassiotto et al. (2016) conducted a study on gender stereotypes for women in medicine. Namely, the researchers incorporated the Sense of Social Fit Scale within their measures of stereotype threat and conducted a principles component analysis to assess whether the survey items were correlated to fundamental factors seen in past research. The scale demonstrated good internal consistency, with Cronbach's alpha of 0.82. The statistical software Stata 13 was used to perform the analyses. In another study by Cook et al. (2012), the researchers used an adapted version of the Sense of Social Fit Scale developed by Walton and Cohen (2007) to measure the SoB of students. The researchers also undertook a principal component analysis of the Sense of Social Fit Scale and found that the questionnaire items were significantly associated with essential factors previously identified in past research (Cook et al., 2012). More importantly, the Sense of Social Fit (SSF) Scale, as validated by Maghsoodi et al. (2023), stood out for its high reliability and superior fit. The psychometric study conducted by Maghsoodi et al. delved into the intricacies of this scale, specifically measuring the SoB to one's academic department based on four crucial factors: identification with the university, social match, social acceptance, and cultural capital. According to Maghsoodi et al., most studies utilizing the SSF Scale employed a one-factor model focusing on partial sections of the scale (e.g., measuring only social acceptance or social match). Maghsoodi et al. rigorously explored and validated the SSF's factor structure and other psychometric properties. They found that a one-factor model was inadequate for measuring SoB. This led them to explore the four-factor model (i.e., identification with the university, social match, social acceptance, and cultural capital) through exploratory factor analyses. Subsequent findings confirmed the superiority of a bifactor model, which incorporated the four specific factors. This in-depth understanding of the SSF's multidimensional nature facilitated a nuanced measurement approach, effectively capturing the general college belonging and specific factors, such as identification with the university, social match, social acceptance, and cultural capital, among diverse university students. The validation of this model spans across various demographic groups and aligns cohesively with established measures of belonging and related constructs (Maghsoodi et al., 2023).

Data Analysis Plan

The software that I used for analyzing the data was IBM SPSS Statistics (Version 28.0; IBM Corp., 2021). Before conducting the analyses of the data and to ensure reliability and validity, I performed data cleaning and screening procedures. For example, missing data from the survey responses were identified and addressed through methods such as deletion or imputation. Outliers were examined using boxplots to identify extreme values and data entry errors were checked. The data distribution for normality was assessed, and the assumptions of each statistical analysis were examined. The following section presents the research questions and hypotheses.:

RQ1: Are there differences in the SoB as measured by the Social Fit Scale of UFDS in STEM as a function of their university setting (online vs. campus)?

H_0: There are no statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

H_a: There are statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

RQ2: Are PFILQ as measured by the Inclusive Leadership scale and/or university setting (campus/online) a predictor for SoB of UFDS in STEM?

H_0: PFILQ and/or university setting are not significant predictors of SoB scores of UFDS in STEM.

H_a: PFILQ and/or university setting are significant predictors of SoB scores of UFDS in STEM.

For RQ1, I performed an independent samples *t* test with subjective scores of UFDS's SoB compared between a campus and an online university setting. The independent variable was the university setting with a categorical level of measurement with two groups (university setting campus and university setting online). The dependent variable was the SoB, with a continuous level of measurement and, a minimum score of 1.0 and a maximum of 5.0. In order to check the assumptions for the independent samples *t* test for RQ1, I assessed the normality of data distribution using the Shapiro-Wilk test and examined histograms of the dependent variable per group. For violations of normality, I employed the Mann-Whitney test. For assessing the assumption of homogeneity of variance, I used Levene's test (Frankfort-Nachmias & Guerrero, 2018; Warner, 2013).

For RQ2, I performed a regression analysis with subjective scores of UFDS's PFILQ and university setting (Campus/Online) as predictors of the UFDS's SoB. The research analysis included Multiple Linear Regression (MLR) with one dependent variable SoB with a continuous level of measurement, one continuous independent variable (PFILQ), and one dichotomous categorical dummy variable (university setting campus and university setting online) to predict the UFDS's SoB. In order to ensure the assumptions for the MLR were met, I checked the independence of error with Durbin-Watson diagnostics (to check the correlation between residuals). Additionally, I checked the multicollinearity assumption (I assessed the Variance Inflation Factor to see if the independent variables have a high correlation with each other) and Cooks for no undue influence. Finally, I diagnosed the normal distribution of errors and heteroscedasticity with the Kolmogorov-Smirnov test depending on the sample size (i.e., if the sample size is fairly large, it could potentially impact the interpretation of the predictive ability of the independent variables). For assumption violations, I considered various options (e.g., transformation of the data for nonnormal distribution not assumed, data modification, nonparametric regression, etc.; Frankfort-Nachmias & Guerrero, 2018; Warner, 2013).

Threats to Validity

One potential threat to external validity was sampling bias, which concerned the specific population this research targeted (DeVellis, 2017). The sample of UFDS in STEM might not have been representative enough to ensure a broad selection of the overall UFDS's in the STEM population. This meant that the results might not have been generalizable to other populations. Consequently, to mitigate this, I used a random sampling method to ensure that participants were selected from a larger pool of UFDS in STEM. Another threat to external validity concerned the constructs of PFILQ and SoB.

Namely, the possibility that these constructs might have been generalizable to other populations and environments needed to be considered. To mitigate this, I conducted an extensive literature review of the constructs, incorporating studies that employed the instruments for measuring PFILQ (Inclusive Leadership; Carmeli et al., 2010) and SoB (Sense of Social Fit Scale; Walton & Cohen, 2007; Walton et al., 2012) and I demonstrated that the scales had high internal consistency. By doing so, I ensured that the measures were reliable and valid and had been utilized for similar populations.

Furthermore, one threat to internal validity was selection bias; thus, I applied random sampling methods to mitigate this threat. Another potential threat was maturation. The target population was women who had pursued a doctoral degree in STEM and attained or did not attain (or quit) their degree and women who were, at the moment of the study, pursuing a doctoral degree in STEM. It is conceivable that women who had previously pursued a doctoral degree in STEM fields might have been influenced by time-related factors, which could have potentially affected their survey responses. One solution would have been to control for time variables in a regression analysis; however, I did not add any time-related questions in the survey; thus, maturation remained a limitation in this study (Creswell & Creswell, 2018). Finally, on the subject of statistical conclusion validity, the sample size might have been considered a threat; however, a power analysis was conducted to determine the appropriate sample size (n = 230, which also accounted for incomplete responses) and an adequate number of participants was ensured to be recruited.

Ethical Procedures

Concerning ethical considerations for the extant research, I achieved IRB approval from Walden University's Ethics Committee (approval number: 07-31-23-0458090), and I followed policies related to international research, education, and human participants. In the first part of the online survey, I included an informed consent form outlining that the study was entirely voluntary, and participants had the right to withdraw at any moment within the survey. I ensured confidentiality and anonymity throughout the study, informing participants of their anonymity both at the beginning and end of the survey. I recruited participants through professional and social communication platforms, and the surveys were completed anonymously. I collected responses using Survey Monkey software and stored them on a password-protected hard drive (with a two-factor authentication method) for a maximum of five years. The password was only known to me, and I planned to erase the hard drive, thus destroying the data after the five-year period.

Summary

In this chapter, I discussed a nonexperimental comparative research design that aimed to examine the differences in university settings and PFILQ on the SoB among UFDS in STEM. I employed two scales: the "Inclusive Leadership" scale from Carmeli et al. (2010) to measure PFILQ and the "Sense of Social Fit Scale" from Walton and Cohen (2007) to measure SoB in university students. Threats and mitigations to validity, including sampling bias, construct validity, selection bias, maturation, and statistical conclusion validity, were considered. The sample size was discussed as a potential threat to validity. Finally, ethical considerations aligned with Walden's social change goals and Institutional Review Board (IRB) processes were addressed. Chapter 4 presents the results of the data analyses.

Chapter 4: Results

Introduction

The purpose of the conducted quantitative nonexperimental comparative study was to explore the SoB among UFDS in STEM, comparing online and campus university settings while also investigating the relationship between UFDS's PFILQ and SoB. RQ1 and RQ2 addressed differences in SoB based on the university setting and the predictability of SoB by PFILQ and/or university setting, respectively. In Chapter 4, I explore detailed data collection methods, deviations from the plan, baseline characteristics, and covariate justifications. The results section includes precise descriptive statistics, evaluations of statistical assumptions, and a systematic presentation of findings linked to research questions and hypotheses. Finally, the concluding summary synthesizes the research question answers, setting the stage for the prescriptive content in Chapter 5.

Data Collection

The data collection process commenced following approval from the Institutional Review Board (IRB) on July 31, 2023, permitting the collection and analysis of data through anonymous surveys via SurveyMonkey. The initial recruitment strategy involved outreach through email, social media platforms, and educational and professional networks, with a focus on women in doctoral STEM programs studying either online or on campus. Challenges encountered included incomplete responses and difficulty in attaining a substantial participant pool. When I sought guidance during the third residency, my professors and chair suggested utilizing either Qualtrics or Amazon MTurk for crowdsourcing participants, resulting in a successful recruitment that initially yielded double the expected number of participants. However, during data screening, violations of the normal distribution assumption for the dependent variable (SoB) surfaced. Further analysis revealed a response bias issue, with a significant number of respondents choosing neutral responses. Following recommendations from Cobanoglu et al. (2021) to enhance data reliability and validity on crowdsourcing platforms, I introduced attention questions to identify and filter out incomplete or insincere responses. Over 50% of the collected survey responses were subsequently excluded based on these attention questions.

Despite encountering outliers, I opted to retain them in light of the substantial dataset, considering them inherent to the survey responses. In total, 638 survey responses were collected, and after excluding 426, from the remaining 212 responses, nine survey responses were excluded (ones that identified hybrid as a university setting due to assumption violations for RQ1). This change was acceptable as it aligned with RQ1, which focused on the difference in SoB between a campus and online university setting and not a hybrid setting. Finally, five semicompleted responses were included, where participants solely completed the Sense of Social Fit Scale (which measured SoB). Although the targeted participant count was set at 230, reflecting a 30% increase from the G*Power-calculated minimum to account for potential incomplete responses, the actual obtained sample size of 191 surpassed the initial requirement of 171 and was considered satisfactory for the analysis.

Demographic Characteristics

In total, 638 survey responses were collected, with 191 responses meeting the criteria for subsequent analysis. Markedly, eight semicompleted responses were included, where participants solely completed the Sense of Social Fit scale. Table 5 demonstrates the race/ethnic profile of UFDS in STEM and highlights predominantly women identifying as having a White ethnic background, constituting 80.1% of the participants. Black or African American participants made up 3.1%, while Asian, Native American, or American Indian participants comprised 3.7%. Furthermore, the majority of participants' university geographic location was the United States (68.6%), followed by diverse global locations such as Armenia, India, Australia, and the United Kingdom, as seen in Table 6. In terms of STEM specializations, Table 7 displays prevalent fields such as information technology (14.1%), physics (12.6%), and so on.

Furthermore, the sample population in this study was selected to ensure its appropriateness as a representative sample of UFDS in STEM. Additionally, the utilization of probability sampling techniques during data collection ensured a comprehensive representation of the target population, especially regarding STEM specializations. As access to the entire population of UFDS in STEM was not plausible, the results drawn from this sample were considered generalizable to the broader population. Furthermore, the final sample size of 191 participants exceeded the minimum required sample size, reinforcing the robustness and validity of this study's findings.

Table 5

Race/Ethnicity Percentages and Frequencies

Race/Ethnicity	Frequency	Percentage
White	153	80.1%
Black or African American	6	3.1 %
Asian	7	3.7%
Native American or American Indian	7	3.7%
Indigenous or First Nations	3	1.6%
Ashkenazi Jewish	2	1.0%
Mixed or Multiracial	3	1.6%

Table 6

University Geographic Location Percentages and Frequencies

Location of university	Frequency	Percentage
USA	131	68.6%
Armenia	9	4.7%
India	7	3.7%
Australia	6	2.8%
United Kingdom	5	2.6%
Portugal	3	1.6%
Italy	3	1.6%
Netherlands	2	1.0%

Table 7

STEM Specialization Percentages and Frequencies

Field	Frequency	Percentage
Information technology	27	14.1%
Physics	24	12.6%
Biochemistry	15	7.9%
Biotechnology	13	6.8%
Genetics	11	5.8%
Microbiology	9	4.2%
Geology	11	5.8%

Results

This section provides descriptive statistics of the variables used in all statistical analyses, including additional analyses derived from the assessments of the hypotheses. Additionally, in this section, I evaluate statistical assumptions for RQ1 and RQ2 and present the results of the analysis.

Descriptive Statistics

Categorical Variables

The descriptive frequencies and percentages of all the categorical variables (including ones utilized for additional statistical analyses), university setting, POI, and education status are demonstrated in Table 8.

Table 8

University Setting, Percentage Online Involvement, and Education Status Percentages and Frequencies

University setting			Percentage online involvement (3 levels)			Education status		
	f	%		*f*	%		*f*	%
Campus	100	52.4	Campus (0–29%)	49	29.7	Currently enrolled	129	57.1
Online	91	47.6	Hybrid (30–69%)	60	31.4	Failed or stopped	41	21.5
			Online (70–100%)	82	42.9	Attained degree	41	21.5

Continuous Variables

Table 9 presents descriptive statistics and mean comparisons for the variables POI, SoB, and PFILQ. The descriptive statistics include the number of participants (*N*), mean, and standard deviation for each variable. The table also provides mean comparisons of SoB and PFILQ across different categories, such as university setting (online, campus), POI levels (online, campus, hybrid), and education status (currently enrolled, failed or stopped, attained degree). These comparisons include mean values and standard deviations for the mean.

Table 9

Descriptive Statistics and Mean Comparisons

POI, SoB, and PFILQ means and standard deviations

	N	Mean	*SD*
POI	191	55.26	33.157
SoB	191	3.467	0.401
PFILQ	**186**	3.797	0.8219

Mean comparison of SoB & PFILQ by university setting, POI, and education status

SoB & PFILQ by university setting		*N*	Mean	*SD*	SoB & PFILQ by POI		*N*	Mean	*SD*
SoB	Online	91	3.437	0.18229	SoB	Campus	49	3.519	0.57276
	Campus	100	3.494	0.52614		Hybrid	91	3.438	0.29947
	Total	191	3.467	0.40102		Online	51	3.467	0.36135
PFILQ	Online	89	3.825	0.59433		Total	191	3.467	0.40102
	Campus	97	3.772	0.98828	PFILQ	Campus	47	3.676	0.98426
	Total	186	3.797	0.82192		Hybrid	90	3.827	0.75398
						Online		49	3.859
						Total	186	3.797	0.82192

SoB and PFILQ by education status

		N	Mean	*SD*			*N*	Mean	*SD*
SoB	Currently Enrolled	109	3.45	0.41774	PFILQ	Currently Enrolled	106	3.767	0.7507
	Failed or stopped	41	3.388	0.25399		Failed or stopped	41	3.81	0.78577
	Attained Degree	41	3.591	0.45316		Attained Degree	39	3.866	1.03643
	Total	191	3.467	0.40102		Total	186	3.797	0.82192

Research Question 1

RQ1: Are there differences in the SoB as measured by the Social Fit Scale of UFDS in STEM as a function of their university setting (online vs. campus)?

H_0: There are no statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

H_a: There are statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings.

Assumptions for an Independent Samples t Test

Statistical assumptions for the study were assessed. The dependent variable, SoB, was continuous, and the independent variables, representing online versus campus university settings, were categorical. The assumption of independence of observations was met, ensuring distinct participants in each group without overlap or interconnections. To address significant outliers, careful checks were conducted to prevent data entry errors. A new data set, including attention questions, was utilized for this purpose to minimize errors and response biases. The SoB variable was closely monitored to stay within the expected range (1 to 5), with meticulous assessment of measurement errors. Unusual values were identified and retained for their validity and importance; I managed outliers by creating separate files for analyses with and without them. An independent samples *t* test revealed no significant differences, confirming the legitimacy of the outliers. This methodological approach, supported by the substantial sample size, recognized that a few values at the distribution extremes were inherent and should be retained.

In evaluating the assumption of the approximate normal distribution of the dependent variable, I conducted individual assessments for each level. Considering sample sizes exceeding 50, my main focus in determining distribution normality was on QQ plots rather than the Shapiro-Wilk test, following the approach outlined by Mishra et al. (2019). The examination of QQ plots for online (n = 91) and campus (n = 100) data, excluding outliers, demonstrated no significant deviation, with data points aligning closely with the diagonal line. In addition, the Shapiro-Wilk test indicated a normal distribution of SoB scores across campus (p = .585) and online university settings (p = .053). The assumption of homogeneity of variances was fulfilled because I was comparing the difference between university settings with two levels, online (n = 91) and campus (n = 100), on SoB. These two levels showed equal variances. This detail is explicitly noted during the *t* test, along with Levene's test for equality of variance (Table 10).

Independent Samples t Test Analysis and Results

A nondirectional (two-tailed) independent samples *t* test was utilized to compare two nonrelated group means for a continuous scale dependent variable. The independent variable was the university setting with a nominal level of measurement (online and campus), the dependent variable was SoB scores with a ratio level of measurement (with scores ranging from 1 to 5), and the unit of analysis was UFDS. In this research design, the aim was to examine any potential statistically significant differences in the mean SoB scores of UFDS between an online and campus university setting.

The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p < .05$); therefore, the analysis assumed unequal variances (Table 10). The independent samples *t* test indicated no statistically significant differences between the SoB scores of UFDS online ($M = 3.43$, $SD = .182$) and on campus ($M = 3.49$, $SD = .526$), $t(124) = -1.031$, $p = .304$. Finally, as the level of significance was set at $\alpha = 0.05$, the null hypothesis was not rejected. The results indicate that there were no statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for online versus campus university settings. A summary of the results can be found in Table 10.

Table 10

RQ1: Independent Samples t Test

		Levene's test for equality of variances				Significance			
		F	Sig.	*t*	*df*	One-sided *p*	Two-sided *p*	Mean difference	Std. error difference
SoB	Equal variances assumed	59.418	< **.001**	-.994	189	.161	.322	-.05773	.05810
	Equal variances not assumed			-1.031	124.45	.152	**.304**	-.05773	.05598

Research Question 2

RQ2: Are PFILQ as measured by the Inclusive Leadership scale and/or university setting (campus/online) a predictor for SoB of UFDS in STEM?

H_0: PFILQ and/or university setting are not significant predictors of SoB scores of UFDS in STEM.

H_a: PFILQ and/or university setting are significant predictors of SoB scores of UFDS in STEM.

Assumptions for a Multiple Linear Regression Analysis

I conducted diagnostics to assess whether the multiple regression assumptions had been met. Table 11. presents the findings from the assumptions check and the subsequent multiple linear regression analysis. The Durbin-Watson statistic was 2.029. This statistic provides information about the independence of errors. The common rule states values between 1.0 and 3.0 are considered “safe”. Therefore, there was no correlation between the residuals, the overall model was significant at $p < .000$, and the assumption was met. Examination of multicollinearity through Variance Inflation Factor (VIF) tests indicated low values for all predictors (university setting = 1.001, and PFILQ = 1.001), well below the critical threshold of 10. Cook's Distance analysis revealed no specific outliers exerting a significant impact on the model, with values ranging from 0.00 to .097. This absence of undue influence confirmed the assumption's validity. Analysis of the histogram displayed a fairly normal distribution of errors (SD = 0.995; Figure 1), and the scatterplot demonstrated a linear relationship between variables with homoscedastic errors (Figure 2). The shape of the scatterplot, while forming a rectangular pattern, did not indicate a significant deviation from linearity. In summary, the data-driven and visual assessments suggested that the assumptions of independence of errors, multicollinearity, absence of undue influence, normal distribution of errors, and linearity were met in the regression model.

Table 11

RQ2: Regression Analysis Summary With Coefficients and Collinearity Statistics

Model summary						
Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson	
	.517 [a]	0.267	**0.259**	0.3435	**2.029**	
Residuals statistics						
	Minimum	Maximum	Mean	Std. deviation	*N*	
Cook's distance	**0**	**0.097**	0.006	0.014	186	
ANOVA						
Model		Sum of squares	*df*	Mean square	*F*	Sig.
	Regression	7.861	**2**	3.93	**33.311**	**< .001** [b]
	Residual	21.593	**183**	0.118		
	Total	29.454	185			
Coefficients						
	Unstandardized coefficients		Standardized coefficients			Collinearity statistics
	B	Std. error	Beta	***t***	**Sig**	VIF
(Constant)	**2.415**	0.144		16.769	**< .001**	
PFILQ	**0.248**	0.031	0.512	8.081	**< .001**	**1.001**
University setting (Online and campus)	**0.071**	0.05	0.089	1.412	0.160	**1.001**

[a] Dependent variable: SoB. [b] Predictors: (Constant), university setting (online and campus), PFILQ.

Figure 1

Histogram Residual Errors RQ2

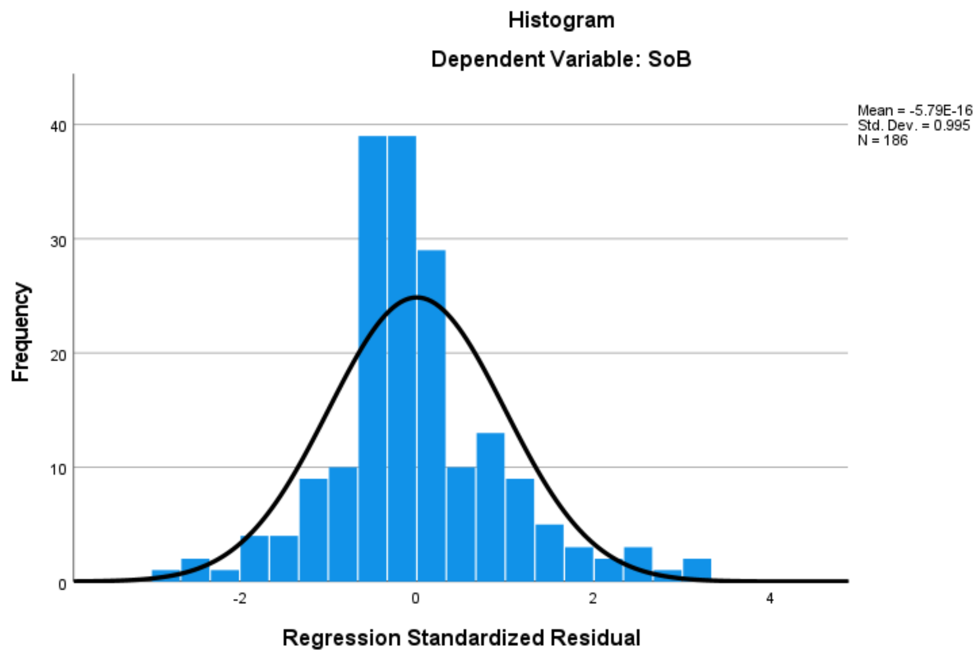
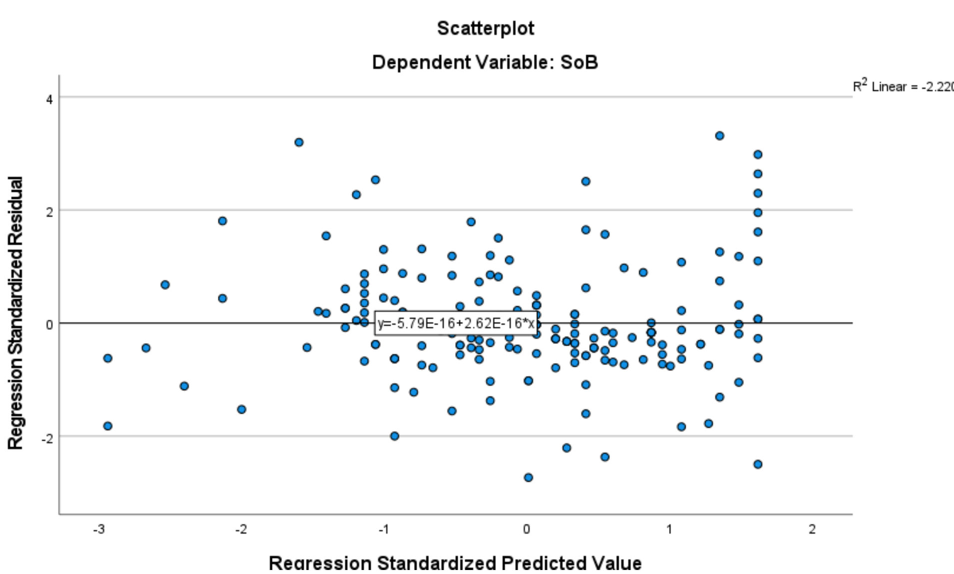


Figure 2

Scatterplot Residual/Predicted Errors RQ2



Multiple Linear Regression Analysis and Results

I conducted a multiple regression analysis to predict SoB using PFILQ and university setting (Online and Campus) as predictors. The results are presented in Table 11. The overall model was statistically significant, $F(2, 183) = 33.311$, $p < .001$, explaining 25.9% (adjusted R for multiple predictors) of the variance in SoB ($R^2 = 0.259$).

The regression equation was significant, predicting SoB as 2.415 + 0.071(university setting) + 0.248(PFILQ), where university setting and PFILQ were measured in individual units. The adjusted R^2 of .259 indicated that 25.9% of the variability in participants' SoB was explained by the combination of their university setting and PFILQ. Analysis of Variance (ANOVA) demonstrated significance at $p < .000$, confirming the overall predictive power of the model. Notably, only PFILQ showed significant statistical value (unstandardized coefficient = .248, $p < .05$), implying that for every unit increase in participants' PFILQ, their SoB was expected to increase by .248 units.

In examining individual predictors, PFILQ emerged as a significant positive predictor of SoB ($b = 0.512$, $t = 8.081$, $p < .001$). This indicated that higher PFILQ scores were associated with an increased SoB. However, university setting (Online and Campus) did not significantly predict SoB ($b = 0.089$, $t = 1.412$, $p = 0.160$), suggesting that the type of university setting did not have a statistically significant influence on the SoB after accounting for other variables.

These findings underscored the role of PFILQ in shaping students' SoB in the university context, offering insights for enhancing students' overall well-being.

Consequently, the null hypothesis suggesting no predictive value of PFILQ and/or university setting for SoB scores of UFDS in STEM was partially rejected, with university setting showing no significant predictive value. The primary predictor for the UFDS's SoB was identified as their PFILQ.

Additional Statistical Testing

Additional testing was carried out to replace the independent variable (IV), "university setting" (campus/online), with a transformed continuous variable POI (see Tables 8 & 9 for the descriptive statistics). This variable was transformed into another nominal IV — "percentage online involvement (3 Levels)" — with categories representing 0-29% campus, 30-79% hybrid, and 80-100% online POI. Informed by a consensus on the definitions and proportions of online, face-to-face, and blended/hybrid learning, scholars posit that in hybrid/blended learning models, an optimal balance is achieved when 30% to 79% of content delivery occurs online, thereby substantiating a considerable online presence (Allen et al., 2007). This rationale underscored my decision to incorporate three distinct levels—online, face-to-face, and blended/hybrid—rather than solely dichotomizing between online and campus modalities.

More explicitly, in the literature, there is a consensus on the definitions and proportions of online, face-to-face, and blended/hybrid learning. Authors suggest that in hybrid learning, 30% to 79% of content delivery occurs online, establishing a significant online presence (Bernard et al., 2014). This ratio is supported by studies advocating for a 1:1 balance between online and classroom instruction (Müller & Mildenberger, 2021) and aligns with student preferences for higher online proportions (Asarta & Schmidt, 2015).

Hybrid learning, as defined by Allen et al. (2007), integrates both online and face-to-face elements, with online content delivery falling within the 30% to 79% range. This definition ensures a substantial online teaching component while differentiating hybrid learning from purely online formats.

It's essential to note that the definition of the proportion of face-to-face, hybrid, and online learning is complex, and the literature varies depending on student perceptions and university education delivery styles (Müller & Mildenberger, 2021). For this study, I added a question on students' perceptions of online involvement as an independent variable to cover all grounds related to the university setting. According to recent research (Cameron et al., 2021), even when a university planned for face-to-face classes, they might have shifted entirely to online learning during COVID-19. This shift could influence the SoB scores of the participants and research outcomes, especially if there were differences in the SoB scores or if the type of university setting predicted SoB.

One-Way ANOVA Analysis and Results

I employed a one-way ANOVA to compare two non-related group means for a continuous scale dependent variable. The ANOVA results are presented in Table 12. The independent variable was the POI with a nominal level of measurement (campus, hybrid, and online), and the dependent variable was SoB scores with a ratio level of measurement (with scores ranging from “1” to “5”) and the unit of analysis was the UFDS. In this analysis, the aim was to examine any potential statistically significant differences in the means of SoB scores of UFDS between a campus, hybrid, and online POI as perceived by the participants’ POI.

The assumptions regarding the one-way ANOVA were met as the sample utilized was independent of each other and random. The levels of measurements were continuous for the dependent variable and nominal, with three categories for the independent variable. The population was assumed to be normally distributed as the total number of cases was higher than $N > 50$. Equality of variances was not assumed, and therefore, the null hypothesis of homogeneity of variance was rejected with Levene's test for homogeneity of variances $F(2, 188) = 19.766$, $p < .001$; consequently, I used a Games-Howell test to test the data for equal variances not assumed (Table 13). I set the significance level at 0.05 level. There were a total of ($N = 191$) survey responses. Based on the ANOVA, the results yielded no significant differences in the POI (campus, hybrid, and online) and the SoB scores, $F(2, 188) = -.646$, $p = .526$. As the significance value was set at .05, the findings indicated that there were no statistically significant differences between the SoB scores as measured by the Social Fit Scale for UFDS in STEM for campus, hybrid, and online POI.

Table 12

Descriptive Statistics and Homogeneity Tests for POI Categories in SoB

Descriptives				Tests of homogeneity of variances				
	N	Mean	*SD*		Levene statistic	df1	df2	Sig.
POI campus 0-29	49	3.5198	0.5728	Based on mean	19.766	2	188	< .001
POI hybrid 30-79	91	3.4389	0.2995					
POI online 80-100	51	3.4671	0.3614					
Total	191	3.4672	0.401					

ANOVA

	Sum of squares	*df*	Mean square	*F*	Sig.
Between groups	0.208	2	0.104	0.646	0.526
Total	30.555	190			

[a] Dependent variable: SoB. [b] Independent variable: percentage of online involvement (POI [campus, hybrid, and online]).

Table 13

Multiple Comparisons of Mean Differences in SoB Scores for POI Categories

POI			Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
						Lower bound	Upper bound
Games-Howell	POI campus	Hybrid 30–79	0.08089	0.08764	0.628	-0.1295	0.2913
		Online 80–100	0.05268	0.09620	0.848	-0.1770	0.2824
	POI hybrid	Campus 0–29	-0.08089	0.08764	0.628	-0.2913	0.1295
		Online 80–100	-0.02821	0.05955	0.884	-0.1702	0.1137
	POI online	Campus 0–29	-0.05268	0.09620	0.848	-0.2824	0.1770
		Hybrid 30–79	0.02821	0.05955	0.884	-0.1137	0.1702

Multiple Linear Regression Analysis

The aim of this analysis was to predict the UFDS's SoB scores based on the data collected for their PFILQ and POI (campus, hybrid as a reference category, and online). Multivariate linear regression was utilized for the prediction of SOB based on PFILQ and POI (campus, hybrid [reference category], and online). The results of the analysis are presented in Table 14. The independent variable was the POI with a nominal level of measurement (campus, hybrid, and online) and the PFILQ with a ratio level of measurement (with scores ranging from "1" to "5"). The dependent variable was the SoB scores with a ratio level of measurement (with scores ranging from "1" to "5") and the unit of analysis were the UFDSs. The regression equation was found significant at $F(3, 182) = 23.443$, $p < .001$) with an adjusted R^2 of .267.

The predicted SOB was equal to 2.466 + .136(POI Campus) + .026(POI Online) + 0.253(PFILQ), where POI Campus and Online and PFILQ were measured in individual units (Table 14). The adjusted R^2 (.267) indicated that 26.7% of the variability of the participant's SOB was explained by the combination of their POI and PFILQ. The ANOVA analysis of the model demonstrated significance at $p = .001$. Not all independent variables added were statistically significant to the prediction, $p < .05$, and only PFILQ and POI campus compared to POI hybrid showed significant statistical value.

Examining individual predictors, PFILQ emerged as a significant positive predictor of SoB ($b = 0.52$, $t = 8.233$, $p < .001$). This suggests that higher PFILQ scores were linked to an elevated SoB. However, POI campus also significantly predicted SoB ($b = 0.149$, $t = 2.208$, $p = 0.03$), indicating a positive relationship, while POI online did not reach statistical significance ($b = 0.029$, $t = 0.431$, $p = 0.67$).

More specifically, the unstandardized coefficient for PFILQ was .253 ($p < .05$). This means that for every unit increase in the participants' PFILQ, their SOB will increase by .253 units. For POI campus the unstandardized coefficient was .136, ($p =.029$) compared to POI hybrid. This reflected how POI campus compares to POI hybrid in their SoB scores and indicated that the mean SoB for campus POI was .136 units higher than POI hybrid. For POI online the unstandardized coefficient was .026, ($p = .667$) compared to POI hybrid. This indicated that the mean SoB for POI online was .026

units higher than POI hybrid; however, this difference was not significant. Consequently, the predictive value of PFILQ and POI (campus, hybrid [reference category] and online) for SoB was partially supported (POI online had no significant predictive value), and the best predictors for the UFDSs SoB was PFILQ and POI campus as compared to POI hybrid.

Table 14

Regression Analysis Summary With Coefficients and Collinearity Statistics

			Model summary			
Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate	Durbin-Watson	
	.528 [a]	0.279	0.267	0.3417	2.056	
			Residuals statistics			
Cook's distance	0	0.090	0.007	0.015	186	
			ANOVA			
Model		Sum of squares	*df*	Mean square	*F*	Sig.
	Regression	8.209	3	2.736	23.44	< .001 [b]
	Residual	21.244	182	0.117		
	Total	29.454	185			
			Coefficients			
	Unstandardized coefficients		Standardized coefficients			Collinearity statistics
	B	Std. error	Beta	***t***	**Sig**	VIF
(Constant)	2.466	0.123		20.08	< .001	
PFILQ	0.253	0.031	0.52	8.233	< .001	1.008
POI campus	0.136	0.062	0.149	2.208	0.03	1.144
POI online	0.026	0.061	0.029	0.431	0.67	1.138

[a] Dependent variable: SoB. [b] Predictors: (Constant), percentage of online involvement (POI [campus, hybrid (reference category) and online]), PFILQ.

Assumptions for the Multiple Linear Regression

I conducted diagnostics to assess whether the multiple regression assumptions have been met. Table 14. presents the findings from the assumptions check and the subsequent multiple linear regression analysis. The Durbin-Watson statistic was 2.056. This statistic provides information about the independence of errors. The common rule states values between 1.0 and 3.0 are considered “safe”. Therefore, there was no correlation between the residuals, the overall model was significant at p =.001 and the assumption was met. Examination of multicollinearity through variance inflation factor (VIF) tests indicated low values for all predictors (POI campus = 1.144, POI online = 1.138, and PFILQ = 1.008), well below the critical threshold of 10. Cook's Distance analysis revealed no specific outliers exerting a significant impact on the model, with values ranging from 0.00 to .090. This absence of undue influence confirmed the assumption's validity. Analysis of the histogram displayed a fairly normal distribution of errors (*SD* = 0.992; Figure 3), and the scatterplot demonstrated a linear relationship between variables with homoscedastic errors (Figure 4). The shape of the scatterplot, while forming a rectangular pattern, did not indicate a significant deviation from linearity. In summary, the data-driven and visual assessments suggest that the assumptions of independence of errors, multicollinearity, absence of undue influence, normal distribution of errors, and linearity were met in the regression model.

Figure 3

Histogram Residual Errors

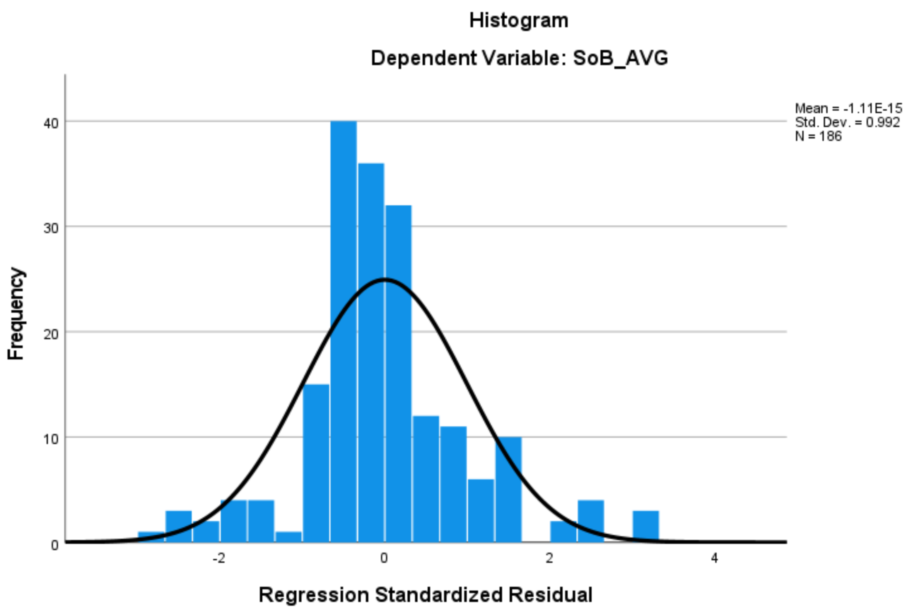
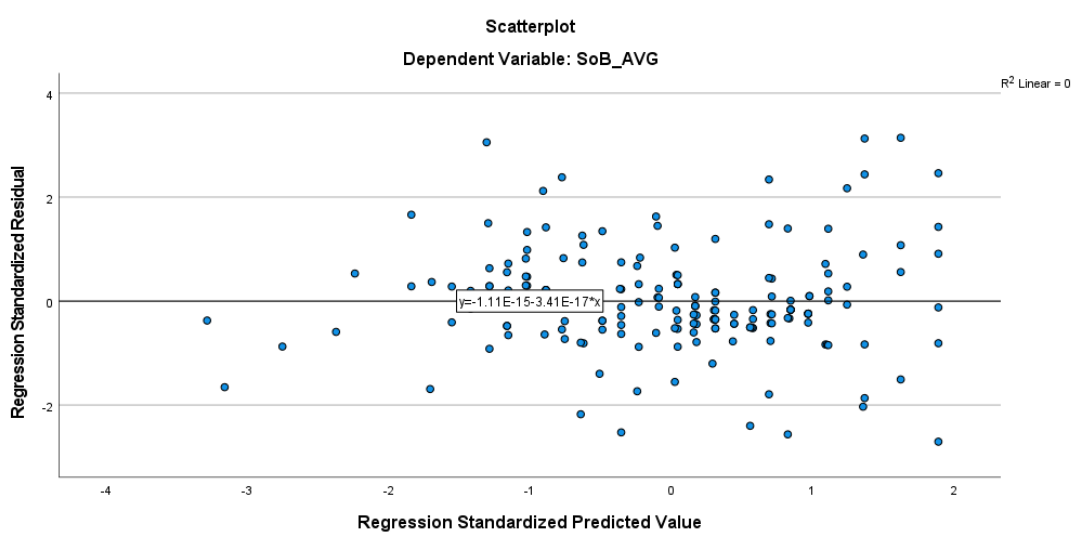


Figure 4

Scatterplot Residual/Predicted Errors



Effect Sizes

For RQ1, comparing SoB scores between online and campus university settings, I utilized a conservative Cohen's d effect size of .30. This effect size was chosen considering the limited research on the relationship between UFDS's SoB and university settings, aiming for sensitivity to detect any potential effect. In the case of RQ2, which involved a multiple linear regression to predict UFDS's SoB based on PFILQ and university setting and POI, the effect size was expressed as f^2, with a medium effect size set at .15. This choice aligned with the conservative approach to account for the relatively unexplored nature of the predictive relationship between UFDS SoB and PFILQ, and university setting. The consideration of effect sizes aimed to improve the study's reliability and reduce the risk of a type II error (Nikpeyma et al., 2020). Below are the reported effect sizes and interpretations for the statistically significant results:

Research Question 2—Multiple Linear Regression

Outcome: PFILQ showed predictive value, while university setting had no significant predictive value.

Effect Size: For PFILQ, the unstandardized coefficient (0.248) can be interpreted as the effect size. It indicates that for every one-unit increase in PFILQ, SoB increased by 0.248 units.

Additional Statistical Testing with POI—Multivariate Linear Regression

Outcome: PFILQ and POI (campus compared to hybrid) showed predictive value.

Effect Size: Similar to the initial RQ2 analysis, the unstandardized coefficient for PFILQ (0.253) represents the effect size, indicating that for every one-unit increase in PFILQ, SoB increased by 0.253 units. Additionally, for POI campus compared to POI hybrid, the unstandardized coefficient (0.136) can be interpreted similarly.

Summary

In the extant quantitative nonexperimental comparative study, I aimed to explore the SoB among UFDS in STEM. The study involved comparing online and campus university settings and investigating the relationship between UFDS's PFILQ and SoB. A total of 638 survey responses were collected, with 191 meeting the analysis criteria. In addressing RQ1, I conducted an ANOVA in the SoB among UFDS, specifically considering the university setting (campus vs. online). Utilizing an independent samples *t* test, the findings revealed no statistically significant differences in SoB scores for UFDS between online and on-campus settings. Consequently, the hypothesis positing significant differences was rejected. Furthermore, in RQ2 I investigated PFILQ and/or university setting as predictors for UFDS's SoB. The multiple linear regression demonstrated a significant model with PFILQ showing predictive value. However, the university setting had no significant predictive value. Therefore, the null hypothesis was partially rejected, concluding that PFILQ significantly predicted UFDS's SoB while the university setting did not.

Furthermore, I conducted additional statistical testing to refine the independent variable of the study, namely, the university setting (campus/online).). I introduced transformed continuous variable, POI and categorized into "Percentage Online

Involvement (3 Levels),"—representing 0-29% campus, 30-79% hybrid, and 80-100% online involvement. Therefore, additional analyses involved a one-way ANOVA comparing SoB scores across campus, hybrid, and online POI categories. The results showed no significant differences in SoB scores among these categories. Moreover, the analyses aimed to predict UFDS's SoB based on PFILQ and POI. Notably, the multivariate linear regression demonstrated significance, with PFILQ showing predictive value. Finally, POI campus compared to POI hybrid also showed significant statistical value, suggesting that the mean SoB for campus POI was 0.136 units higher than POI hybrid. Consequently, the best predictors for UFDS's SoB were identified as PFILQ and POI campus compared to POI hybrid.

In Chapter 5, I examined the study's outcomes to determine their alignment, deviation, or expansion of existing insights into the experiences of UFDS in STEM. This examination is rooted in a comprehensive review and comparison with relevant peer-reviewed literature in the field, particularly focusing on Fiske's (2018) core social motives, such as the SoB. By employing an interpretive lens, I contextualize the findings for SoB, PFILQ, and university settings, shedding light on their implications and contributions to the broader academic discourse. Following this critical analysis, I will address the limitations of the study in this chapter, providing insights into its scope. To conclude, I propose recommendations for future investigations and explore the potential implications of this research for catalyzing positive social change within STEM and broader academic environments.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Through this quantitative nonexperimental comparative study, I aimed to address gaps in the existing scholarly landscape. The principal objective centered on unraveling the intricate dynamics of the SoB among women involved in doctoral degrees in STEM fields, with a specific lens on comparing their SoB in online versus campus university settings. Additionally, the predictive relationship between participants' SoB and their PFILQ was examined, utilizing a sociopsychological framework—Fiske's (2018) core social motive SoB. An independent samples *t* test and regression were employed to fill a gap in the literature regarding the influence of inclusive leadership on the SoB of UFDS in STEM and the role of the university setting (e.g., online or on campus). The investigation focused on understanding the impact of inclusive leadership style, university setting, and PFILQ in shaping the SoB, particularly within the context of the primary research supervisor as the research group leader.

Key findings from this study included the conclusion that UFDS's SoB was significantly predicted by PFILQ, thereby predicting that inclusive leadership qualities of primary research supervisors positively shape the SoB of UFDS in STEM. In contrast, SoB was not predicted by university setting, thereby drawing attention to the specific influence exerted by PFILQ in this context. Additional analyses included the evaluation of POI and its role in SoB, results of which established that both PFILQ and POI served as significant predictors of SoB, presenting a nuanced understanding of these variables. Importantly, the distinction between POI campus and POI hybrid was made, revealing differences in their respective contributions to the SoB of participants, thus further enriching the interpretation of the study's findings.

Interpretation of the Findings

In the literature review, I delved into the challenges encountered by female graduate students in STEM, consistently highlighting the prevalent issue of a low SoB (e.g., Blackburn, 2017; Cabay et al., 2018; Corbett, 2015; Hill et al., 2010; Hughes et al., 2017; Okahana et al., 2018). It is noteworthy that the average SoB scores for the participants in this study were slightly above neutral (see Table 9 for the mean SoB scores), with a cumulative mean of 3.467 on a scale of 1 to 5, where 5 indicates the highest SoB. The score range further underscores the diversity within the sample, ranging from a low SoB score of 2.24 (indicating participants who pursued but did not complete a STEM doctoral degree) to the highest at 4.88 (reflecting currently active students at the time of the survey). For detailed mean comparisons of SoB and PFILQ across different categories such as university setting (online, campus), POI levels (online, campus, hybrid), and education status, please refer to Table 9.

No Differences in a Sense of Belonging Across University Settings

In addressing RQ1, which explored differences in SoB based on university setting (campus vs. online), an independent samples *t* test was employed. Results unveiled no significant differences in SoB scores for UFDS in online and on-campus settings. This discovery challenged prevailing notions in the education and psychology field regarding the relationship between educational settings and SoB. It contradicted certain literature strands suggesting that online learning environments, lacking physical presence, might lead to lower SoB (Besser et al., 2020; Farrell & Brunton, 2020; Gedera et al., 2015; Jackson, 2016; Martin et al., 2020; Pedler et al., 2022; Thomas et al., 2014).

Furthermore, a noteworthy gap existed in the literature concerning direct comparisons of the effects of different university settings on underrepresented students' SoB. This study addressed this scarcity, contributing valuable insights by comparing university settings and their impact on students' SoB. Importantly, it was concluded that the institutional assignment of a university's learning delivery system did not significantly differ in SoB between online and on-campus delivery systems. In essence, by comparing the SoB of UFDS in STEM between on-campus and virtual higher education institutions, this research provided a new understanding of the challenges related to female underrepresentation in STEM and SoB. It suggests that a campus or online setting does not make a significant difference in their SoB. All in all, the study's results indicate that the university setting is not a predictor of UFDS's SoB (controlling for PFILQ-RQ2), at least not when measuring the university setting by asking if it is online or not.

POI Contribution to Understanding University Settings

Interestingly, university setting, as the measurement approach, considered the institutional assignment of the university's learning delivery system (a face-to-face, online, or hybrid university). However, it is crucial to recognize the complexity of defining the proportions of face-to-face, hybrid, and online learning, with variations in the literature based on student perceptions and university education delivery styles (Müller & Mildenberger, 2021). For this reason, I assessed the role of POI, aiming to categorize students based on their online involvement levels. The POI was based on the participants’ responses about their perceived online involvement levels during their studies, expressed as a percentage.

Furthermore, recent research also highlighted the potential impact of shifts to online learning during COVID-19, emphasizing the need to consider such changes in the investigation of SoB and research outcomes (Cameron et al., 2021). Therefore, this study transformed the variable POI into a nominal variable with three categories: 0–29% campus, 30–79% hybrid, and 80–100% online, aligning with a consensus in the literature on definitions and proportions of online, face-to-face, and blended/hybrid learning. Hybrid learning, typically defined as 30% to 79% online content delivery, integrates both online and face-to-face elements, maintaining a substantial online presence (Allen et al., 2007). This definition is consistent with studies advocating for a balanced 1:1 ratio between online and classroom instruction (Müller & Mildenberger, 2021) and reflects student preferences for higher online proportions (Asarta & Schmidt, 2015).

Consequently, with the new variable, subsequent testing with a one-way ANOVA across campus, hybrid, and online POI categories still indicated no significant differences in SoB scores. The literature often underscored the potential challenges of online learning for SoB (Besser et al., 2020; Farrell & Brunton, 2020; Gedera et al., 2015; Jackson, 2016; Martin et al., 2020; Pedler et al., 2022; Thomas et al., 2014). However, this study's nuanced approach, incorporating POI, demonstrated that there is no evidence to support the idea that the extent of online involvement or the university setting (campus, hybrid, or online) contributed to variations in the SoB scores among the participants. To conclude, the findings challenged preconceptions about the impact of online settings on UFDS SoB, suggesting a more complex relationship that warranted further exploration.

Faculty Inclusive Leadership and University Settings in SoB Prediction

The findings for RQ2 and the subsequent analyses with POI instead of the university setting contribute significantly to the existing literature on the predictors of SoB among UFDS in STEM. Results revealed that PFILQ significantly predicted UFDS's SoB, while university setting did not. In integrating the literature review, the findings align with studies highlighting the positive impact of faculty interactions on students' SoB (Barreto & Hogg, 2017; Kirby & Thomas, 2021; van Rooij et al., 2021). This research underscores the critical role of the faculty, specifically the primary research supervisor, in predicting the SoB of Ph.D. candidates (van Rooij et al., 2021). Additionally, a gap in the literature has been bridged by focusing on inclusive leadership within the context of relational leadership, a less-explored area (Aboramadan et al., 2021; Ashikali et al., 2021; Canlas & Williams, 2022; Carmeli et al., 2010; Javed et al., 2019; Komives et al., 2015; Pressentin & Harris, 2022; Ramamoorthi et al., 2021; Uhl-Bien, 2006). Moreover, the scarcity of research on the effects of inclusive leadership on SoB in education, especially in doctoral studies of women in STEM, underscores the novelty and importance of the findings. Further analyses with POI instead of the university setting further extended the knowledge by introducing POI as a predictor. The results from the multiple linear regression analysis indicate that the POI in both campus and hybrid settings emerges as a significant predictor of SoB levels. Specifically, the influence of POI on SoB is observed to differ between the two settings, with campus (as compared to hybrid) participation showing a positive association leading to increased SoB, while hybrid (as compared to campus) participation is associated with a decrease in SoB. These findings underscore the nuanced impact of the mode of online involvement on students' SoB. Consequently, the results could indeed affirm that SoB is intricately linked to two-way interactions, notably influenced by PFILQ and POI.

All in all, the findings of this study contribute significantly to the literature on the predictors of SoB among UFDS, particularly in the context of intragroup relations (Barreto & Hogg, 2017; Chiu et al., 2016; Fiske, 2018; Sax et al., 2018; Stachl & Baranger, 2020). The importance of considering the roles of group members, especially the leader (e.g., thesis supervisor), as influential factors that can affect SoB either positively or negatively has been confirmed. Then, PFILQ emerged as a crucial predictor, with increasing PFILQ associated with higher SoB (Barreto & Hogg, 2017; Kirby & Thomas, 2021). Consistent with the theoretical framework, which underscores the positive influence of supportive faculty leadership on the SoB among UFDS (Barreto & Hogg, 2017; Fiske, 2018; Kirby & Thomas, 2021), the results align with prior research emphasizing the critical role of the primary research supervisor in shaping UFDS's SoB through faculty interactions (Aboramadan et al., 2021; Barreto & Hogg, 2017; Kirby & Thomas, 2021; Pressentin & Harris, 2022; Rosado & Toya, 2015; van Rooij et al., 2021).

Fiske's (2018) conceptualization of SoB as integral to sustaining group memberships served as a theoretical anchor. The study's findings align with Fiske's notion, emphasizing the importance of SoB in maintaining positive interactions and lasting bonds. The broader literature, too, underscores the significance of a strong SoB for academic retention and overall well-being (Pedler et al., 2022; Soria et al., 2019). The study contributes by examining these dynamics within the unique context of UFDS in STEM, thus extending the application of Fiske's framework. In conclusion, the study offers nuanced insights into the intricate interplay between intragroup relations and SoB. The confirmation of PFILQ and the introduction of POI as predictors significantly enhance the comprehension of SoB among UFDS. The results underscore the critical role of the faculty's inclusive leadership style, especially that of the primary research supervisor, in shaping the SoB of female doctoral students underrepresented in STEM.

Limitations of the Study and Future Recommendations

In discussing the methodological limitations of the study, it is noteworthy that while I did not directly compare the SoB of men and women in STEM in this research, the findings revealed slightly above-neutral SoB in women. This discovery aligned with existing literature on the persistent below-average SoB of graduate women in STEM and the challenges that accompany them (Blackburn, 2017; Charlesworth & Banaji, 2019; Fassiotto et al., 2016; Hill et al., 2010; O’Connell & McKinnon, 2021; Okahana et al., 2018; O’Meara et al., 2017). Moreover, additional limitations warranted further consideration. The overrepresentation of participants who identified as White (80.1%) raises concerns about generalizing findings to more diverse populations within UFDS. Additionally, the limited representation of Black, African American, Asian, Native American, or American Indian participants (combined 7.8%) may restrict comprehensive conclusions about the unique experiences of these underrepresented groups. The majority of participants being from the United States (68.6%) may have influenced findings to be more reflective of the U.S. university context, limiting cross-institutional applicability and external validity. Future research could focus on the intentional recruitment of a more geographically diverse participant pool to ensure a representative institutional sample. Therefore, addressing these limitations might enhance the robustness and applicability of the findings.

Another limitation concerns the oversight of not accounting for variations in doctoral degree structures, such as the distinction between paid positions with preassigned topics and self-funded Ph.D. programs where candidates select their research topics, as highlighted by Mogaji et al. (2021). The potential influence of having autonomy over one's research topic on the SoB, persistence, and motivation of UFDS in STEM has not been systematically explored in this study. To address this limitation and enhance the depth of future research, it is recommended to incorporate specific survey questions related to the nature of PhD research undertaken by participants.

An additional limitation worth considering is the temporal aspect as a potential confounder in the research design. Specifically, the nominal variable education status is categorized into three levels: currently enrolled, failed or stopped, and attained degree. The literature review underscores the relevance of time in influencing the SoB as a dynamic construct that may evolve over time (Strayhorn, 2012). However, Sax et al. (2018) found significant differences in SoB over time for women compared to men, although the effect size was relatively small (Cohen’s $d = 0.114$). It is noteworthy that Sax et al.'s research measured SoB over the duration of a course, not longitudinally across a lifespan. Although additional analyses were not performed in this regard in the extant study, it would be intriguing to explore potential differences in SoB over time as indicated by education status, comparing SoB means across the different education status levels and measuring SoB scores overtime. Nevertheless, a cursory examination of Table 9 reveals that individuals who have attained a degree exhibit the highest SoB scores (μ = 3.59), while those who failed or stopped show the lowest scores (μ = 3.38). This observation aligns with logical expectations of degree achievement and SoB (Pedler et al., 2022). Further investigation and analysis could shed light on this nuanced aspect of the relationship between education status and the trajectory of SoB.

Finally, in measuring university setting as a variable, complexities arose due to the intricate nature of defining proportions of face-to-face, hybrid, and online learning, influenced by student perceptions and diverse education delivery styles (Müller & Mildenberger, 2021). In this study, I introduced POI as a nuanced variable, categorizing students based on their POI levels. I further transformed the variable into three categories: 0–29% campus, 30–79% hybrid, and 80–100% online, aligning with established definitions in the literature (Allen et al., 2007; Asarta & Schmidt, 2015; Müller & Mildenberger, 2021). Despite common concerns about online learning's negative impact on SoB (Besser et al., 2020; Gedera et al., 2015), testing with a one-way ANOVA indicated no significant differences in SoB scores across campus, hybrid, and online POI categories. This suggests that the proportions of face-to-face, hybrid, and online learning, as categorized by POI, do not inherently influence students' feelings of belonging. The findings emphasize the need for a more nuanced understanding of the impact of varied educational settings on SoB.

Discussion and Implications

Belonging Disparities and Science, Technology, Engineering, and Mathematics Support Initiatives

A high SoB has been found to be positively correlated with improved well-being, serving as a mitigating factor against academic attrition (Ysseldyk et al., 2019). The connection between a SoB, student well-being, and academic success is supported by the literature highlighting the impact of belonging on student retention and academic performance in higher education (Ahn & Davis, 2020; Hoffman et al., 2002; Suhlmann et al., 2018; van Rooij et al., 2021, etc.). Nonetheless, underrepresented groups, including ethnic minorities and female students in STEM across undergraduate, graduate, and doctoral levels, often grapple with a diminished SoB in comparison to their peers (Blaney & Stout, 2017; Gopalan et al., 2022; Gopalan & Brady, 2020; O'Meara et al., 2017; Stachl & Baranger, 2020, etc.). This underlines the pressing need to create an inclusive educational environment that embraces diversity, inclusion, and student well-being to fortify persistence and retention and increase their SoB. Therefore, higher education institutions with a STEM focus have developed actionable strategies to connect with and support these underserved groups (Palid et al., 2023; Pearson et al., 2022).

Diverse Approaches to Enhance Science, Technology, Engineering, and Mathematics Inclusivity

Diverse strategies exist to promote inclusivity in STEM, involving comprehensive intervention programs focused on supporting underrepresented student populations (Palid et al., 2023; Pearson et al., 2022). These multifaceted initiatives commence with pivotal stages such as recruitment and admissions, aiming to attract participants and heighten commitment to STEM pursuits. Beyond academic aspects, intentional interventions encompass social support elements, including mentorship and financial aid, strategically crafted to establish a sense of community and address the diverse needs of underrepresented, first-generation, and low-income STEM students. Subsequent exploration will delve into the specific components and strategies employed by these intentional intervention programs, drawing insights from recent studies (Palid et al., 2023; Pearson et al., 2022).

The initial phase of an intervention program, targeted at enhancing the retention and persistence of underrepresented student populations in STEM, involves recruiting and admissions (Pearson et al., 2022). This is crucial to raise awareness and attract as many participants as possible, fostering a heightened level of commitment. Moreover, intentional intervention programs aim to offer comprehensive support for underrepresented, first-generation, and low-income students in STEM. These programs encompass both academic and social components. Academic support involves professional development, networking opportunities, and research experiences, with an emphasis on real-world applications and faculty mentorship. Additionally, tutoring, study skills, and targeted academic interventions are integrated to assist students in coursework, providing options for individual preferences. Finally, graduate school preparation is also a focus, offering insights into the application process and admissions seminars (Palid et al., 2023; Pearson et al., 2022).).

On the social support front, mentoring plays a central role, contributing to both academic and social needs (Pearson et al., 2022). Mentoring approaches include supportive and familial roles, intentional matching based on shared backgrounds, and the use of senior students and alumni as mentors. Moreover, social integration experiences, community service, and transition/summer bridge programs are additional components of these intentional interventions. These programs also prioritize financial support as a crucial element, intending to alleviate economic burdens for participants pursuing STEM degrees. The overall emphasis is on creating a sense of community and fostering connections through group activities, STEM organizations, living-learning communities, community service, and financial support. Overall, these intentional intervention programs are designed to holistically support underrepresented, first-generation, and low-income students in their STEM pursuits (Palid et al., 2023; Pearson et al., 2022).

Continuous Development in Science, Technology, Engineering, and Mathematics: Faculty Leadership Training

Numerous initiatives within institutions of higher education offer faculty training programs aimed at enhancing their professional competencies. In response to heightened awareness of gender disparities and an increased emphasis on diversity and inclusion, universities have instituted training modules designed to cultivate faculty skills in inclusive behaviors and best practices. More explicitly, leading universities such as UC Berkeley, Dartmouth, and Carnegie Mellon actively facilitate faculty-led discussions on diverse and inclusive topics centered on promoting inclusive teaching practices (Carnegie Mellon, 2023; Dartmouth, 2023; UC Berkeley, 2023). Additionally, Carnegie Mellon's

College of Engineering prioritizes unconscious bias training within its Center for Faculty Success to address potential biases affecting faculty roles. Furthermore, UC Berkeley supports equity and inclusion initiatives by providing department planning toolkits while also appointing Faculty Equity Advisors, under the guidance of school deans, to play a key role in fostering inclusivity across campus programs (Carnegie Mellon, 2023; Dartmouth, 2023; UC Berkeley, 2023). Finally, the University of Pittsburgh and the University of California have diversity certificate programs designed for faculty. These programs include specific courses addressing diversity-related topics (University of California, n.d; University of Pittsburgh, 2023.). For example, the University of Pittsburgh offers a Diversity and Inclusion Certificate Program (DICP) designed to uphold core values through workshops. Their workshops address diverse topics, including generational differences, digital accessibility, gender theory, identity, power, privilege, disability accommodation, intercultural competency, microaggressions, religion diversity, supporting trans and nonbinary community members, veteran resources, and workplace bullying (University of Pittsburgh, 2023).

Along the same lines, UC Berkeley, Dartmouth, University of Notre Dame, and Columbia University offer mentoring initiatives tailored for faculty. These programs aim to assist faculty members in their careers and address community needs (Columbia University, 2023; Dartmouth, 2023; UC Berkeley, 2023; University of Notre Dame, 2023). At length, the University of California, Berkeley, offers a comprehensive range of programs and services to promote diversity, equity, inclusion, belonging, and justice among faculty. The university emphasizes ongoing initiatives, events, and resources to foster equity, inclusion, diversity, belonging, and justice on campus, demonstrating a commitment to creating an inclusive academic environment (UC Berkeley, 2023). Following this, Dartmouth College offers a series of inclusive leadership virtual workshops for faculty and staff. The workshops cover diverse topics, including navigating sensitive topics in teaching and research spaces, managing productive conversations with colleagues, insights on leadership from distinguished individuals, and discussions on teaching excellence and free expression (Dartmouth, 2023).

In conclusion, fostering a SoB is crucial for the well-being and success of underrepresented students in STEM. Universities such as UC Berkeley, Dartmouth, and Carnegie Mellon have implemented various initiatives to address this need, including mentoring programs, diversity certificate programs, and faculty dialogue series. Additionally, global strategies like intentional intervention programs and postsecondary STEM intervention programs play a vital role in supporting underrepresented students. Notably, our study adds a pivotal dimension to this discourse by affirming that targeted faculty training on inclusive leadership skills, guided by the relational leadership model (Aboramadan et al., 2022; Ashikali et al., 2021; Canlas & Williams, 2022; Carmeli et al., 2010; Javed et al., 2019; Komives et al., 2015; Pressentin & Harris, 2022; Ramamoorthi et al., 2021; Uhl-Bien, 2006), stands as a potent avenue for further enhancement. Empowering faculty to create more inclusive and supportive environments aligns with the evolving landscape of STEM education. Additionally, a flexible educational setting, allowing students to personalize their balance of campus and online learning, emerges as a significant contributor to the ongoing endeavors of establishing an inclusive and accessible educational community for underrepresented students. These integrated strategies could elevate existing practices and cultivate a stronger SoB among students and graduates, thereby contributing to the collective effort for an inclusive and diverse educational environment.

Positive Social Change

This study contributes to positive social change across individual, organizational, policy, and empirical levels. On an individual level, I delved into the dynamics of the SoB across university settings and examined the role of PFILQ. Subsequently, the research provides valuable insights that could potentially enhance the well-being and academic success of UFDS in STEM. On an organizational level, this research advocates for inclusivity and support within university settings, regardless of the mode of education delivery, be it online, hybrid, or on-campus. Recognizing the significance of inclusive leadership within STEM doctoral groups, the findings confirm the success of the continued efforts of universities in developing a culture that not only embraces diversity but also addresses the unique challenges faced by underrepresented groups in STEM. This suggests the potential for positive additions to policies and practices of the universities' planned interventions. These additions aim to enhance efforts in creating a more inclusive research academic environment, benefiting not only underrepresented women in STEM but also academic staff. Consequently, understanding the influence of faculty, specifically primary research supervisors, in their interactions with students contributes to fostering a supportive educational environment for UFDS at the institutional level. This indirect influence extends to shaping their social support systems and encouraging their academic goals.

Furthermore, this study significantly contributes to the ongoing discourse on equity, diversity, and inclusion in STEM at both societal and policy levels (EC & DGRI, 2021). Focusing on the experiences of underrepresented women pursuing doctoral degrees in STEM, the research offers insights that can enhance the development of policies aimed at supporting this demographic. By emphasizing the necessity for targeted interventions, such as training primary research supervisors in inclusive leadership skills based on the relational leadership model (Aboramadan et al., 2022; Ashikali et al., 2021; Canlas & Williams, 2022; Carmeli et al., 2010; Javed et al., 2019; Komives et al., 2015; Pressentin & Harris, 2022; Ramamoorthi et al., 2021; Uhl-Bien, 2006), the study adds to the existing knowledge and practices in place (Carnegie Mellon, 2023; Dartmouth, 2023; UC Berkeley, 2023). While the implications of the study extend beyond its immediate scope, recognizing the broader need for ongoing efforts to promote diversity and inclusion in STEM, it is important to note that the study, on its own, does not remove existing barriers for underrepresented women in STEM. However, it does shed light on a novel element in this context, emphasizing the ongoing need for additional research and potential reinforcement of existing practices from a policy perspective.

Finally, this study empirically establishes a foundation for future research to delve deeper into the dynamics of UFDS experiences in STEM, potentially uncovering additional variables that influence their SoB. In terms of practical recommendations, the pivotal role of faculty members, particularly research supervisors, in shaping the SoB of

UFDS is underscored. Educational institutions have the opportunity to bolster their mentorship programs, training initiatives, and policies by incorporating the relational model of inclusive leadership practices for thesis supervisors. This integration has the potential to significantly enhance efforts toward fostering a more supportive academic environment, particularly for underrepresented students, including women pursuing doctoral research in STEM fields.

Conclusion: Addressing Literature Gaps—Predictors for Enhancing Women's Sense of Belonging in Science, Technology, Engineering, and Mathematics

This study contributes to the collaborative efforts of universities and STEM organizations, actively participating in the establishment of a more diverse and inclusive STEM environment for underrepresented women. By delving into the experiences of underrepresented women pursuing doctoral degrees in STEM, this research informs policies addressing literature gaps and identifying predictors for enhancing women's SoB in STEM. The emphasis on tailored interventions, such as training primary research supervisors to be inclusive leaders, broadens the study's implications for promoting diversity and inclusion in STEM. While existing barriers may not be directly eliminated, this study brings to light a novel element in this context, underscoring the ongoing importance of policy-driven efforts. To conclude, in recognizing the need for further research, this study acts as an agent for sustained discussions and actions, aiming to foster a more inclusive environment for underrepresented women in STEM.

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Appendix A: Invitation Text

There is a new study about the perceptions of women in STEM doctoral degrees, specifically focusing on their sense of belonging and the impact of their primary research supervisor's inclusive leadership qualities. You are invited to complete a 5-minute anonymous survey.

<u>Seeking volunteers that meet these requirements:</u>

- 18 years old or older
- Identify as women.
- -Have not completed their doctoral degree OR

  -Have obtained their doctoral degree OR,

  -Are currently pursuing a doctoral degree in STEM
- Are available to participate in the study during the data collection period.

This study is part of the doctoral program for Elisavet Chaoua Intoumpor-Beukers, a Ph.D. student at Walden University. The survey will be open until the end of December 2023.

Please click the link below to view the consent form and begin the survey.

Appendix B: Demographic Questions

1. Please select the statement that is true for you today:

   • I am currently enrolled as a doctoral student in a STEM field.

   • I was enrolled in the past as a doctoral student in a STEM field but did not complete my program.

   • I was enrolled in the past as a doctoral student in a STEM field and have attained my degree.

2. What is/was the geographic location of your university?
3. Area of STEM specialization: In which specific STEM field are/were you pursuing your doctoral degree?
4. How do you self-identify in terms of gender?
5. What percentage of your total time during your doctoral studies was spent Online (fully remote)?: (slider 0-100%)
6. How do you self-identify in terms of race/ethnicity?
7. Did you study at an online university, a campus-based university, or a hybrid of both?