ABSTRACT

TOPLICEANU, ANA-MARIA. Mentoring Experiences of Graduate STEM Students. (Under the direction of Dr. Margaret Blanchard).

There is an increasing need for Science, Technology, Engineering, and Mathematics (STEM) professionals in the United States (U.S.) to support the country's competitiveness in the world and its advancements in innovation and technology. Although the number of graduate STEM students has increased, they face demanding academic environments, unsure career prospects, and an imbalance of academic work and personal life. Mentoring is a key component of addressing high attrition rates and supporting the success of graduate students in STEM majors. Despite its importance, little is known about the mentoring experiences of graduate students in STEM majors. This dissertation study used two separate studies to investigate the mentoring experiences of graduate STEM students.

In the qualitative study, interviews with eight STEM mentors and twenty domestic and international mentees, recent doctoral graduates from four large public, research-intensive universities in the southeastern U.S., were analyzed. The research questions guiding this study were: 1) Overall, how did mentors and mentees describe mentors' mentoring approaches? 2) What mentoring approaches do mentors use to support the development of graduate STEM students? 3) How do graduate STEM students describe their mentor's mentoring approach and aspects that are supportive (or lacking) of their development? and 4) What does a dyad analysis reveal about the differing perspectives of the mentor and mentee on perceived mentoring approaches? Yob and Crawford's (2012) conceptual framework of mentoring and Chandler et al.'s (2015) ecological systems theory were used in this study. The mentors and the mentees described the mentor using academic behaviors such as induction, challenge, availability, and competence and psychosocial behaviors such as emotional support, communication, and personal qualities to support their development. Six of eight mentors described mostly academic behaviors. Seven of the nine domestic and six of the eleven international mentees described mostly academic behaviors. Four international mentees described mostly psychosocial behaviors that supported their development.

In the quantitative study, the mentoring graduate STEM students' survey was developed using mentoring constructs from the academic and psychosocial behaviors, findings from the qualitative study, and aspects related to student program completion and career support. The survey was distributed to graduate STEM students at a large, public, research-intensive, Southeastern university in the U.S. Exploratory factor analysis was used to test the validity and reliability of the survey, with 280 responses. A 5-factor, 38-item model was determined with the following subscales: psychosocial support, program completion, research and writing, career expectations, and career support. The survey explained 60.2% of the variance in the data, and the factors' values for Cronbach's alpha ranged between 0.80 and 0.96. Implications for mentoring graduate STEM students are discussed.
Keywords: graduate students, STEM, mentoring, ecological systems theory, theory of role modeling, exploratory factor analysis, interview study

Mentoring Experiences of Graduate STEM Students

by
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DEDICATION

To my parents and grandparents, I am what I am because of you. You worked hard to give me all I needed to succeed.

To my husband, Razvan, you were always by my side.

To my sons, Tudor and David, you are the light of my eyes. I love you so much, the most in this world. I am so lucky to have you.

To all the hard-working people who inspired me to become better.

BIOGRAPHY

I was born and raised in Romania, in a small town, Orlat, in the mountains, during communism. I was always proud of belonging to my hometown, whose first written attestation dates back to seven centuries ago. People in my town were close to each other, and they made me feel Orlat was the best place in the world to grow up. I felt like a strong link in a long-lasting chain. My parents and grandparents always surrounded me with love. My mom, Ana, had high expectations of me. It was instilled in me that education is a golden opportunity. I have always believed it, and I still believe it. My fondest memories from childhood are of being with my family during winter time, with lots of snow, and stories told by my grandmother, Ana, by a hot stove.

I always did extremely well in school. My role models were some of my teachers. After completing middle school in my town, I took and passed an entrance exam to the top high school, mathematics and physics focused, in the county capital, Sibiu. I rented a room from an older lady downtown and went home to my family during weekends. I initially felt intimidated by my high school classmates because they grew up in the city and had parents who completed high school and college, unlike my parents. Soon, however, I realized that I could achieve great academic success despite my origins.

After graduating with a Bachelor's degree in Physics, I became a teacher. I mainly taught physics to high schoolers in Romania for nine years before coming to the United States in 2006. In the United States, I have taught science and mathematics courses in the same county for the past 18 years to low-income, underrepresented students. Teaching brings me joy; I believe that one of the noblest professions is to be a teacher. In 2009 and 2013, I gave birth to two precious boys, Tudor and David.

In 2018, I was selected to be one of the teachers participating in a USDA-funded grant with Dr. Meg Blanchard and Dr. Richard Venditti at NC State University. That was the beginning of a wonderful learning experience. As a participant, I took online graduate courses and participated in professional development. I have always dreamed of being a doctor. In 2020, I applied to graduate school, was accepted, and asked Dr. Blanchard to be my advisor. I remained a full-time classroom teacher while being a part-time graduate student. The graduate school opened a door of learning opportunities for me, for which I am grateful. Most importantly, it allowed me to develop relationships with many fantastic, intelligent, hard-working, and inspiring people.

ACKNOWLEDGMENTS

To my mentor, Dr. Blanchard, I am so grateful for all you have done for me. I am thankful for your humor, kindness, warmth, knowledge, patience, availability, and all the opportunities you gave me to learn and connect with others. You challenged me to improve, and I loved every minute we spent together. You gave me opportunities to participate in research, which meant a lot to me as a part-time student. Being an international part-time student made me feel unfamiliar with graduate school. But you always answered my emails and texts, helped me choose my classes, and helped me deal with an overabundance of notifications received twice daily from the university's health services. You always had a smile, which meant the world to me.

To my committee members, Dr. K.C. Busch, Dr. Carla Johnson, and Dr. Richard Venditti, I appreciate your support, warmth, and kindness. Your feedback on my work and research ideas greatly improved the quality of my work and knowledge in the field. You guided me to learn and challenged me to improve my work and raise to high standards of rigor. I learned so much from you. I have always looked up to you. Thank you for all you have done for me.

To my dear friend Dr. Karen Collier, whom I met through the USDA-funded grant, you were fun to talk with and knowledgeable. You helped me navigate the program and encouraged and inspired me. You helped me analyze quantitative data, shared many resources, and gave me research ideas. I cherish the times when we went to conferences, drove in the same car, shared a room, walked in nature, and had good laughs. I am so grateful I met you.

To Dr. Katie McCance, you helped me learn so much about analyzing qualitative data and reporting research. I thoroughly enjoyed the summer months when we met weekly to prepare manuscripts. I also had a great time preparing presentations, presenting at conferences, and learning about your nephew or your neighbor's "cutting" the grass techniques. To my colleagues, Jennifer Sollinger and Dr. Sera Harold, and researchers Dr. Shana McAlexander and Dr. Tyler Harper-Gampp, you inspired and encouraged me. I am so lucky to have met you.

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Chapter 1

Introduction

The U.S. graduate STEM education is one of the best in the world, as evidenced by the high number of domestic and international students studying in the U.S. (NASEM, 2018). The number of master's and doctoral degrees awarded in STEM disciplines have increased continuously (NSB, 2024a), but attrition rates remain high (Bahnson & Berdanier, 2023; Sowell et al., 2015), and there is still gender, racial, and ethnic underrepresentation in STEM fields. However, the population of graduate STEM students becomes more diverse in terms of demographics, needs, and desired career paths (NASEM, 2018). The National Academies of Sciences, Engineering, and Medicine asserts, "The greatest benefit [of graduate STEM education] to U.S. society will only come when students from all segments … succeed in graduate school" (NASEM, 2018, p. 38). NASEM called for a revitalization of graduate STEM education for the 21st century, and one way to do it was through mentoring. Many studies recognize mentoring as essential to the success of graduate STEM students, fostering their academic achievement and personal growth and giving them the confidence to succeed in their programs (Antonio & Baek, 2012; Karalis Noel et al., 2022; Kumar & Coe, 2017). There is a gap in the literature on how mentoring in graduate STEM education can become more student-centered so that graduate students can reach their educational and professional goals (Collier & Blanchard, 2024; NASEM, 2018).

Literature Review

Challenges of Graduate STEM Students

Graduate STEM students in the U.S. face a range of challenges, including academic pressure, lack of research support, resource competition, gender and identity issues, and financial strain (Collier & Blanchard, 2024; Crede & Borrego, 2014; Dutta, 2015; Han & Appelbaum, 2016; Lim et al., 2021; Zhou, 2014). They are overly specialized but unprepared for their writing tasks and lack awareness of career options (Deshpande, 2016; Harshman, 2020; Thiry et al., 2015; Zerbe & Berdanier, 2019). International graduate STEM students face additional challenges, as they encounter cultural, racial, and social barriers, and language, communication, and writing difficulties (Han & Appelbaum, 2016; Jiang, 2014; Rodriguez et al., 2024) and are unfamiliar with U. S. norms and rules (Steele et al., 2015).

Mentoring

Mentors play a critical role in graduate students' success; a study by Lovitts and Nelson (2000) found that students perceived their relationship with mentors as the most important factor in whether to withdraw or persist in the program. Mentees expect mentors to provide research and career guidance and psychological support and to help them develop into independent thinkers (Richard & Yoon, 2023). Cantwell et al. (2018) found that positive relationships with mentors are crucial for students' academic and personal development. Mentors can be a source of academic guidance and personal support and are often available to mentees in professional situations (Lechuga, 2011; Marijanovic et al., 2021). Posselt (2018) found that mentors provide psychosocial support as they validate underrepresented STEM doctoral students' competence and potential, reduce their anxiety, and promote a growth mindset.

Ineffective mentoring practices can inhibit the students' research productivity and increase stress and the likelihood of leaving the program (Montgomery et al., 2022). Tuma et al. (2021) found that negative mentoring was manifested in ways that were specific to the research the graduate STEM students conducted and to their stage in the program. Limited psychosocial and career support, the mentor's unavailability, and limited mentor's interpersonal abilities and expertise were some common forms of negative mentoring (Tuma et al., 2021).

This dissertation includes two studies and investigates the mentoring experiences of graduate STEM students. The first study included interviews with domestic and international mentors and their former doctoral mentees. Mentees were recently graduated STEM PhDs who were both domestic and international. This study focuses on understanding the mentoring experiences the mentors used to support the development of graduate STEM students, from the perspective of the mentors and their mentees. The following research questions guided the qualitative study:

1. Overall, how did mentors and mentees describe mentors' mentoring approaches?
2. What mentoring approaches do mentors use to support the development of graduate STEM students?
3. How do graduate STEM students describe their mentor's mentoring approach and aspects that are supportive (or lacking) of their development?
4. What does a dyad analysis reveal about the differing perspectives of the mentor and mentee on perceived mentoring?

In the quantitative study, a survey, Mentoring Experiences of Graduate Students (MEGSS), was developed and validated. The following research questions were addressed:

1. Is the Mentoring Experiences of Graduate Students Survey (MEGSS) a valid and reliable instrument for measuring graduate STEM students' perceptions of their mentoring experiences that were supportive of their development?
2. What are the differences in graduate STEM students' perceptions of their mentoring experiences:

a. Based on gender?

H1: Female students will have more negative experiences with the measured mentoring factors (i.e., less psychosocial and career support).

b. Based on citizenship status?

H2: International graduate STEM students will have more negative experiences with the measuring mentoring factors (i.e., career expectations and career support).

c. Based on enrollment status?

H3: Part-time students will have more negative experiences with the measured factors (i.e., research and writing, career expectations, and career support).

d. Based on academic discipline?

H4: The mentoring experiences of graduate students regarding the measured factors (i.e., research and writing, program completion, career support, and career expectations) will differ.

3. Will the constructs of the survey have an impact on graduate STEM students' program completion and career expectations?

H5: The composite scores for psychosocial support, research and writing, and career support will have a significant impact on students' composite scores for program completion in a regression model.

H6: The composite scores for psychosocial support, research and writing, and career support will have a significant impact on students' composite scores for career expectations in a regression model.

Theoretical Frameworks

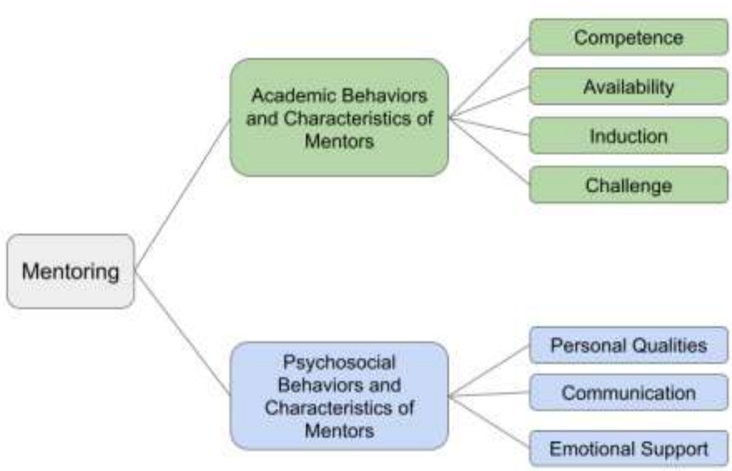
In the qualitative study, Yob and Crawford's conceptual framework of mentoring and Chandler et al.'s (2011) ecological systems theory were used. The quantitative research was guided by Yob and Crawford's (2012) conceptual framework of mentoring and Morgenroth et al.'s (2015) motivational theory of role modelling.

Yob and Crawford's Conceptual Theory of Mentoring

Yob and Crawford (2012) conducted a literature review on mentoring doctoral students. They found fifty-five behaviors or actions of mentors that supported the development of students, which were grouped into academic and psychosocial domains. Most studies focused on doctoral students and few on mentors' perceptions. The academic domain of mentoring includes competence, availability, induction, and challenge, while the psychosocial domain includes the faculty member's personal qualities, communication, and emotional support (Yob & Crawford, 2012) (Figure 1.1).

Figure 1.1

Conceptual Framework of Mentoring (Re-drawn from Yob and Crawford, 2012)



Academic Behaviors

The *competence* of mentors is reflected in their knowledge of the field, program requirements, and available resources and how to access them (Yob & Crawford, 2012). The *availability* of mentors includes sharing time to discuss professional and non-professional issues. Mentors are responsible for the students' *induction* into the program, department, and new professional roles by connecting them with other professionals and networks, helping them learn skills, working with mentee to design, conduct, and report research, and working together on writing grants and publishing papers (Yob & Crawford, 2012). *Challenging* the mentee includes constructive criticism of the academic work and guidance toward achieving learning and professional goals.

Psychosocial Behaviors

The psychosocial domain of the conceptual framework of mentoring includes the faculty member's personal qualities, communication, and emotional support (Yob & Crawford, 2012). Yob and Crawford (2012) found the following *personal qualities* of the mentors: trust, friendliness, sense of humor, patience, and comfort with the student's growing independence. *Communication* is described as active listening, effective dialogue, being trusted, and openness (Yob & Crawford, 2012). The mentors' *emotional support* is described as increasing students' self-esteem and confidence, encouraging and affirming the students' potential, promoting students' academic interests, modeling self-care during the program, and encouraging acceptance, caring, and encouragement.

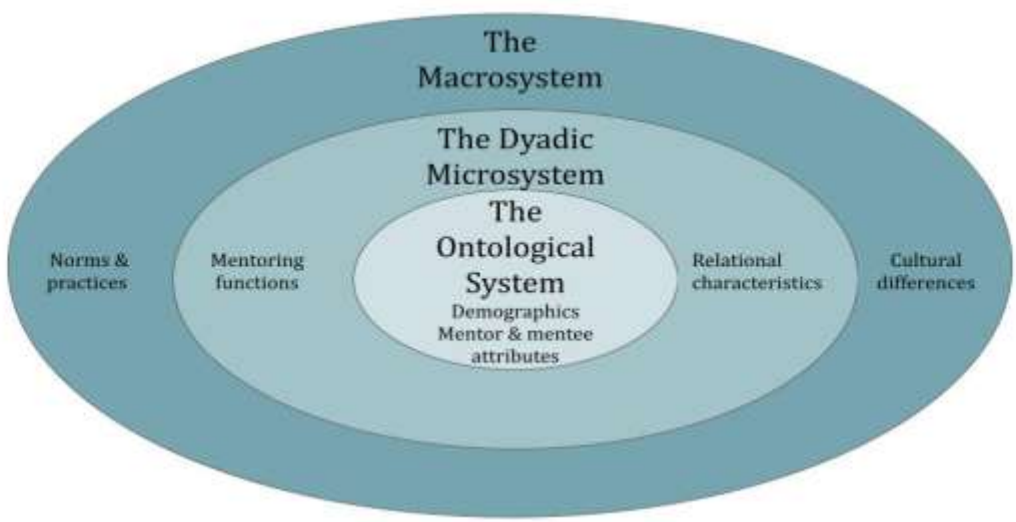
Yob and Crawford (2012) identified the need to further investigate whether faculty members, students, and graduates agree on what constitutes effective mentoring. Also, they noted "there are few if any studies that systematically compare student, alumni, and faculty member perceptions of mentoring" (Yob and Crawford, 2012, p.44). Their framework is used in this study in several ways. In the qualitative study, their framework is used to understand what mentoring approaches mentors used to support the development of graduate STEM students, from both the mentors' and former mentees' (recent graduates') perspectives. In the quantitative study, aspects of the academic and psychosocial behaviors were used to develop many of the survey items.

Chandler et al.'s (2011) Ecological Systems Theory

Ecological systems theory (Bronfenbrenner, 1977; Chandler et al., 2011) is a framework for understanding human development. It emphasizes that a person's development is influenced by connecting environmental systems (Figure 1.2).

Figure 1.2

Ecological Systems Theory (Re-drawn from Chandler et al., 2011)



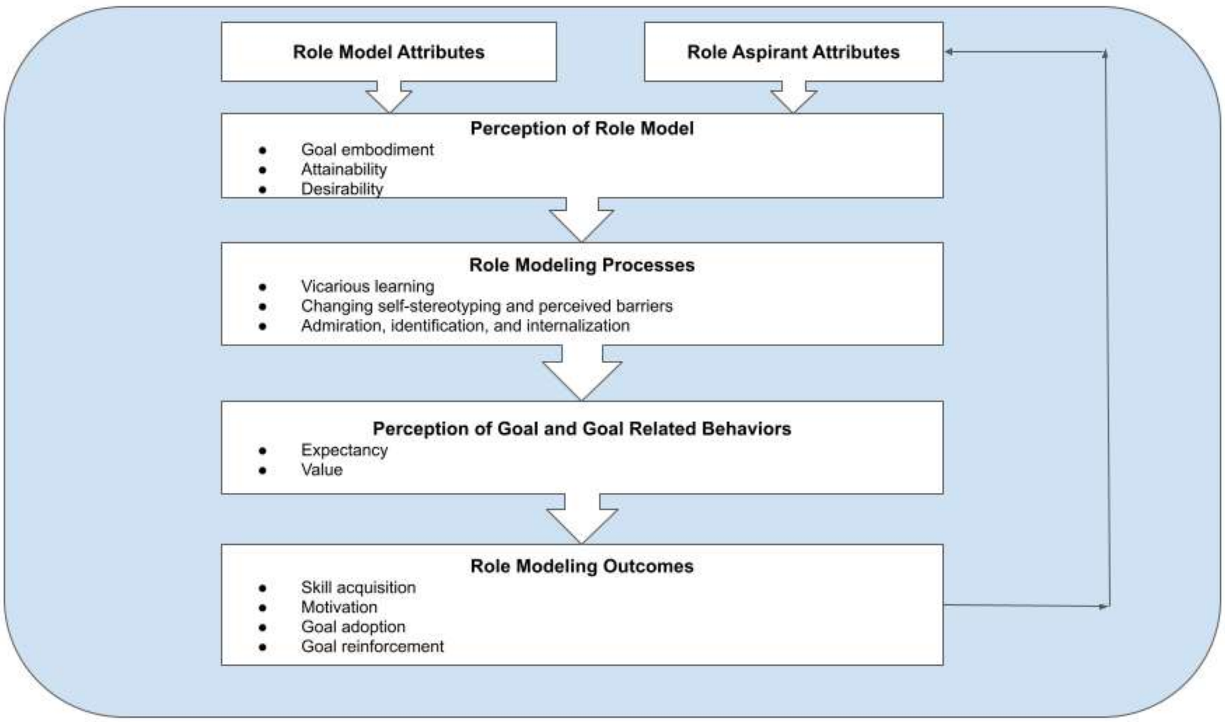
Chandler et al. (2011) described the inner circle, the *ontological* system, as individual characteristics and behaviors that affect how people respond to their social environment, such as mentoring. Examples of ontological factors are demographics, such as gender, race, nationality, and stage in the program, and mentor and mentee attributes. The next circle, *the microsystem*, is the immediate environment in which a person interacts, such as the dyadic relationship with a mentor, network structure, or organizational mentoring program characteristics. The dyadic relationship with a mentor includes mentoring functions and processes (e.g., mutual learning, empathic teaching, or sensitivity). The next circle, *the macrosystem*, refers to organizational, technological, and societal forces, such as institutional patterns, cultural and societal factors, power dynamics, mentoring in multicultural places, beliefs, and norms. Chandler et al.'s (2011) framework provides a way to better understand the complex, layered-nature of graduate student development, as mentoring includes not only the academic and psychosocial behaviors mentors used but also cultural and ethnic factors and norms and practices present in society and (in this case) STEM fields.

Morgenroth et al.'s (2015) Motivational Theory of Role Modeling

A role model is a person, such as a mentor, whose behavior serves as an example for others to follow, such as a graduate STEM student. Morgenroth et al. (2015) described role models as individuals who, acting as behavioral models and being representations of the possible as well as inspirations, influence role aspirants' achievements, motivation, and goals. The framework is presented from the viewpoint of the role aspirants, such as graduate STEM students, by linking the role model attributes (success and competence), and the role aspirant attributes (pre-existing goals) with the perception of role model, role modeling processes, perceptions of goals and goals related behaviors, and outcomes (Figure 1.3).

Figure 1.3

Overview of the Motivational Theory of Role Modeling (Adapted from Morgenroth et al., 2015)



Morgenroth et al. (2015) introduced four propositions in their theory to explain how role models help role aspirants achieve outcomes: 1) Identified goal embodiment shapes expectancy, motivation, and goals by initiating vicarious learning; 2) Identified goal embodiment and identified attainability combine to shape expectancy, motivation, and goals by altering self-stereotyping; 3) Identified goal embodiment and identified attainability combine to shape expectancy, motivation, and goals by altering identified external barriers; 4) Identified desirability shapes value, motivation, and adoption of new goals by initiating personal identification, internalization, and admiration (Morgenroth et al., 2015, pp. 472 - 477). This framework provides insight into how the academic and psychosocial support the mentees described their mentor provided impacts students' outcomes in terms of program completion and career expectations. This framework has also been adapted to describe how graduate STEM students served as role models (Topliceanu et al., 2025).

Purpose

The purpose of this dissertation's first study was to investigate the mentoring approaches mentors used to support the development of graduate STEM students from the perspectives of mentors and their former mentees, recent doctoral graduates. The findings from this study informed the development of the mentoring experiences of graduate STEM students' survey, which was distributed and validated, in the second study, with a larger population of domestic and international students. The purpose of the second study was to understand how graduate STEM students' perceived mentoring support, and how these may have impacted students' program completion and career expectations outcomes. Ultimately, the goal of the dissertation was to understand how to improve the mentoring experiences of domestic and international graduate STEM students and improve attrition rates. The survey could be a useful instrument for universities, colleges, and departments to assess mentoring in graduate programs.

Organization of Dissertation

There are four chapters in this dissertation. The first chapter is an introduction to the entire dissertation. In the second chapter, which is a qualitative study, interview data from eight mentors and twenty former mentees, recent STEM doctoral graduates, were analyzed to reveal perceptions of the mentoring approaches the mentors used to support the development of students. The perspectives of both mentors and former mentees were described to get a more nuanced description of mentoring. Deductive and inductive coding was used. The findings allowed gaining a richer understanding of the mentoring experiences than quantitative analysis would reveal.

The third chapter, which is a quantitative study, details the development and administration of a survey for graduate students' perceptions of their mentoring experiences, their expectations for program completion and career support. The graduate mentoring experiences survey was developed and validated using exploratory factor analysis with 280 domestic and international graduate STEM students from one large, public, research-intensive public university in the southeastern U.S. Item analyses revealed differences in psychosocial support, program completion, research and writing, career expectations, and career support for varied subgroups based on gender, citizenship status, stage in the program, and STEM discipline.

The fourth chapter, which is a summary chapter, connects the findings from the two studies. This dissertation's findings, conclusions, recommendations, and implications are presented, as well as future areas of research that could be used by academic institutions to improve the mentoring experiences of domestic and international graduate STEM students.

CHAPTER 2

Graduate STEM Mentoring through Mentor and Mentee Perspectives: A Qualitative Study

Abstract

Science, Technology, Engineering, and Mathematics (STEM) professionals are needed in the United States (U.S.) Although the number of domestic and international graduate STEM students has increased, the attrition rates remain high. Mentoring is a key component of addressing high attrition rates and supporting the success of graduate STEM students. In this qualitative study, interviews with eight STEM mentors and twenty domestic and international mentees, recent doctoral graduates from four large public, research-intensive universities in the southeastern U.S., were analyzed. Yob and Crawford's (2012) conceptual framework of mentoring and Chandler et al.'s (2015) ecological systems theory were used in this study. The mentors and the mentees described the mentor using academic behaviors such as induction, challenge, availability, and competence and psychosocial behaviors such as emotional support, communication, and personal qualities to support their development. Six of eight mentors described mostly academic behaviors. Seven of the nine domestic and six of the eleven international mentees described mostly academic behaviors. Implications for mentoring graduate STEM students are discussed.

Keywords: graduate students, STEM, mentoring, ecological systems theory, interview study

Introduction

There is an increasing need for Science, Technology, Engineering, and Mathematics (STEM) professionals in the United States (U.S.) to support the country's competitiveness in the world, its advancements in innovation and technology, and an elevated quality of living for its citizens (American Immigration Council, 2022). Compared to 2021, STEM jobs in the U. S. are expected to grow by 10.8% by 2031 (Krutsch & Roderick, 2022), and there are not enough U.S. citizens to fill in STEM careers (National Science Board [NSB], 2022). In 2021, 43% of all science and engineering jobs at the doctoral level were held by foreign-born individuals (NSB, 2024b). Foreign-born individuals are important to the STEM workforce, as well as in higher education institutions. U. S. universities rely greatly on foreign-born individuals to fill their graduate STEM programs, which have attracted international students with strong aptitudes in STEM (NSB, 2022).

The U.S. is a leader in graduate STEM education, as evidenced by the high number of international students who come to study in the country (Leshner & Scherer, 2019). In science and engineering graduate programs alone, over 300,000 graduate students were studying in the U.S. in 2022 (NSB, 2024b). However, despite the high enrollment of domestic and international students in graduate STEM education programs (National Academies of Sciences; Engineering; and Medicine [NASEM], 2018), attrition rates in graduate STEM programs remain high (Bahnson & Berdanier, 2023; Sowell et al., 2015). Graduate STEM students experience "high-pressure environments, cloudy career prospects, [and] an imbalance of work and life" (NASEM, 2018, p. 83). International graduate STEM students face additional challenges as they experience a different culture and language while studying STEM in the U.S. (Collier & Blanchard, 2024; NASEM, 2018; Rose, 2005).

Mentoring is a key component ensuring the success of graduate STEM students (NASEM, 2018; Yob & Crawford, 2012) from both academic and personal perspectives (Antonio & Baek, 2021; Kumar & Coe, 2017). Good mentors offer time management strategies, provide feedback, and set clear expectations for graduate students while remaining flexible in considering their needs and pace (Kumar & Coe, 2017). Multiple studies have indicated the importance of effective mentoring, showing that mentors develop mentees' sense of professional competence (Lechuga, 2011), inspire the mentees to pursue or abandon a career path in academia (Karalis Noel et al., 2022), or give them the confidence to succeed in their graduate programs (Janssen et al., 2021). A skilled, knowledgeable, and responsive mentor is perceived as positively impacting learning, while an unresponsive mentor negatively impacts learning and the student's experiences (Norton & Hathaway, 2008). Advising international students ought to include different considerations compared to domestic students, as international students come from different academic cultures and may have different communication styles and expectations (Zhang & Dinh, 2017). The National Academies of Sciences, Engineering, and Medicine highlight the importance of providing effective mentoring practices and call for a systemic change in the graduate STEM education system "that better meets the evolving needs of its students" (NASEM, 2018, p.127).

Despite effective mentoring's importance, there is scant research that focuses on whether mentors and mentees concur on what constitutes effective mentoring strategies, or doctoral alumni perceptions of the mentoring they received (Yob & Crawford, 2012). Janssen et al.'s 2021) study analyzed how nine dyads of mentors and their former doctoral mentees from social science and engineering programs in the Netherlands perceived the fulfillment of basic psychological needs for autonomy, competence, and relatedness. There were two people in each dyad (former supervisor-student), and all participants were domestic to the Netherlands. Regarding autonomy, they found that both the mentors and the mentees expect the other to take the lead during the dissertation project. Concerning the fulfillment of competence, mentees saw the mentors as "all-inclusive role models…" but the authors cautioned that "mentors can rarely live up to this” (Janssen et al., 2021, p. 2746). Also, mentors believe that mentees should become real researchers while the mentees doubted themselves as being competent researchers; their mentors were barely able to help graduate students to overcome their insecurities. With regard to the fulfillment of relatedness, both mentors and mentees felt that they should develop a personal relationship but without going into too many personal topics. Also, both mentors and mentees concurred on the fact that the mentors should create a sense of belongingness for their mentees. Janssen et al.’s (2021) study did not refer to international participants and examined mentoring from the perspective of psychological needs. This current study aims to build on this work and address gaps by investigating the perceptions of mentors and their (recent) former doctoral domestic and international student mentees regarding their academic and psychosocial mentoring strategies, conducting the work in a different country (the U.S.), and focusing on dyads that include mentors who are both international and domestic, as well as their mentees being both international and domestic. Particularly given the high number of international STEM students enrolled in graduate programs in the U.S., better understanding the experiences of these students could lead to enhanced mentoring practices, better support, retention, and better outcomes for all students in graduate education.

Literature Review

Graduate STEM Students

Graduate STEM students contribute to the advancement of research and innovation, the growth of the U.S. economy, and the well-being of people (NASEM, 2018). In 2024, there were approximately 320,000 full-time master’s students and 260,000 doctoral students enrolled in Science, Engineering, and Health Sciences programs and about 55% of them were domestic students (Smith et al., 2024). STEM graduates find employment in a variety of jobs. The

National Science Board reported that in 2021, 48.8% of the science, engineering, and health research doctorate recipients living in the U.S. worked in a business or industry, 42.3% in a college or university, and 9% in government (NSB, 2024a).

Graduate STEM programs vary from one university to another (Leshner & Scherer, 2019), but they have a notable similarity: graduate students are guided by faculty mentors on how to conduct highly specialized research (Atkinson & Slatta, 2021). Conducting and publishing in doctoral STEM programs is of high importance, while mentoring is thought of as less important to faculty members and institutions (NASEM, 2018). The National Academies of Sciences, Engineering, and Medicine asserts, "The incentive structure under which faculty members operate regarding tenure, promotion, and procuring grants defines the culture of U.S. academic research institutions and deemphasizes the importance of teaching and mentoring" (NASEM, 2018, p. 19). In addition, the pool of graduate STEM students is continuously changing, and some of their educational needs might be overlooked when producing high-quality research (NASEM, 2018). Leshner and Scherer (2019) assert that graduate STEM education in the U.S. needs to implement changes, such as improving the quality of advising and mentoring, with a strategic balance between designing, conducting, and reporting research and mentoring.

International Graduate STEM Students

In 2024, there were more than half a million international students studying in the U.S., an all-time high (International Educational Exchange [IEE], 2024). Over half of them (56%) studied in STEM fields; one-fourth were enrolled in math and computer science and approximately one-fifth in engineering (IEE, 2024). In 2019, 59% of the computer sciences, 58% of the engineering, and 51% of the math and statistics doctoral degrees were awarded to international students (NSB & NSF, 2022).

The reasons international graduate STEM students come to study in the U.S. vary. In a survey of 787 international and 1535 domestic graduate STEM students, Han and Appelbaum (2016) found that 84% of international graduate students reported they were drawn by the higher quality of education in the U.S., and 74% listed future career opportunities in the U.S. as more promising than their domestic country. Consistent with these findings, the high global ranking of the U.S. university is an important factor (Furukawa et al., 2013; Han et al., 2015), as well as better job opportunities, professional networks, better mentorship than in their native country (Han et al., 2015), and an interest in pursuing academic research (Zhou, 2014).

International graduate STEM students are extremely important to research development and innovation in the U.S. (Hegarty, 2014). They add diversity to the institution's community and enhance its academic life (Moglen, 2017). International graduate STEM students represent a valuable workforce for U.S. multinational businesses because they are familiar with their native country and the U.S. (Gesing & Glass, 2019; IEE, 2024). They contribute financially to their academic institutions and to the cities where they live (Ruiz, 2014). In 2023, international students contributed over $50 billion to the economy, constituting a substantial financial gain for the U.S. (IEE, 2024). In addition, there are educational benefits for domestic students who interact with international students. Luo and Jamieson-Drake (2013) surveyed 5,676 U.S. citizens who were alumni from four private research universities in the U.S. They found that their interactions with international students "contributed to U.S. students' serious questioning of their beliefs and values… which was positively related to their acquisition of general education, leadership skills, and intellectual development" (p. 96).

Challenges International Graduate Students Experience while Studying STEM in the U.S.

Han and Appelbaum (2016) conducted a quantitative study on graduate STEM students from 10 U.S. universities with the largest percentages of international students. Using survey data, they found that 63.1% of international graduate students reported cultural challenges, 58.9% social challenges, 47.6% financial challenges, 42.5% academic challenges, and 22.2% racial challenges (Han & Appelbaum, 2016). Proficiency in English skills is a common barrier faced by graduate STEM students from many countries; however, there is a range of linguistic diversity (Agrawal & McNair, 2021), which is based on their prior social and academic experiences (Moglen, 2017). Jiang (2014) conducted an exploratory case study with three Chinese graduate students working as Biology teaching assistants in a public research university in the South of the U.S. The Chinese graduate students felt that the English education they received in China was focused mainly on reading and writing and did not prepare them well for speaking English. Chinese students are taught to be modest and not initiate conversations as part of their cultural identity; low perceptions of the TA’s English skills might result from cultural differences (Jiang, 2014). Gender also impacts the lived experiences of international graduate STEM students. International female engineering students perceived multiple struggles in their STEM programs due to gender and non-U.S. nationality (Dutta, 2015; Lim et al., 2021).

International graduate STEM students encounter a wide variety of barriers, yet all of them have a common denominator: these barriers influence the probability of completing the degree in the U.S. Crede and Borrego (2014) conducted a study with 685 international doctoral engineering students and found that the international students who felt they had to compete for resources such as meeting times with faculty, funds, and materials were more likely to drop out of their graduate STEM program. The international students who felt that they were less likely to complete their graduate degree reported perceived higher levels of competitiveness for resources in research groups and feelings of not fitting in or not being comfortable speaking up in group meetings. In a qualitative study of six Chinese doctoral STEM students in the U.S., Zhou (2014) found that limited academic research support from the advisor led to international graduate students' dissatisfaction with the program. Unmatched expectations between students and advisors, academic and/or mental unpreparedness for challenging research, and loneliness were also reasons for dissatisfaction. However, despite these challenges, the participants felt motivated to stay in their programs because of their high interest in research, high utility value (usefulness) of the U.S. Ph.D. training as a pathway to permanent residence, and shame of failure.

U.S. Norms and Rules

Unfamiliarity with U.S. norms and rules is another barrier international students face (Steele et al., 2015). Steele et al. (2015) conducted two related quantitative studies on ethics training in the Southern U.S. The first involved 57 international and 174 domestic graduate students; the second studied 127 pairs of domestic and international graduate students. The researchers found that international graduate students, most of whom were from Asia, oversimplified ethical problems. The authors concluded that the oversimplification of ethical problems came from international graduate students' unfamiliarity with the rules and regulations present in the U.S.

Mentoring

Mentoring is immersed in higher education programs, representing a key component of graduate student success (Yob & Crawford, 2012). Ideally, mentors are competent professionals who know the field and research methods, educational program requirements and how to navigate them successfully, and how to access institutional and human resources (Yob &

Crawford, 2012). “A mentor’s role combines academic guidance with career advice, role modeling, and varying amounts of emotional support to help students succeed through graduate school” (NASEM, 2018, p.118). Great mentors are generous with their time and invest themselves in the success of their mentees (Bell & Rosowsky, 2021). Regular contact between mentor and mentee is crucial, in terms of gaining the most from mentoring relationships: the higher the interaction frequency, the higher the mentee’s perceptions of support and relationship quality is likely to be (Eby et al., 2013).

The mentee-mentor relationship greatly impacts the quality of graduate STEM students’ experiences (Leshner & Scherer, 2019). There is substantial variation in mentor relationships from positive to negative experiences (Leshner & Scherer, 2019; Tuma et al., 2021) and to comprehend effective mentoring relationships, both positive and negative aspects must be understood (NASEM, 2019).

Meaningful mentoring experiences were reported by underrepresented STEM doctoral students when faculty employed academic, psychosocial, and sociocultural behaviors, promoted a growth mindset, and validated student competence and potential (Posselt, 2018). Posselt (2018) conducted a qualitative study of 29 underrepresented, current or former STEM doctoral students from two research universities. The researcher found that even if the faculty were seen as the last resort for academic support, after peers and postdoctoral fellows, the faculty provided psychosocial support by “reframing situational struggles to reduce anxiety,…disrupting self-doubts with personal validation,…[and] by ‘keeping it real’ about race and gender in the academy” (pp. 12-15). Faculty’s visibility and responsiveness along with professors’ downplaying of their status in the faculty-student hierarchy led to candid conversations and trusting relationships.

Ineffective and damaging mentorship practices are "detrimental to the conduct of research, leading to lower job satisfaction, higher likelihood of leaving, and increased stress" (Montgomery et al., 2022, p. 85). While doctoral students face negative mentoring experiences that are similar to undergraduates and people in the workplace, they also encounter unique negative mentoring forms specific to their research and stage in the program (Tuma et al., 2021). Tuma et al. (2021) conducted a qualitative study involving 40 life science doctoral students from 22 public and private research intensive U.S. universities and reported a list of 17 forms of negative mentoring experiences. The most common forms of negative mentoring include: limited career support (n = 38), inaccessibility of mentor due to too many professional obligations or personal events (n = 38), limited interpersonal abilities of mentors (n = 34), unmatched supervisory styles (n = 34) such as overly controlling or minimal communication or feedback, limited psychosocial support (n = 28) such as not receiving counseling, affirmation, acceptance, or confirmation from the mentor, social undermining (n= 23), and limited expertise (n = 23).

Rice et al. (2009) conducted a study involving 367 international graduate (STEM and non-STEM) students from the University of Florida. Using quantitative and qualitative analyses on a survey that included closed and open-ended questions, the authors found that an ideal advisor shows cross-cultural empathy, has interpersonal relationships with their advisees, provides financial support through scholarship and fair pay, collaborates, and has similar personalities and interests to the international graduate students. The ideal advisor works with international graduate students to overcome cultural and language barriers, meets the students' special needs, and provides guidance and feedback. Rice et al. also included the characteristics of an advisor being personable, respectful, fair, and communicating openly.

In a qualitative study with 28 doctoral candidates in geosciences, chemistry, physics, mathematics, engineering, and life sciences from a research university in the western U.S., De Welde and Laursen (2008) found that the participants received varied levels of career advice, support, and guidance. Based on the participants' narratives, the researchers developed features of an ideal type advisor of doctoral STEM students that included: creating structure for labs, meetings, and communication; offering support; making time for students; setting high standards; fostering independent work; encouraging independent thinking; increasing challenges as students develop; encouraging attending conferences; publishing studies, and writing grants, but also being flexible and concerned with student's well-being and reflecting on their advising style.

Despite the recognized role of mentoring in supporting graduate students' success, only 63.8 % of STEM and 54.6% of non-STEM faculty reported participating in mentoring training (Stolzenberg et al., 2019). A national survey of 20,771 full-time undergraduate teaching faculty at 143 U.S. colleges and universities by Stonzelberg et al., found that the faculty who participated in mentoring training considered themselves more skilled in their mentoring relationships than those who did not. Skills included giving constructive feedback, taking into consideration the biases and prejudices they bring to the mentor-mentee relationship, and being an advocate for the mentee.

Frameworks

Yob and Crawford's (2012) conceptual framework of mentoring and Chandler et al.'s (2011) ecological systems theoretical framework are used in this study. These two frameworks together add a more nuanced understanding of the mentoring experiences than each individual framework would do as Yob and Crawford's academic and psychosocial behaviors of mentors are mapped onto Chandler et al.'s ecological systems.

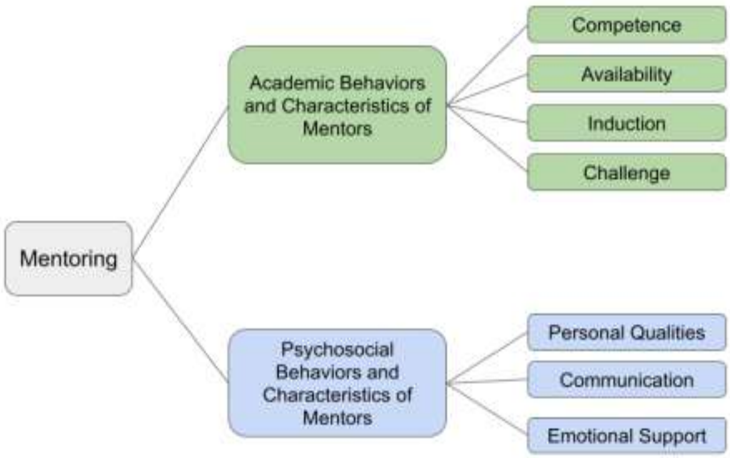
Yob and Crawford's (2012) Conceptual Framework of Mentoring

Yob and Crawford's framework was influenced by Kram's (1983) research on the stages of a mentoring relationship. Kram studied 18 relationships in the corporate setting and described the mentor relationship between two individuals as an avenue to enhance both individuals' career and psychosocial development. The *career* functions of mentoring include sponsorship, coaching, protection, exposure and visibility, and challenging work assignments. In contrast, *psychosocial* functions refer to a sense of competence, clarity of identity, and effectiveness. The participants in Kram's research were 15 young managers, White males working at a large northeastern U.S. public utility (Kram, 1983) and the study was conducted at a time when underrepresented groups were even less present than today in the workforce and higher education (Dominguez & Hager, 2013).

In their literature review of studies on mentoring doctoral students, Yob and Crawford (2012) found "at least four lines of inquiry around mentoring: perceptions of successful mentoring in general, mentoring of doctoral dissertations in particular, mentoring specific to the online environment, and relative importance of mentoring behaviors" (Yob & Crawford, 2012, p. 34). Fifty-five behaviors or actions of mentors that supported doctoral students' success were identified. The researchers clustered the findings on mentoring into a model with academic and psychosocial domains (Figure 2.1). The included studies were not specific to a discipline. Most of the studies included in the literature review focused on doctoral students, while "very few studies focused on mentors' perceptions" (Yob & Crawford, 2012, p.36).

Figure 2.1

Conceptual Framework of Mentoring (Re-drawn from Yob and Crawford, 2012)



The academic domain of mentoring includes competence, availability, induction, and challenge, while the psychosocial domain includes the faculty member's personal qualities, communication, and emotional support (Yob & Crawford, 2012). The *competence* of mentors is reflected in their knowledge of the field, program requirements and available resources and how to access them. The *availability* of mentors includes "sharing their time outside of class for student needs" (Yob & Crawford, 2012, p. 39) to discuss professional and non-professional issues, in various places. Mentors are responsible for the students' *induction* into the program, department, and new professional roles by connecting them with other professionals and networks, helping them learn skills, working with mentee to design, conduct, and report research, and working together on writing grants and publishing papers. Not only that, but "the mentor is a gatekeeper to the profession by screening candidates for emotional, ethical, interpersonal, and academic fitness" (Yob & Crawford, 2012, p. 40). *Challenging* the mentee, including constructive criticism of the academic work and guidance toward achieving learning and professional goals, is an essential aspect of the academic domain of mentoring.

The psychosocial domain of the conceptual framework of mentoring includes the faculty member's personal qualities, communication, and emotional support (Yob & Crawford, 2012). In their literature review, Yob and Crawford found the following *personal qualities* of the mentors: trust, friendliness, sense of humor, patience, and comfort with the student's growing independence. *Communication*, through "active listening" and "effective dialogue," evolves in time, acquires "a more mutual and collegial quality" and grows when "trusted and open" (Yob & Crawford, 2012, pp. 42-43). The mentors' *emotional support* represents a primary component of the psychosocial domain. Increasing students' self-esteem and confidence, encouraging and affirming the students' potential, promoting students' academic interests, modeling self-care during the program, and encouraging acceptance, caring, and encouragement are all significant attributes of successful mentoring practices.

Yob and Crawford (2012) asserted that "current literature indicates that mentoring approaches need to be adjusted to take into account the gender and cultural or ethnic backgrounds of both mentees and mentors in higher education today" (p. 44). In addition, the researchers noted that "future research needs to confirm, disconfirm, extend, or contrast the two domains and seven attributes that form the conceptual framework for mentoring based on the literature review" (Yob & Crawford, 2012, p. 44).

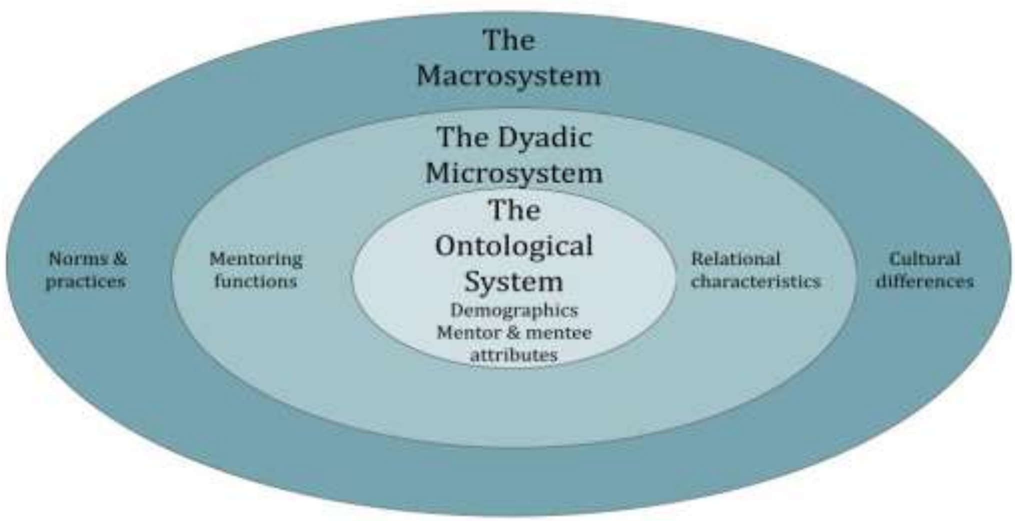
Chandler et al.'s (2011) Ecological Systems Theoretical Framework

Ecological systems theory (Bronfenbrenner, 1977; Chandler et al., 2011) is a framework for understanding human development. It emphasizes that a person's development is influenced by interconnected, multiple-level environmental systems (Figure 2.2). Chandler et al. (2011)

proposed thinking about mentoring as more than an interaction between mentor and mentee in a dyadic relationship, but also "as a property of the whole system" (p. 521). Mentoring is situated at the intersection of social and psychosocial structures, has a systemic nature, and the outcomes of mentoring depend not only on the mentor's and mentee's attributes and dyadic factors, but on larger factors, such as support and structure of the network and the organizational and societal contexts.

Figure 2.2

Ecological Systems Theory (Re-drawn from Chandler et al., 2011)



The ecological system consists of the ontological system, microsystem, and macrosystem. Chandler et al. (2011) described the inner circle, the *ontological system,* as individual characteristics and behaviors that affect how people respond to their social environment, such as mentoring. Examples of ontological factors are demographics, such as gender, race, nationality, and stage in the program, and mentor and mentee attributes. The next circle, *the microsystem*, is the immediate environment in which a person interacts, such as the dyadic relationship with a mentor, network structure, or organizational mentoring program characteristics. The dyadic relationship with a mentor includes mentoring functions and processes (e.g., mutual learning, empathic teaching, or sensitivity). The next circle, *the macrosystem*, refers to organizational, technological, and societal forces, such as institutional patterns, cultural and societal factors, power dynamics, mentoring in multicultural places, beliefs, and norms.

Methods

Research Design

This is a qualitative study (Merriam, 2009). In this research design, "the purpose is to understand how people make sense of…their experiences" (Merriam, 2009, p. 23). This study focused on individual interviews with former domestic and international doctoral STEM students as well as their international and domestic doctoral faculty mentors to understand their mentoring experiences. This study investigates the STEM mentors' experiences as well as the domestic and international mentees' perceptions of the mentoring they received while doctoral students.

Research Questions

To better support an increasing body of international and domestic graduate STEM students and improve graduate STEM education in the U.S., this study seeks to understand mentoring experiences from both the perspectives of mentors and mentees. The participants in this study were STEM faculty and their former mentees, recent graduates. The following research questions are addressed:

1. Overall, how did mentors and mentees describe mentors' mentoring approaches?

2. What mentoring approaches do mentors use to support the development of graduate STEM students?
3. How do graduate STEM students describe their mentor's mentoring approach and aspects that are supportive (or lacking) of their development?
4. What does a dyad analysis reveal about the differing perspectives of the mentor and mentee on perceived mentoring approaches?

Context

This study drew some of its participants from two grant-funded projects, which had involved work with science and engineering professors and some of their doctoral students. The first was a USDA-funded grant project focused on increasing student awareness and interest in bioproducts and the bioeconomy for undergraduates and high school students who are from underrepresented groups in science and engineering (Blanchard et al., 2021). The second project is a four-year National Science Foundation grant involving STEM and Education colleges from three large, public, and private research universities (Zhu et al., 2022). The grant's purpose was to conduct interdisciplinary research to develop biodegradable, flexible electronics and promote high school students' interest in STEM careers through Zoom visits, field trips to campus laboratories, and STEM career explorations. Three STEM professors involved in the two grant projects were some of the participants in this study.

Participants

There were 28 participants in this study: eight professors (mentors) and twenty STEM doctoral graduates (mentees) (Table 2.1). There were four international and four domestic professors; four male and four female. There were thirteen male and seven female graduates.

Eleven graduates were international, and nine were domestic. One STEM graduate had two mentors, both of whom were interviewed.

Table 2.1

Description of STEM Mentors and Mentees

		Mentors		
Name	**STEM field**	**Country of origin**	**Gender**	**Names of mentees**
Dr. Powell	Materials Science	U.S.	male	Maria (int), Gabriel (dom)
Dr. Benito	Natural Resources and Engineering	U.S.	male	Maria, Sonja, Roman, and Luna (int), and Jack (dom)
Dr. Yao	Chemical Sciences	East Asian country	male	Quinn (int), and John, Christian, and Joshua (dom)
Dr. Day	Chemistry	U.S.	female	Musah (int), Thomas (dom)
Dr. Soleil	Mathematics	European country	female	Sebastian (int), Zara (dom)
Dr. King	Computer Science	East Asian country	female	Collin and Jon (int)
Dr. Gray	Engineering and Marketing	South American country	male	Florian (int)
Dr. Brooks	Technology	U.S.	female	Amelia (int) and Max and Antonia (dom)
		Mentees		
Name	**STEM field**	**Country of origin**	**Gender**	**Name of mentor**
John	Chemical Sciences	U.S.	male	Dr. Yao
Thomas	Biological Sciences	U.S.	male	Dr. Day
Gabriel	Biology	U.S.	male	Dr. Powell
Quinn	Chemical Sciences	East Asian country	female	Dr. Yao
Maria	Natural Resources and Engineering	South American country	female	Dr. Benito and Dr. Powell
Zara	Mathematics	U.S.	female	Dr. Soleil
Musah	Biology	South Asian country	male	Dr. Day
Sonja	Natural Resources	East Asian country	female	Dr. Benito
Collin	Technology Systems	East Asian country	male	Dr. King
Florian	Natural Resources	South American country	male	Dr. Gray
Jon	Technology	East Asian country	male	Dr. King

Table 2.1 (continued)

Christian	Chemical Sciences	U.S.	male	Dr. Yao
Sebastian	Mathematics	South Asian country	male	Dr. Soleil
Joshua	Chemical Sciences	U.S.	male	Dr. Yao
Roman	Ecology	South American country	male	Dr. Benito
Antonia	Technology	U.S.	female	Dr. Brooks
Jack	Engineering and Natural Resources	U.S.	male	Dr. Benito
Luna	Natural Resources	South American country	female	Dr. Benito
Amelia	Technology	East Asian country	female	Dr. Brooks
Max	Technology	U.S.	male	Dr. Brooks

Note. All names are pseudonyms and some specific details have been generalized to maintain the anonymity of the individuals. int = international, dom = domestic

Recruitment

Recruitment began by seeking input from the researcher's mentor. She recommended a list of names of STEM professors from large public research-intensive universities who had collaborated with her on previous grant projects or dissertation committees, were current collaborators, and who had mentored international and domestic doctoral students who graduated recently. The decision to choose recent graduates was suggested by the dissertation committee, in order to reduce the power dynamics of current doctoral students and their advisors. It also potentially provided a bit of perspective of the individuals on their mentor/mentee relationships. Institutional Review Board approval was obtained for the study.

The researcher sent individual emails to the initial list of STEM professors, asking if they were willing to participate in an interview that focused on their experience of mentoring international and domestic graduate STEM students. In addition, they were asked if they were willing to share names of their recent STEM graduates who might be interested in participating in an interview. Also, the researcher sent out email invitations to other STEM professors from large, public, research intensive universities, who seemed likely to have mentored graduate students, based on their research grant activity.

After the STEM professors agreed to participate in the study they were asked to provide names and contact information of their former mentees, recent doctoral graduates who they thought might be interested in participating in the study. The former STEM graduates were contacted by email and asked if they were willing to share their mentoring experiences. If at least one international STEM graduate agreed to participate in the study, then the STEM graduate was interviewed through Zoom. After at least one former international graduate STEM student was interviewed, their graduate mentor was contacted and interviewed through Zoom.

Each participant took part in an individual, semi-structured Zoom interview carried out by the same researcher (Appendices A and B). The interviews were conducted to understand the perceptions of the mentoring experiences that the mentors provided and that the mentees received (Mertens, 2019). Interviews lasted between 18 and 42 minutes. The participants were asked what they considered effective or important mentoring strategies, what strategies they provided/received that supported their development as a graduate STEM student, and what challenges they encountered while they mentored the mentee or were mentored by the mentor.

Data Analysis

Mentors' and mentees' interviews were audio recorded, and data were transcribed verbatim, resulting in 807 single-spaced pages of interviews from the 28 participants. All data were deidentified, and pseudonyms were assigned to names. The transcripts were loaded in Atlas.ti 9. Initial, deductive coding was done by the lead researcher using Yob and Crawford's

(2012) academic and psychosocial categories. The codes that were used were: induction, competence, availability, challenge, personal qualities, communication, and emotional support. To establish trustworthiness, a second coder was recruited, a doctoral candidate who was familiar with the nature of the research. In the first round of coding, six full interviews (21% of all data) were coded by the two researchers using Yob and Crawford's academic and psychosocial a priori codes (induction, competence, availability, challenge, personal qualities, communication, and emotional support). The researchers discussed the a priori codes together to align their interpretations.

Interrater reliability was established between the researcher and the second coder using a unitization approach with 21% of the data (Campbell et al., 2013). In this approach, the text segment is selected by the initial coder, but the assigned code is hidden. The second coder can see the unit of text selected, and assigns their own code to that text. After the researchers were calibrated on the meaning of the codes to be used, and had a code book of sample codes, copies of the transcripts were shared with the second coder, highlighting segments from the transcripts indicating the blocks of text to be coded (Campbell et al., 2013). The two researchers independently coded six interviews that were average in length and included both international and domestic mentees and mentors. The interrater reliability score was calculated (88%), and all disagreements were discussed and negotiated until 100% agreement was achieved (Patton, 2015).

In a second round of coding, finer-grain coding was employed, which allowed a deeper analysis of nuances within interview data rather than relying solely on the academic and psychosocial categories (Yob & Crawford, 2012). New inductive codes within the academic and psychosocial categories were generated to reflect each individual mentoring experience (see

Table 2.2). For this second coding round, one full interview (of a mentor, 3.6%) of the transcript data was co-coded. The interrater reliability score was calculated (93%), and all disagreements were discussed until 100% agreement was reached (Patton, 2015). Given the high degree of agreement, the lead researcher coded the rest of the data.

Table 2.2

Examples of Prevalent Mentoring Behaviors Codes

Mentor	**Mentees**
Induction	Induction
• Helping the mentee learn skills • Providing resources (e.g., equipment, money to travel or attend conferences) • Connecting with people in the field • Tailoring strategies unique to the mentee	• Helping the mentee learn skills • Helping with job search • Practicing presentations • Providing guidance and feedback and giving independence to explore
Challenge	Challenge
• Challenge to improve academic writing • Challenge to improve English skills • Challenge to be independent in coming up with their project • Challenge to publish papers	• Challenge to improve academic writing • Constructive criticism • Challenge to improve English skills • Challenged by the long time the mentor took to provide feedback
Availability	Availability
• Availability in professional situations	• Availability in professional situations • Responsiveness
Competence	Competence
• Mentor has knowledge in their field • Mentor has knowledge working with international students (e.g., funding, rules to maintain visas, culture) • Mentor has knowledge of working with students	• Mentor has knowledge of research methods • Competent in providing mentee access to resources • Competent in teaching independence
Communication	Communication
• Clear and open communication • Take time to know the mentee • Communication difficulties due to English skills	• Clear, open, and constant communication • Take the time to know the mentee • Active listening
Emotional support	Emotional support
• Encouraging • Providing affirmation • Providing cultural and social support to international students • Providing personal support	• Encouraging • Providing cultural and social support to international students • Protecting from additional work and lessening workload • Developing confidence and self-esteem

Table 2.2 (continued)

Personal qualities	Personal qualities
• Straightforward • Aware and adaptive to student's needs • Comfortable with mentee's growing independence	• Trust • Friendly, nice, caring • Understanding • Inviting students to mentor's house

Positionality

The researcher is a high school science teacher who has worked in Romania for nine years and in low-income communities in the U.S. for 19 years. She was also a part-time international graduate student. She has encountered the unfamiliarity of a different culture and language and faced additional challenges as a teacher and part-time international graduate student. This insider status (Merriam, 2001) provided a deeper understanding of some of the experiences shared by the graduate participants. Several strategies were used to reduce potential biases, including ongoing critical reflection on the interpretations of the data and recognizing that having similar history and experiences as the graduates does not imply they are the same as those of the researcher. Rich descriptions and quotes of participants were included to help the reader judge the findings and enhance trustworthiness. Member checking was conducted to ensure the researcher's interpretations accurately represent participants' experiences. Nine participants responded to the member checking emails, confirming the interpretations.

Findings

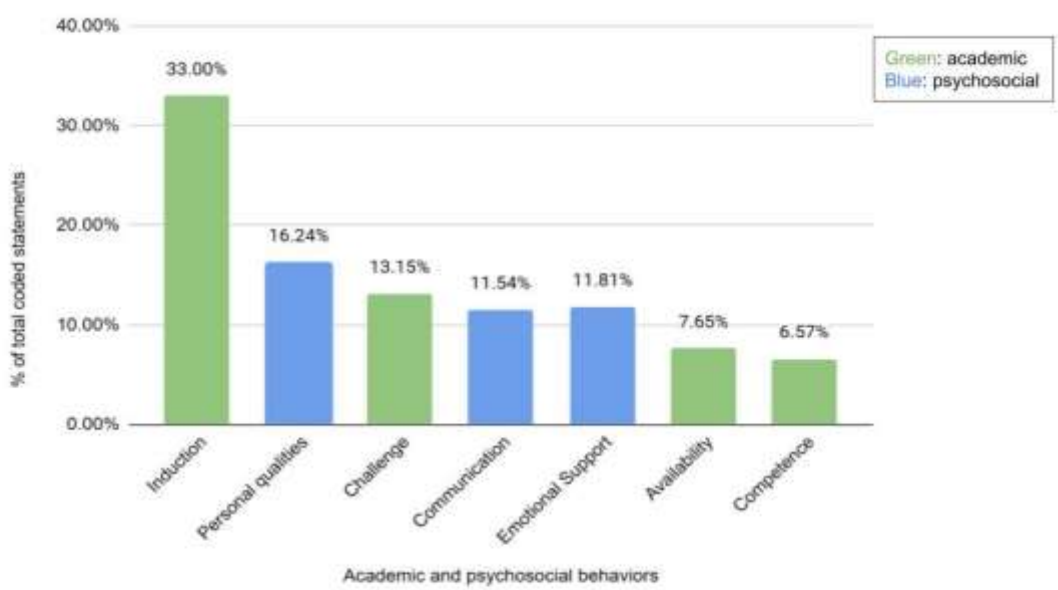
There were eight mentors interviewed but the number of their mentees participating in the study varied between one and five. However, each mentor had an international mentee who was interviewed, and most also had domestic mentees.

Overall Mentoring Approaches Described by Mentors and Mentees

Mentoring strategies were described by both mentors and mentees. The academic a priori codes used were competence, availability, induction, and challenge; the psychosocial a priori codes were personal qualities, communication, and emotional support (see Figure 1.1). Overall, the most prevalent themes the mentors and mentees described were induction (33% of the total coded statements), personal qualities (16.2%), challenge (13.2%), communication (11.5%), and emotional support (11.8%) (see Figure 2.3).

Figure 2.3

Overall Prevalence of Academic and Psychosocial Themes, Mentors and Mentees



Note. In green, there are academic behaviors, and in blue, psychosocial behaviors. Total coded statements: 745.

Overview of Mentors' Academic and Psychosocial Behaviors

To begin to address research question two, the eight mentors' approaches are briefly described, below.

Dr. Benito (male, domestic)

Effective mentoring is a cycle where the mentor discusses objectives and activities with the mentee, the mentee attempts to do them, and then the mentor provides feedback. The mentor helps the mentee develop the research, meet the program requirements, develop their writing and presentation skills, and ensure their research aligns with their career goals. Also the mentor ensures there is a plan for approaching potential employers. Dr. Benito changed his mentoring in response to the student's needs. The international students (Maria, Sonja, Luna, and Roman) were better prepared for research, and more driven, responsible, and committed to their research, while the domestic one (Jack) seemed to be distracted, and didn’t spend as much time on their research (see Appendix C for more details).

Dr. Gray (male, international)

Dr. Gray was from South America. Mentoring was a self-discovery learning experience. Trust was vital in mentoring. He was protective and available, trained his mentees to communicate and think fast and pushed them to do things they were not doing before. He identified their strengths and weaknesses and designed professional development to help them improve. His students worked hard. Dr. Gray organized retreat meetings with the whole team once per year to plan the research. He looked for self-motivated, creative mentees who wanted to change the world. Dr. Gray enjoyed working with his students (Florian, int, m) (see Appendix D for more details).

Dr. Soleil (female, international)

Dr. Soleil grew up in Europe. She emphasized clear expectations, goals, and regular re-evaluations to ensure they align with the student’s development. Transparency, weekly meetings, and providing constructive criticism were also important. She praised the students, and had high standards and a hard time making compromises regarding the quality of work. She shared with her students (Sebastian, int, m, and Zara dom, f) that she didn't like to provide completely ignored feedback, although she respected students' independence and insights. She provided opportunities for students to deepen their knowledge and tailored the mentoring to the student's strengths and needs (see Appendix E for more details).

Dr. King (female, international)

Dr. King used a project-based approach to mentoring; the students were junior scholars fully involved in interdisciplinary research projects. To mentor Collin and Jon (international), she strongly encouraged them to read and understand more about their field, be social, communicate with others, and create social networking at conferences. Collin and Jon were hard-working, with intrinsic motivation and resilience. International students were generally more stressed because of visa issues or their need for financial support (see Appendix F for more details).

Dr. Yao (male, international)

Dr. Yao emphasized the importance of understanding what a mentee wants to achieve in the doctoral program. The international students, in general, spent more time in the lab and were more interested in research than domestic students. He helped them improve their English skills. Writing skills were challenging for international and domestic students. Dr. Yao organized monthly social activities; they played volleyball and kayaking or had gatherings at home (see Appendix G for more details).

Dr. Powell (male, domestic)

Dr. Powell believed a mentor should help mentees grow academically or personally and adapt to each student's needs. Growing the mentees into independent thinkers was a difficult process, as sometimes the doctoral students felt they needed to be told what to do. Dr. Powell felt a power differential exists between mentors and mentees, and mentors must be aware of it. He described Maria (international) and Gabriel (domestic, underrepresented) as some of his top and easier mentees he worked with (see Appendix H for more details).

Dr. Day (female, domestic)

Dr. Day was an energetic middle-aged professor who grew up in the U.S. She emphasized the relationship of mentoring and the importance of building trust. She believed each mentee was unique and, therefore, took time to understand their interests, strengths, and ways she could support them (see Appendix I for more details).

Dr. Brooks (female, domestic)

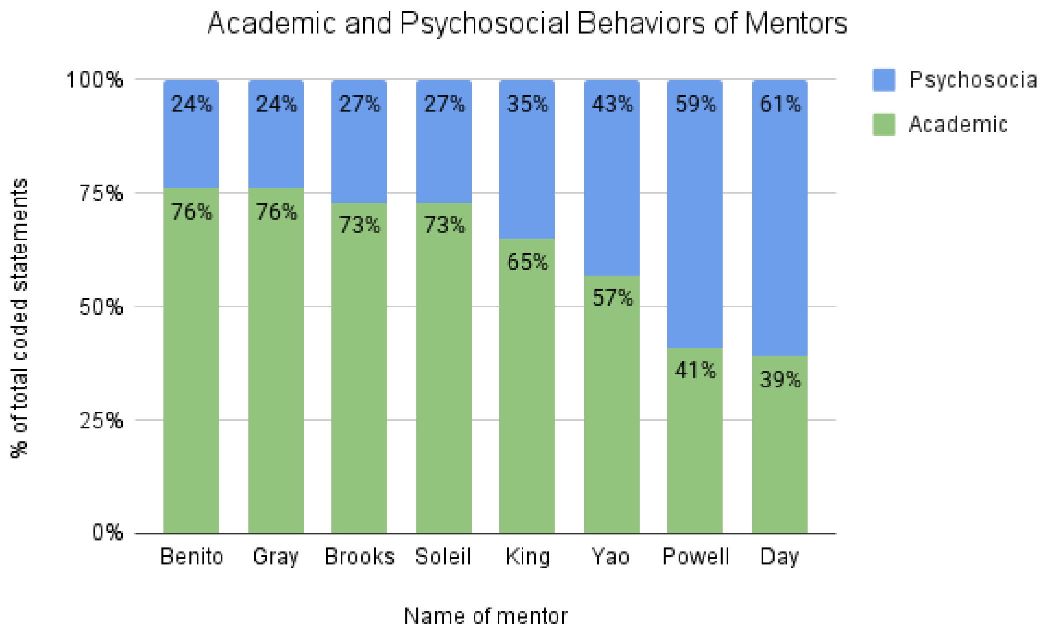
Dr. Brooks highlighted that mentors must advocate for their mentees and help them see how their actions are connected to their goals and career and personal needs. She spent time with the mentees to get to know them and understand their motivations and goals. Mentoring should be tailored to each student. Clear and open communication of expectations, setting and resetting the expectations, frequency of meetings, what kinds of work the mentees should bring to the meetings, and what kind of connections the mentees expect were important in mentoring. The most efficient way to interact with mentees was around artifacts, as she could provide feedback and guidance. She was straightforward and wished to know more about the international students' educational context (see Appendix J for more details).

Analyses of the eight Mentors' Mentoring Practices

The eight mentors described using academic and psychosocial behaviors differently from each other (see Figure 2.4). Overall, mentors were more likely to describe academic mentoring behaviors (n = 6) over psychosocial mentoring behaviors (n = 2).

Figure 2.4

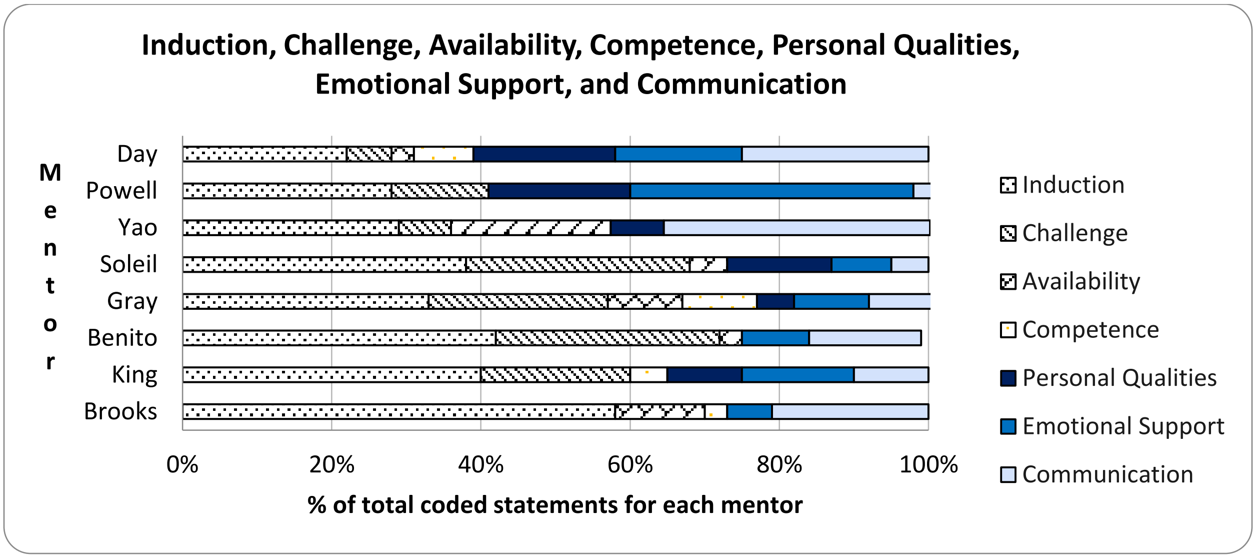
Overall Academic and Psychosocial Behaviors for Each Mentor



Mentors were grouped into two categories based on the types of behaviors they exhibited the most (over 50% of coded behaviors): highly academic and highly psychosocial. Six mentors (75%) talked more about academic behaviors they used compared to psychosocial behaviors (see Figure 2.5). Two mentors (25%) talked more about psychosocial than academic behaviors. In the highly academic category, the academic behaviors varied between 65% and 76% (*M* = 70%) of different mentors' coded statements, while the psychosocial behaviors varied between 24% and 35% (*M* = 30%). In the highly psychosocial category, psychosocial behaviors varied between 59% and 61% (*M* = 60%) of mentors' coded statements, while academic behaviors comprised between 39% and 41% (*M* = 40%).

Figure 2.5

Academic and Psychosocial Behaviors Described by Mentors



Note. Black and white patterns indicate academic behaviors (induction, challenge, availability, and competence). Blue indicates psychosocial behaviors (personal qualities, emotional support, and communication).

Academic Behaviors. The academic behaviors are presented in order of their prevalence in mentors' interviews.

***Induction*.** Induction was the most prevalent academic behavior found in all eight mentors' interviews. It ranged between 29% and 58% of the total individual coded statements for one mentor (*M* = 40%) in the highly academic group of professors and between 22% and 28% (*M* = 26%) for the highly psychosocial group. Induction refers to mentors' behaviors such as tailoring strategies unique to the mentee (5 out of 8 professors); helping the mentee learn skills (5 out of 8 professors); working with the mentee in designing, conducting, and reporting research (5 out of 8 professors); working productively in teams (3 out of 8 professors), connecting with people in the field (3 out of 8 professors); helping mentee grow academically (3 out of 8 professors); giving guidance, feedback, and independence (3 out of 8 professors); providing resources (e.g., equipment, money to travel or attend conferences; 2 out of 8 professors); helping mentee with job skills and job search (1 out of 8 professors); and modelling effective professional skills (1 out of 8 professors).

Tailoring unique strategies to the mentee was a behavior found in five mentors' interviews. Note. The following abbreviations are used to help identify the gender and status of each of the professors and graduate students: f = female, m = male, int = international, and dom = domestic. Dr. Soleil (f, int) recognized the importance of tailoring mentoring: "I normally personalize the mentoring, depending on the students. Some students have some strengths, other have different strengths." Similarly, Dr. Brooks (f, dom) said that "mentoring strategies for supporting each student should be tailored to that particular student …to their personal goals for their careers, and for their learning and …where they are right now."

Helping mentees learn skills was found in five mentors' interviews. Dr. King (f, int) found it effective "to encourage them [the mentees] to reach out to different literature, different articles and be willing to learn more about …the methodology of the different fields." Differently, Dr. Benito (m, dom) helped mentees learn a multitude of skills at once:

> One thing that I do during my mentoring, which I don't think a lot of professors do, is I will invite the students into my office every week or two. And we will put the paper up on a big TV and I will go over the paper, line by line, by line, I'm trying to teach them a million different things at the same time. I'm trying to teach them about the science,… telling a story in a logical way,… not making statements unless you have some kind of justification,… how to communicate, how to present data, how to write, English skills, all these things.

Challenge. Challenge was the second most prevalent academic behavior, found in seven mentors' descriptions of how they supported the development of their mentees. It ranged between 0% and 30% of the total individual statements for each professor from the highly academic group (M = 18.5%) and between 6% and 13% for the highly psychosocial group (M = 9.5%). Challenge refers to instances when the mentee encountered difficult tasks, such as being challenged to grow (5 out of 8 professors), challenged to improve academic writing (4 out of 8 professors), challenged mentee to publish papers (2 out of 8 professors); providing constructive criticism (2 out of 8 professors); and challenged mentee to stay focused (1 out of 8 professors).

Dr. Soleil (f, int) challenged her mentees to grow by "read[ing] out papers to grow and …see ideas from other areas that we can bring in our own field…or teach a course or…material that they haven't learned yet." Dr. Gray (m, int) challenged his mentees to grow and improve "in the art of communicating, speaking, [and] thinking fast," because the doctoral program is "a self-discovery experience for them, where I push them to do those things that they were not doing before." He described his role as a mentor to develop self-confident mentees who are able to discover new things:

> My challenge as a mentor is for a typical, ordinary person to make extraordinary things, and that they discovered by themselves that they can do it and create. They can have self-confidence...I think that's part of my challenge as a mentor, and I would have loved to have received that when I was [a doctoral student].

Dr. Yao (m, int) challenged his mentees, both domestic and international, to improve their academic writing, because "a lot of people, they just can't write."

Availability. Availability was the third most common behavior the mentors used, appearing in six mentors' interviews. It ranged between 0% and 21% from the total individual statements for each professor in the highly academic group (*M* = 8.5%) and between 0% and 3% in the highly psychosocial group (*M* = 1.5%). The mentors described being available in professional situations (5 out of 8 professors) and being responsive (1 out of 8 professors). Regular meetings, once per week or a meeting every two weeks, were the most frequent way to support the development of mentees. Dr. Brooks (f, dom) said that "spending enough time with mentees makes [a] difference" while Dr. Day (f, dom) saw mentoring based on "responsiveness in a relationship." Dr. Soleil (f, int) found it "crucial that [she's] meeting with [her] students…on zoom or in person" though when the meeting is about coding or interpretation of data, "having the meeting on zoom makes the meeting more efficient."

Competence. Competence was the least common academic behavior professors described. It was found in four mentors' descriptions of their mentoring experiences and ranged between 5% and 10% from the total individual coded statements for each professor in the highly academic group (*M* = 3%) and between 0% and 8% in the highly psychosocial group (*M* = 4%). Competence was used when the mentor talked about their knowledge in their field (1 out of 8 professors), developing knowledge while working with international students (such as funding, rules to maintain visas, knowledge of international students' culture, 1 out of 8 professors), or knowledge of working with students, management or leadership skills (1 out of 8 professors). Dr. Day (f, dom) asked her students, based on their strengths, areas of growth, and long and short-term goals, what "help [she] can offer…because [she has] more experience in the field." Dr. Brooks (f, dom) found it challenging for her not being familiar with international mentees' cultures:

> I think one challenge when mentoring international students is not understanding the educational context where they come from. So even if they tell you what school they're

> from ... it's very unlikely for you to know anything about it, and even if you ask them, you know them telling you is not the same as sort of having gone through an institution that's like theirs....And also not having an understanding of the background, what was it like? Even growing up, K through 12 and undergrad, and any other prior preparation that someone has is really different because you don't understand the international context very much.

Psychosocial Behaviors. The psychosocial behaviors are presented in order of their prevalence in mentors' interviews.

Communication. Communication was the most prevalent psychosocial behavior, found in all eight mentors' descriptions of the mentoring experiences. It ranged between 5% and 36% of the total individual coded statements for each professor in the highly academic group (M = 16.2%) and between 3% and 25% in the highly psychosocial group (M = 14%). Communication was used in instances when clear and open communication was mentioned (6 out of 8 professors), when the mentor took the time to know the mentee (4 out of 8 professors), or when active listening was described (2 out of 8 professors). Dr. Day (f, dom) described using clear communication, as she always tried "to be transparent" and "really clear about what I felt I could do, and also what I felt like, given his [Musah's] interest, he'd need to either figure out on his own, or we'd need to get other expertise."

Dr. Yao (m, int) considered taking the time to know the mentee as an essential step to effective mentoring:

> The most important thing…is …to understand what a student wants for the Ph. D., because… somebody wants to be academics after Ph.D., somebody wants to get a job afterwards. So their expectations will be very different. It's not like me forcing them to

> go either direction. You have to respect their own choice. Then you try to tell your approach to… understand what is the best way to help them grow up in their own career choice.

Similar to Dr. Yao, Dr. King (f, int) described getting to know the mentee at the beginning of mentoring: ”You have to understand where they are coming from, their cultural backgrounds, what they care about, to maybe suggest one topic that somehow is in alignment with what they are really interested in [researching].” For Dr. Gray (m, int), communication came in the form of sharing with the doctoral students “a road map” of the research:

> Sometimes he [the international mentee] didn't understand why I was asking to do things. And then, there was even time that he challenged me like, why are you doing this? [It] doesn't make sense. I say, okay, that's a good point. Let me explain. So I have to give him background, why we were there, and once I gave him the background, the constraints and the background of the research project or the administration project…Now I get it. It's like, provide good information on the background of why we are doing something.

Emotional Support. Emotional support was the second most common psychosocial behavior, found in seven mentors’ interviews. It ranged between 0% and 15% of the total individual coded statements for each professor in the highly academic group (M = 8%) and between 17% and 38% in the highly psychosocial group (M = 27.5%). Emotional support refers to instances or behaviors when the mentor provided affirmation and encouraged the mentee (6 out of 8 professors), developed mentee’s confidence and self-esteem (3 out of 8 professors), provided personal support (2 out of 8 professors), supported mentee’s religious practices (1 out of 8 professors), protected from additional work or lessened workload (1 out of 8 professors) or checked in to see how things are going (1 out of 8 professors). Dr. Soleil (f, int) provided affirmation to her mentees: “I do praise the students, and there's nothing that makes me happier than seeing them that they grow and they achieve great things… [Providing] opportunities to gain confidence was a game changer.” Dr. Powell (m, dom) emphasized the importance of encouraging his mentees and checking with them to see how things are going from a psychological perspective:

> Most of them [mentees] are capable of doing the academic work, and getting through that they might struggle a little bit with that they might have some motivation issues… But I always think that the underlying background is checking in with them…to see how they're doing from a mental wellness,…psychological aspect. I always encourage them …to take a little bit of time away,…you need at least 30 minutes to an hour every day for yourself. Most of the students that I mentor, I'd say pretty much all of them…my first question that I always ask right as I go through this, and this is something you build over time. How are you doing?

Personal Qualities. Personal qualities surfaced from the interviews of six mentors. It ranged between 0% and 14% from the total individual coded statements in the highly academic group (*M* = 6%) and equaled 19% for the professors in the highly psychosocial group. Personal qualities refer to mentors’ characteristics that enhanced the work with their mentees, such as trust (2 out of 8 professors), being clear, open, direct (2 out of 8 professors), being aware and adaptive to student’s needs (1 out of 8 professors), being aware of the power differential (1 out of 8 professors), being supportive of mentee’s needs (1 out of 8 professors), being comfortable with mentee’s growing independence (1 out of 8 professors), having passion and dedication (1 out of 8 professors), or checking own biases (1 out of 8 professors). Dr. Day (f, dom) found it important to “build a sense of trust” and being “direct” and “clear from the beginning of our mentoring relationship." Dr. Powell (m, dom) found effective mentoring strategy to be "adaptive to what that particular student needs" because:

> Different students need different sorts of support. Some of them are super capable academically, and will want to take on too much, and a lot of that is about working with them to refine and understand what they can accomplish in the particular times that they need. Some of them really need a lot of emotional psychological support through the process.

Dr. Powell (m, dom) noted that being aware is important, as "there is a power differential that exists" between faculty mentor and mentee. Also, being aware of the additional needs and the extra pressure the international students have is crucial when mentoring them:

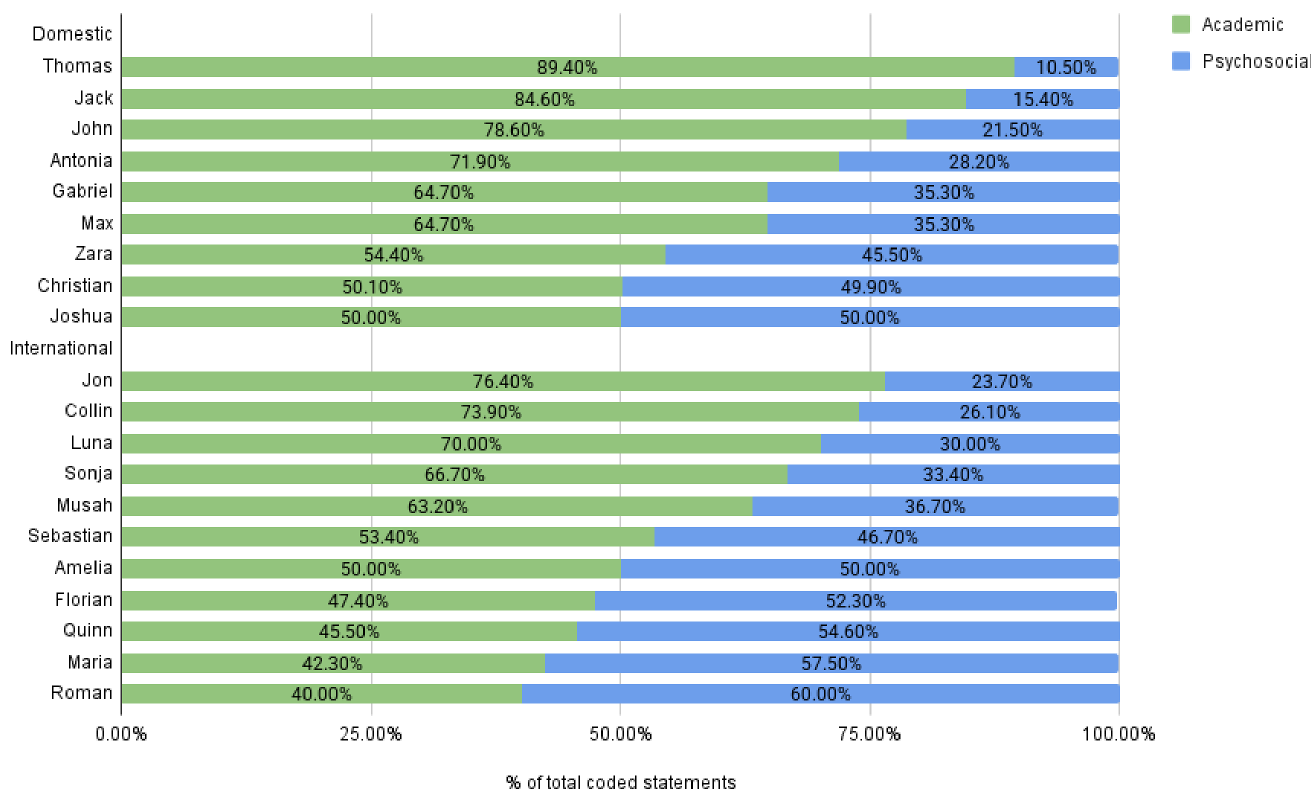
> As a mentor you have to be aware of this additional pressure or stress that they [international students] have [trying to establish themselves in US]…that their ability to stay here is very closely tied to their ability to get their degree, and they have a whole different pressure that's on them…I don't necessarily treat them differently, but you have to be aware of [it].

STEM Graduates' Description of Mentors' Academic and Psychosocial Strategies

The third research question focused on how the mentees viewed their mentors. Overall, thirteen out of twenty (65%) STEM graduates described mostly academic behaviors their mentors used to support their development, four (20%) mentioned predominantly psychosocial behaviors, and three (15%) spoke equally about academic and psychosocial behaviors (Figure 2.6).

Figure 2.6

Percentage of Academic and Psychosocial Behaviors Each Mentee Narrated

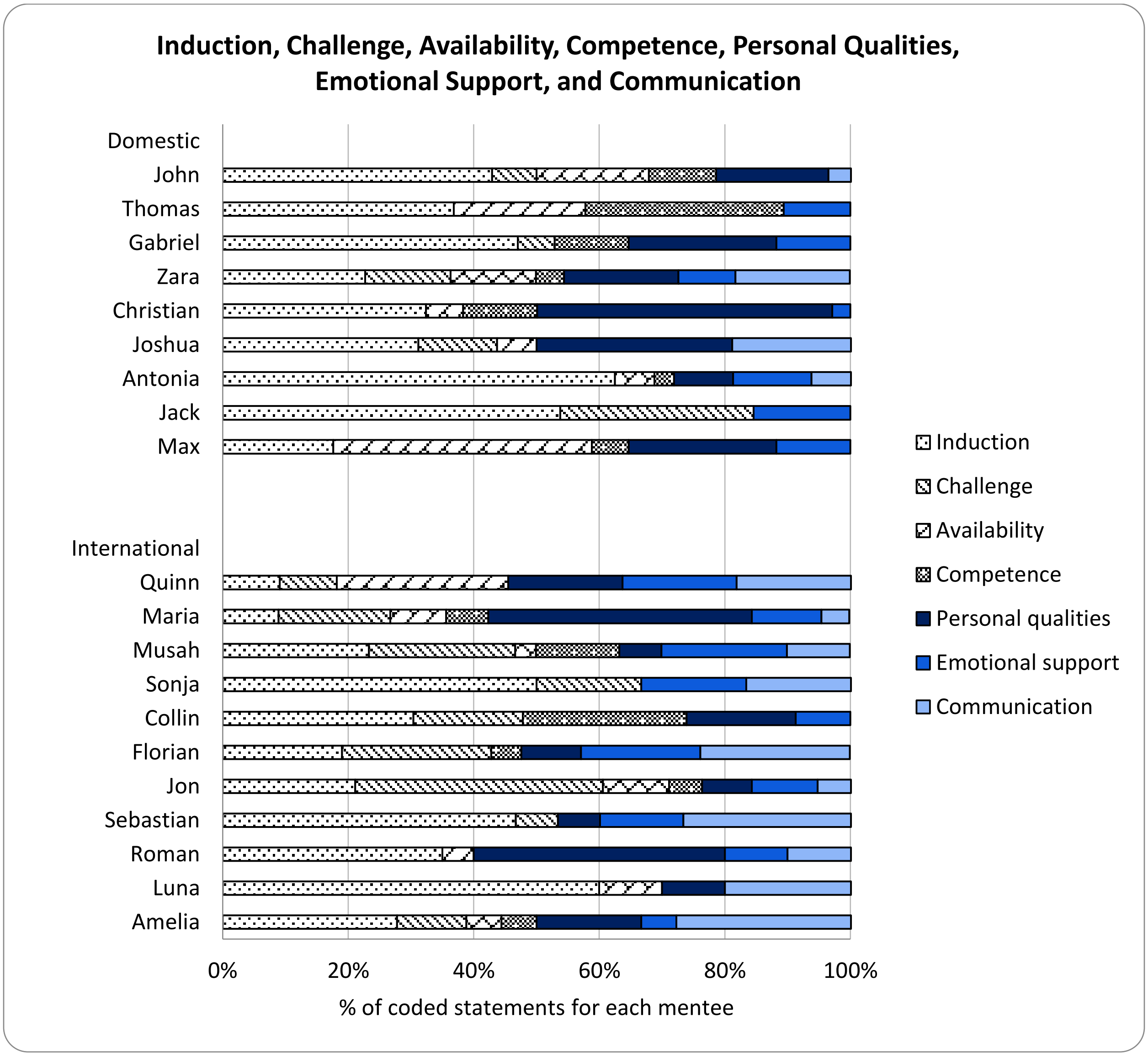


Note. Academic behaviors are in green; psychosocial behaviors are in blue. Individual total percentages might not add up to 100, due to rounding.

The domestic and international STEM graduates' descriptions of their mentoring experiences differ. Overall, the majority of the domestic graduates narrated mostly academic behaviors. Seven of nine domestic STEM graduates (77.8%) described mostly academic behaviors their mentors used, while the other two (22.2%) spoke equally about academic and psychosocial behaviors. Six of eleven international STEM graduates (54.5%) reported mostly academic behaviors, while four (36.4%) narrated mainly psychosocial behaviors. One international STEM graduate (9%) spoke equally about academic and psychosocial behaviors. The academic and psychosocial behaviors each mentee reported are captured in Figure 2.7.

Figure 2.7

Academic and Psychosocial Behaviors Each Mentee Described



Note. Black and white patterns indicate academic behaviors (induction, challenge, availability, and competence). Blue indicates psychosocial behaviors (personal qualities, emotional support, and communication).

Academic Behaviors

The academic behaviors the mentees described as receiving from their mentors are presented below in order of their prevalence in graduates' interviews.

Induction. Induction was the most prevalent strategy found in all domestic and international STEM graduates' interviews, mirroring what was found in mentor interviews. Overall, induction accounted for 33.9% of all twenty mentees' coded statements, varying between 17.6% and 62.5% of the domestic graduates' individual total coded statements of mentoring received from a mentor (*M* = 38.5%) and between 8.9% and 46.7% for the international graduates (*M* = 30.1%). Table 2.3 depicts the induction strategies found in the mentees' interviews, and includes quotes from domestic and international graduates. Within each category, there were positive and negative aspects of mentoring described by mentees. A negative aspect is in the red text in the table.

Table 2.3

Induction Strategies Described by Domestic and International Graduates

Domestic student quote	International student quote
Code: Connecting/Not connecting with people in the field (8 out of 20 mentees)	
Pointing the student to…counseling, or whatever that could have been beneficial, to additional resources that can help provide emotional support …because it is very hard for many people, and I probably had it easier than most. But that can be, I think, a really mentally challenging journey as a graduate student…[Dr. Benito, m, dom] (Jack)	*He* [Dr. Benito, m, dom] *will connect me along with microbiology, with biotechnology, with different people that will help me extend my knowledge.* (Maria)
Code: Helping/Not helping mentees learn skills (7 out of 20 mentees)	
[Dr. Powell, m, dom] *gave me a very strong foundation.* (Gabriel)	*She* [Dr. King, f, int] *always allowed me to observe everything…And then try to replicate some things, whether it is polishing, or not.* (Jon)
Code: Helping/Not helping mentees grow (e.g., helping women succeed in STEM, helping international students succeed) (7 out of 20 mentees)	
I think I was more frustrated in the moment during graduate school by not always getting that… more specific hands-on guidance which maybe would have been helpful when I wasn't sure what to do next. (John)	[Dr. Brooks, f, dom] *does have a strong interest in helping women succeed…Being an international woman helped to connect."* (Amelia)

Table 2.3 (continued)

Code: Working/Not working with mentee in designing, conducting, and reporting research (6 out of 20 mentees)	
He [Dr. Benito, m, dom] *enabled me to set a course, an idea [of research], and …choose my approach and my …process.* (Jack)	*And I think that* [Dr. Benito, m, dom]*'s strategy is to throw everything, every idea on you. And some is overwhelming at the beginning, when you don't know him. But …with time you realize he doesn't mean to do everything.* (Maria)
Code: Helping/Not helping with job search (e.g., writing letters of recommendation) (6 out of 20 mentees)	
When it came to professional opportunities I wished he [Dr. Yao, m, int] *connected me more …with experts because he knows so many …maybe could have connected me with someone he knows who had a job.* (John)	*Dr.* [Benito, m, dom] *was a big support during my job search, so he put me in contact with some people he knew that they were looking for some people in this area. So I got my job because of one of his contacts.* (Luna)
Code: Tailoring and implementing/Not tailoring and implementing strategies that are unique for each student (5 out of 20 mentees)	
[Dr. Brooks, f, dom] *set up specific mentoring relationship that was …tailored to me…I have learning disability in reading. And so sometimes, when reading academic papers, I would get frustrated. And she's like, 'if you don't understand something, give it fifteen minutes, and then come see me.'* (Antonia)	[Dr. King, f, int] *recommended readings for the necessary skills that I lacked…for example, statistical analysis, or some other technical skills that I lacked... And I'm really grateful for being pushed to learn those skills.* (Collin)
Code: Providing/Not providing guidance and feedback, and giving/Not giving independence to explore (5 out of 20 mentees)	
He [Dr. Yao, m, int] *kinda left me in the weeds....So a little bit …of more hand holding at the very beginning, maybe like first three quarters of my first year would have would have been a little bit helpful.* (Christian)	*Sometimes I didn't have much progress. But she* [Dr. King, f, int] *always asked me any updates. …that really helped me to make me aware of what I'm doing …* (Jon)
Code: Working in teams (4 out of 20 mentees)	
We didn't have a lot of people leave our lab. More people came because of her [Dr. Brooks, f, dom] *mentoring and her passion to let you research your passion and her ability to be relaxed enough to let you do what you want.* (Antonia)	*One of the things that could be done to improve… my progress is … finishing one project…and starting that other project.* (Sebastian)
Code: Providing resources/Not providing (e.g., supporting mentee to attend conferences) (4 out of 20 mentees)	
She [Dr. Brooks, f, dom] *did always have money for me to do research…that's a huge benefit…And this shouldn't be understated…because had I not had that funding available I wouldn't have been able to do a Ph. D.* (Max)	*He* [Dr. Benito, m, dom] [was] *also helping me to get some scholarships that were from the department.* (Roman)
Code: Practicing/Not practicing presentations (3 out of 20 mentees)	
[Dr. Yao, m, int] *gave me practice to present a little bit because I would always come in with slides and we would go over…* (John)	*…when I'm doing some kind of conference presentation or something like that sometimes my accent could be kind of difficult for other people to understand…But he's* [Dr. Benito, m, dom] *kind to…point out and then make me develop about the delivery.* (Sonja)

Table 2.3 (continued)

Code: Modelling/Not modelling effective professional and interpersonal skills (e.g., setting up goals, having structure, rising from failure) (3 out of 20 mentees)	
…capitalizing on the smaller things and just putting together a diversified portfolio…Sometimes a diversified portfolio is much better than a…singular portfolio. And that has served me well because it's allowed me to, as I manage projects myself, it's allowed my brain to be able to hop between projects . (Gabriel) *Where things went well, what things went wrong? Why did things go wrong? …What things to take out of the things that went wrong and how to course correct for moving forward?* (Christian)	Not found
Code: Number of mentees (2 out of 20 mentees)	
She [Dr. Brooks, f, dom] *had 14 mentees [at once]…. I also think that sometimes she got overwhelmed because she had so many students.* (Antonia)	*[Planning for gaining job skills is] limited by her [number of students]. She* [Dr. Brooks] *doesn't have the time.* (Amelia)
Code: Mentee sharing knowledge with the mentor (2 out of 20 mentees)	
Once I was a more senior graduate student there were techniques that I was learning … [that] she did not necessarily know. And so that was expertise that I was willing to share with her [Dr. Day, f, dom]. (Thomas)	Not found
Code: Working jointly on publications and grants (1 out of 20 mentees)	
She [Dr. Day, f, dom] *shared a lot of her knowledge relating to grantsmanship and being able to write and get successfully funded proposals and so that sort of the like hallmark of being in science as being able to get grant money.* (Thomas)	Not found
Code: Nominating mentees for awards (1 out of 20 mentees)	
She [Dr. Soleil, f, int] *recommended me for the awards within the department or within the College of Science…She got out on her way to promote whatever I do well. I didn't even know until later. I found out the… fight with everybody to get me the award, because she feels I did so much, and deserve it. I didn't know until I didn't get it, because I was 2 of the finalists out of 4,000 students.* (Zara)	Not found
Code: Introducing and initiating students to culture of institutions and their processes and expectations (1 out of 20 mentees)	
He taught me how to observe and how to let situations come to you. So one of the things about being a minority, you don't always…are familiar with the new offices And so Dr. [Powell, m, dom] *kind of helped me to understand how to observe and manage the politics of an environment.* (Gabriel)	Not found

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

Connecting with people in the field was a strategy used with both domestic and international graduates to support their development. Thomas (domestic) recounted his mentor's

[Dr. Day, f, dom] great ability to connect him with others in the field: "She was really good …when there was a problem or something that she didn't necessarily know how to do,…[at] connecting me with someone who could provide [help]." John (domestic) wished his mentor [Dr. Yao, m, int] would connect him with other professionals so he could make faster progress in his research: "I think it would have been helpful if he had more, he had even more aggressively connected me with experts who could help me with my projects." Luna (international) explained that her mentor connected her with people who would help her academically and personally:

> [Dr. Benito, m, dom] put me in contact with different industrial partners that helped me to…get feedback on my research or get more ideas how to perform my research. He also helped me not only in the academic way. He also…put me in contact with other [people from Country 1 in South America] or international people that could help me through the process to understand all the steps or the process that I need to go through at the university or paperwork, so he supported me in both areas, academic and… personally.

Helping mentees learn skills was found in both domestic and international graduates' mentoring experiences. Jack (domestic) recounted how his mentor [Dr. Benito, m, dom] helped him learn knowledge and how to communicate it with others:

> We would spend a good amount of time going through the research or the paper, or ideas, and he would always get me to explain what it was to him, and he'd ask sometimes seemingly simple, dumb questions that were actually really smart questions that, like, were seemingly obvious to the person in the moment. But when you actually try to think about a deeper level and explain it, sometimes it's very challenging. He asked all the questions, and if you get through all of his questions you knew it very well, and you

> could answer any of the questions to anybody else, because he's already asked, and you answered all the questions that pretty much could be.

Jon (international) talked about how his mentor [Dr. King, f, int] helped him improve his professional skills: "She was really helpful to me to advance myself [as an independent thinker and problem solver], and then improve myself."

Challenge. Challenge was the second most prevalent strategy found in fourteen out of twenty (70%) STEM graduates' mentoring experiences. Five out of nine (56%) of the domestic graduates and nine out of eleven (81.2%) international graduates described being challenged by their mentor. It ranged between 0% and 30.8% (*M* = 7.8%) from the total individual coded statements of mentoring received from professors for the domestic students and between 0% and 39.5% for the international graduates (*M* =15%). Table 2.4 depicts challenge strategies the domestic and international graduates described.

Table 2.4

Challenge Strategies Described by Domestic and International Graduates

Domestic student quote	International student quote
Code: Challenged/Not challenged mentee to grow (8 out of 20 mentees)	
He [Dr. Benito, m, dom] *wanted me to figure it out. But that journey had to be mine, but it had to be to again that high level of excellence and high level of] rigor and thought. But it had to be my thought*.(Jack)	*She* [Dr. Soleil, f, int] *challenged the way I wanted to go about analyzing my data because I was working with qualitative data I wanted to use*.(Musah)
I'm struggling with coding. It was not easy, and she [Dr. Soleil, f, int] *had to help me with my first project, entirely, basically walk me through after I tried for a year. She made it better.* (Zara)	*Sometimes he* [Dr.Benito, m, dom*] is kind of pointing out the kind of things that need to be improved...which ...I appreciate because as an international student it is more easier to understand*. (Sonja)
Code: Constructive/Not constructive criticism (6 out of 20 mentees)	
She [Dr. Soleil, f, int] *gave me feedback without any hesitation…she didn't sugar coat. If I didn't do anything well, she would directly tell me and she'll give me clear directions where to go. I think that's very, very important for… adult students like me. I don't need fancy stuff. I need you to tell me if I didn't do well. So I think that's very, very important to me.* (Zara)	*Providing good feedback* [Dr. Benito, m, dom] (Quinn)

Table 2.4 (continued)

Code: Challenged/Not challenged to improve academic writing (2 out of 20 mentees)	
Not found	*When it came to writing, I think she* [Dr. Day, f, dom] *challenged me…a lot.* (Musah)
Code: Challenged/Not challenged mentee to publish papers (2 out of 20 mentees)	
We were publishing my first author paper and we had really long delays because we had collaborators who were taking forever and [Dr. Yao, m, int] *wanted to submit to journals as well that I thought were not very realistic or maybe not the best fit. But he was pretty adamant and also I was at that time I was new to publishing so I wasn't sure either. So certainly that would have been an example of a challenging time with [Dr. Yao].* (John)	*Dr.* [Benito, m, dom] *was the person putting a lot of pressure... Let's get papers…Let's have like tangible stuff to show off.* (Maria) *Let's work with what we have, even though it's not perfect. That's good enough. We can work with this, and we can publish it. We can make it work.* (Maria)
Code: Questioning to challenge the mentee (2 out of 20 mentees)	
Sometimes that was a bit frustrating to me because he [Dr. Powell, m, dom] *was kind of always. What do you think? And you know…every mentor style is different. And that style of mentorship was a little bit more challenging for my personality.* (Gabriel)	*He* [Dr. Benito, m, dom] *also trained us with some time, challenging questions and kind of teaching us how to address them.* (Sonja)
Code: Challenged/Not challenged to be independent (1 out of 20 mentees)	
Not found	*She* [Dr. Day, f, dom], *let me figure that* [coming up with own project] *out.* (Musah)
Code: Challenged by mentor's high standards (1 out of 20 mentees)	
He [Dr.Benito, m, dom] *would establish pretty high level of expectation in terms of quality and rigor.* (Jack)	Not found
Code: Challenged productively/Not productively to improve English skills (1 out of 20 mentees)	
Not found	*She* [Dr. King, f, int] *sometimes just joined in virtually and …after the intervention, she says 'your English should be improved'.* (Jon)
Code: Challenged by too many tasks (1 out of 20 mentees)	
Not found	*Another thing that* [Dr. Gray, m, int] *was good at was pushing your limit. Let's say, it's asking for more than you could possibly deliver…asking for ten things. And then you can only do five*. (Florian)
Code: Challenged mentee to stay focused (1 out of 20 mentees)	
There is definitely a few times I think I probably needed to hear like [Joshua], *what the hell were you thinking, you know, like a little bit of,…I don't wanna say reprimand, but…you need to be told every once in a while, … get your* [stuff] *together.... like a wake-up call.* (Joshua)	Not found

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

Jack (domestic) was *challenged to grow* by improving his field knowledge and science communication, as he stated: "[Dr. Benito, m, dom] challenged me to achieve pretty high level of understanding the fundamental aspects of my science, communicating those things in publications and presentations and making sure that the research is worthy of the education that I should be receiving."

Collin (international) was challenged to improve his academic writing skills, as his mentor, Dr. King [f, int], gave him "detailed feedback on the manuscripts [he] wrote." Jon (international) was challenged by the same mentor, Dr. King, to improve his English skills. Jon was challenged as an international graduate student to grow and have clear career and academic goals:

> What I heard from her is you are international student. So you should really improve. And then also show your performance twice or three times better than English native. Please think about your future boss' perspective …if you are international candidate with less English proficiency…what is your strong point? How would you make you outstanding?

Availability. Availability was a strategy found in fourteen out of twenty (70%) graduates' interviews. Seven out of nine (78%) domestic and seven out of eleven (64%) international graduates found their mentor's availability supportive of their development. It ranged between 0% and 41.2% from the total individual coded statements of mentoring a domestic graduate received from the professor (*M* = 12.5%) and between 0% and 27.3% for the international graduates (*M* = 6.4%). Table 2.5 includes availability strategies described by domestic and international graduates.

Table 2.5

Availability Strategies Described by Domestic and International Graduates

Domestic student quote	International student quote
Code: Availability/No availability in professional situations (13 out of 20 mentees)	
We [two graduate students] *had gotten annoyed about ...submitting papers at ...2 in the morning, or whatever time it was...We had actively written the paper months in advance...like 2 months, 3 months in advance ...We're ready to go...9 weeks before the deadline. ...Essentially we couldn't get it reviewed because for her* [Dr. Brooks, f, dom] *it wasn't paper time yet.* (Max)	*We always had a weekly meeting…She* [Dr. King, f, int] *was always around me. She spent so much time on writing design ...even more time spending than with other doctoral students.* (Jon) *Whenever you need him* [Dr. Powel, m, dom], *he was available.* (Maria)
Code: Responsiveness (2 out of 20 mentees)	
Being really responsive to student needs (Thomas)	Not found
Code: Availability at professor's home (1 out of 20 mentees)	
Not found	*She* [Dr. Brooks] *always was able to devote a large amount of time to help your work. I've been in her room in her house when she was breastfeeding, and she still looked at my work and gave me ...direct feedback on the work.* (Amelia)

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

Like most graduates, Thomas (domestic) recalled the availability of his mentor. They had "frequent meetings" as he and his mentor, Dr. Day [f, dom] "interacted a lot." Luna (international) also recounted having frequent meetings: "He [Dr. Benito, m, dom] was pretty available. We had like weekly, biweekly meetings to discuss, to get feedback or brainstorming." Sometimes graduates described availability as a negative experience; for example, Antonia (domestic) said: "I got frustrated when I couldn't reach her [Dr. Brooks, f, dom]. You know, if I needed something, or sometimes when you have a paper due at eight in the morning she would get on at eleven or twelve, but that's because she got to it the night before."

Competence. Competence was found in thirteen out of twenty (65%) of STEM graduates' interviews. Seven out of nine (78%) domestic graduates and six out of eleven (55%)

international graduates found their mentor's competence helpful to their development as doctoral students. It ranged between 0% and 31.6% of the total individual coded statements for domestic graduates (M = 8.8%) and between 0% and 26.1% for the international graduates (M = 5.6%). Table 2.6 includes competence strategies the domestic and international graduates described.

Table 2.6

Competence Strategies Described by Domestic and International Graduates

Domestic student quote	International student quote
Code: Mentor has leadership skills (e.g., working with students) (4 out of 20 mentees)	
She [Dr. Brooks, f, dom] *was probably managing anywhere between 12 and 20 students at any given time.* (Max)	[Dr. Brooks, f, dom] *is a strong leader.*(Amelia)
Code: Mentor has knowledge in field (3 out of 20 mentees)	
[Dr. Soleil, f, int] *is super advanced in her research mathematically.*(Zara) *He* [Dr. Yao, m. int] *is established and I'm sure as mentee that gives you a lot more confidence, knowing that you are guided by someone that is really knowledgeable and connected to the field.* (Christian)	Not found
Code: Mentor has knowledge of research methods (3 out of 20 mentees)	
His [Dr. Yao, m, int] *assessment of my* [research] *development was very, very accurate in terms of positive and negatives.* (Christian)	Not found
Code: Mentor has knowledge of reporting research (3 out of 20 mentees)	
[Dr. Yao, m, int] *really knows in terms of publications, he's very good at knowing how to tell a story, or what to tell for a story.* (Christian)	*One of the things she* [Dr. Day, f, dom] *helped me a lot with was writing.* (Musah)
Code: Competent in providing mentee access to resources (2 out of 20 mentees)	
Helping them get to resources they need. (Antonia)	*Providing a lot of resources* (Collin)
Code: Developing competence working with international students (2 out of 20 mentees)	
Not found	*More contextual understanding of international student is important.* (Jon)
Code: Mentor has knowledge how to grow the mentee (2 out of 20 mentees)	
Not found	*Making very… much impact on how to make myself independent researcher in very hard professional PhD life.* (Jon)
Code: Competent in teaching independence (1 out of 20 mentees)	
Very good at teaching me how to be independent (Gabriel)	Not found
Code: Mentor has/Does not have knowledge of jobs outside academia (1 out of 20 mentees)	
I'm not sure that's her [Dr. day, f, dom] *fault because …she is an academic position, so it's not really reasonable to be asking her to provide career support for careers outside of academia when that's not something that really she knows a lot about.* (Thomas)	Not found

Table 2.6 (continued)

Code: Mentor has knowledge how to write grants (1 out of 20 mentees)	
She [Dr. Day, f, dom] *shared a lot of her knowledge relating to grantsmanship and being able to write and get successfully funded proposals and so that sort of the like hallmark of being in science, as being able to get grant money*. (Thomas)	Not found
Code: Mentor has knowledge of developing and completing projects (1 out of 20 mentees)	
Not found	*She* [Dr. Day, f, dom] *was very good at thinking linearly through and taking a project from start to finish.* (Musah)
Code: Mentor has knowledge of working with funds (1 out of 20 mentees)	
Not found	*He* [Dr. Benito, m, dom] *is very good managing the funds. So everything I needed, I had a very good amount of resources to work with…That was never a constraint.(*Maria)
Code: Mentee assists mentor with new techniques (1 out of 20 mentees)	
Not found	*Assist with anything you know* (Florian)

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

Max (domestic) described his mentor as being extremely knowledgeable of working with students: “She [Dr. Brooks, f, dom] was probably managing anywhere between, you know, twelve and twenty students at any given time,” while Zara (domestic) referred to her mentor’s knowledge in the field: “[Dr. Soleil, f, int] is super advanced in her research mathematically,”

Psychosocial Behaviors

The psychosocial behaviors are presented in order of their prevalence in mentees’ description of effective mentoring strategies their mentor used to support their development.

Personal Qualities. Personal qualities were found in seventeen out of twenty (85%) graduates’ interviews, making them the most narrated psychosocial strategy. Seven out of nine (78%) domestic and ten out of eleven (91%) international graduates described the personal qualities of their mentors as being supportive of their development. It ranged between 0% and 47% of the total individual coded statements of the mentoring the domestic graduates received from their mentor (*M* = 19%) and between 0% and 42 % for the international graduates (*M* = 16%). Table 2.7 includes personal qualities the domestic and international graduates described.

Table 2.7

Mentor Personal Qualities Described by Domestic and International Graduates

Domestic graduate quote	International graduate quote
Code: Hands on, hands off (7 out of 20 mentees)	
Hand off (Max) *The only challenge I had was with* [Dr. Powel, m, dom] *was…he was hands off. And… you really had to nailing down in order to get information out of them.* (Gabriel)	[Dr. Benito, m, dom] *is more hands on tracking every student.(*Maria)
Code: Inviting students to mentor's house (6 out of 20 mentees)	
One of the things that she [Dr. Brooks, f, dom] *often did was hosting either some kind of game night or some kind of social event that was oftentimes at her house…it was a very casual environment.* (Max)	[Dr. Benito, m, dom] *will invite you to his house with his family*. (Maria)
Code: Nice, caring, understanding, patient (5 out of 20 mentees)	
And you have to give your students room to understand not only their environment, but also understand how do you evolve and coexist in it while still contributing. That's a really hard balance to achieve and those two [Dr. Powell and the other mentor] *did achieve it with me.* (Gabriel) *Flexibility of scheduling …was something that was very nice. And he* [Dr. Yao, m, int] *was especially considering that …my wife and I had 2 kids during graduate school.* (Christian)	*Cares about her* [Dr. Brooks, f, dom] *students* (Amelia) *He* [Dr. Benito, m, dom] *was very kind all the time, always saying the positive things, never diminishing you.* (Maria)
Code: Trust (4 out of 20 mentees)	
I could trust them [Dr. Powell and the other mentor]. *And I can still trust them. And that's, I think, something that is rare in today's world.* (Gabriel)	*Making him* [Dr. Gray, m, int] *see that I was a capable person, right? And then that I could you know get the job done. And get it done right. And …developing that sense of trust*. (Florian) *I have a trusted relationship with him* [Dr. Benito, m, dom]. (Maria)
Code: Comfort with mentee's growing independence (4 out of 20 mentees)	
She [Dr. Brooks, f, dom] *tried to give you space to investigate what you wanted.* (Antonia)	*Give independence and freedom to explore what I want, and to figure out …my research identity*. (Collin)
Code: Clear, open, direct (4 out of 20 mentees)	
She [Dr. Soleil, f, int] *is very straightforward.* (Zara)	*Open* (Roman)
Code: Friendly (4 out of 20 mentees)	
She [Dr. Soleil, f, int] *is my friend.* (Zara)	*Friendly* (Maria)

Table 2.7 (continued)

Code: Similar background or prior experiences to the mentee (4 out of 20 mentees)	
She [Dr. Brooks, f, dom] *was very good at flying by the seat of her pants, and I feel like I was, too… Some students aren't as good at that. So I didn't have a problem with it, because that's how she and I were very similar*. (Antonia) *She* [Dr. Soleil, f, int] *is very effective. She offers me more than just mentoring experience. I think because I have children and she's a mother, so that like brings us very close together*. (Zara) *Me and* [Dr. Yao, m, int] *had pretty similar personalities.* (Joshua)	Not found
Code: Father-like (2 out of 20 mentees)	
[Dr. Yao, m, int] *is kind of a father figure where I could talk to him about anything.* (Joshua)	*His* [Dr. Powell, m, dom] *mentoring strategy is …'I'm like father like, I'm here for you.* (Maria)
Code: Full of ideas (2 out of 20 mentees)	
There is so many ideas coming through his [Dr. Yao, m, int] *head.* (Christian)	*His* [Dr. Benito, m, dom] *imagination can go really wild.* (Maria)
Code: Passion and dedication (1 out of 20 mentees)	
Not found	*Passion and dedication* [Dr. King, f, int] (Collin)
Code: Wanting mentees to succeed (1 out of 20 mentees)	
Not found	*Really want to see the students to be successful.* [Dr. King, f, int] (Collin)
Code: Strict, punctual (1 out of 20 mentees)	
Not found	*Strict*, *punctual* [Dr. King, f, int] (Jon)
Code: Protective of students (1 out of 20 mentees)	
Not found	*I think my favorite part of her* [Dr. Brooks, f, dom] *is she's very protective of her student…Talk good about her student and defend her student. To give the student this psychological safety to do their work and graduate.* (Amelia)
Code: Honest and respectful (1 out of 20 mentees)	
[Dr. Yao] *is very honest* [and] *...respectful.*(Christian)	Not found
Code: Adaptive and aware/Not adaptive and not aware of student's progress (1 out of 20 mentees)	
[Dr. King] *didn't touch anything, or even give any kind of a partially feedback…in the early stage of my doctoral,* [program] *…freshman …year. She said great job, you are doing on the right track. So, I was not sure of how much was she aware of what I* [was] *doing.* (Jon)	Not found

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

The domestic graduates talked about their mentors as being “kind,” “friendly,” “caring,” “honest,” “respectful,” interested in learning about them and their families, or “having a good balance between micromanaging.” Christian (domestic) described his mentor [Dr. Yao, m, int] as being understanding of his family situation and displaying “flexibility of scheduling [and] …that was something that was very nice… especially considering that …I had two kids during graduate school.”

Trust was one critical consideration the STEM graduates described. Gabriel’s (underrepresented minority) experience highlights the importance of building trust in the mentoring relationship, especially for people from groups that aren’t historically highly represented in STEM fields nor had positive prior mentoring experiences:

> But I just will emphasize if you get anything from this interview is that in order to be a mentor and mean it, you have to give your students trust. And you have to give your students room to understand not only their environment, but also understand how do you evolve and coexist in it while still contributing. That's a really hard balance to achieve and those two [Dr. Powell and another mentor not participating in this study] did achieve it with me.

Similar personalities, backgrounds, or experiences as the mentor seemed to positively influence the mentoring experiences. For example, Joshua (domestic) revealed that he felt “there wasn't anything that I would ever feel uncomfortable, having a conversation on [with Dr. Yao, m, int]…He is kind of like a father figure…I could talk to him about anything.” Zara (domestic) portrayed Dr. Soleil [f, int] as being “very effective…She offers me more then, just mentoring experience. I think because I have children and she's a mother, so that like brings us very close together." In addition, Zara said "I consider her as not just my supervisor. She's my friend, and very … reliable person I can trust."

International graduates described their mentors in a similar manner. Sebastian portrayed Dr. Soleil [f, int] as comfortable with mentee's independence, as she "gives freedom." Maria described one of her mentors, Dr. Benito [m, dom], as "nice," "hands off," with a "wild imagination," and comfortable with mentee's independence, and "very kind all the time, always saying the positive things, never diminishing you." He would "invite you to his house with his family." She described her other mentor, Dr. Powell [m, dom], as being "hands of," "father like," and friendly, as "he will get deeper in the conversations with you…personal conversations,…more of a friend."

Emotional Support. Similar to personal qualities, emotional support was also the mentees' most described strategy, found in the interviews in the same percentages (85% for the entire group of mentees, 78% for domestic, and 91% for international graduates). In contrast to personal qualities, the ranges differ. It ranged between 0% and 15.4% of the total individual coded statements of mentoring the domestic graduates received from their mentor (M = 8.2%) and between 0% and 20% for the international graduates (M = 12%). Table 2.8 includes emotional support strategies the domestic and international graduates described.

Table 2.8

Emotional Support Strategies Described by Domestic and International Graduates

Domestic Graduate Quote	International Graduate Quote
Code: Personal support (10 out of 20 mentees)	
His [Dr. Yao, m, int] *flexibility in terms of the life of being a parent in graduate school was very helpful and relieved the stress of that combination.* [Christian]	*We don't have pay vacations as a student. I was really confident to asking* [Dr. Benito, m, dom] *for some days off to go for vacation and have some time to relax and he was very comprehensive* [accommodating]. (Roman)
Code: Providing encouragement and affirmation (7 out of 20 mentees)	
He [Dr. Benito, m, dom] *encouraged me.* (Jack)	*He* [Dr. Benito, m, dom] *never forgot encouraging his mentees.*(Sonja)

Table 2.8 (continued)

Code: Protecting/Not protecting from additional work, lessening work (2 out of 20 mentees)	
I had a lot of projects going on at the same time and so you know ultimately it worked out but maybe she [Dr. Day, f, dom] *could have like tried to reel me in and say you have too much on your plate, like start, you know, start doing less*. (Thomas)	*It would have helped …more …free time …giving a little bit more space…There is a lot of burnout and frustration, because of that…you stop enjoying it if you don't pay attention to it. And I feel like nice thing is for your advisor to catch that, and then make sure that you are having a good way for balancing out work and life... I'll say that would have been a good thing.* (Florian)
Code: Developing confidence and self-esteem (1 out of 20 mentees)	
Not found	*Nobody wants to be told that their writing is trash…* [Dr. Day, f, dom] *was … so nice about the way she would critique my work …But I wouldn't feel bad at the end of it.* (Musah)
Code: Checking in to see how things are going (1 out of 20 mentees)	
Not found	[Dr. Powel, m, dom] *was more like 'How are you feeling? How are the things going? Are you feeling okay?'* (Maria)
Code: Providing cultural and social support to international students (1 out of 20 mentees)	
Not found	*Culturally and socially…very sensitive to my needs.* (Musah)
Code: Supporting student's religious practices (1 out of 20 mentees)	
Not found	*Friday afternoons I would go to the mosque*. [Dr. Day, f, dom, would say] *'Okay, just let me know the time'*. (Musah)
Code: Enjoyment (1 out of 20 mentees)	
[Dr. Brooks, f, dom] *…tried to make sure mentees were doing something that they were passionate about, or they were having fun with, because it's not easy*. (Antonia)	Not found
Code: Empathy/lack of empathy (1 out of 20 mentees)	
I think it's really hard to be a graduate student, and to be pushed to the level that he [Dr. Benito, m, dom] *pushes his students. I think, probably some empathy towards the challenge and he did express some of this, but I just remember being particularly hard.* (Jack)	Not found
Code: Teaching resilience (1 out of 20 mentees)	
I just learned patience and how to sit still and if something was bothering me… do the best I can to remedy the situation, but what I can't change, you just have to learn how to adjust and live in spite of. (Gabriel)	Not found

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

One domestic graduate, Antonia, expressed that she received emotional support: “without crossing the line, ensuring that you are providing mental and emotional support.” Gabriel (domestic) felt that his mentor [Dr. Powell, m, dom] “provided the safe space” and taught him resilience, as he “just learned patience and how to sit still and if something was bothering me… do the best I can to remedy the situation, but what I can't change you just have to learn how to adjust and live in spite of.” Jack recalled his mentor “encouraged me” but he wished for more empathy from Dr. Benito [m, dom]:

> “It’s really hard…to be pushed to the level that he pushes his students...some empathy towards the challenge and he did express some… I just remember being particularly hard. The pressing feeling of trying to figure out a question that has no answer. The aspect of research and relating to that challenge in an emotional way.”

The international graduates described how their mentors encouraged them and developed their self-esteem. Sonja said: “He [Dr. Benito, m, dom] never forgot about encouraging his mentees. And then that was really great support, at least for me to keep going without …losing patience.” Musah recalled how his mentor [Dr. Day, f, dom] would support his religious practices. Sebastian described Dr. Soleil [f, int] as being “very helpful in family crisis.” Collin felt that he was “in a very supportive program with very supportive community and mentor.”

Communication. Communication was reflected in fourteen out of twenty (70%) graduates’ interviews. It was less common in domestic graduates’ interviews, as four out of nine (44%) mentioned it and found more in the international graduates’ descriptions of their mentoring experiences; ten out of eleven (91%) international mentees considered it as an effective strategy. It ranged between 0% and 18.8% of the total individual coded statements of the mentoring the domestic graduates received from their mentor (M = 5.2%) and between 0%

and 27.8% for the international graduates (*M* = 14.8%). Table 2.9 includes communication strategies the domestic and international graduates described.

Table 2.9

Communication Strategies Described by Domestic and International Graduates

Domestic graduate quote	International graduate quote
Code: Clear, open, honest communication (9 out of 20 mentees)	
There is nothing we cannot talk about.(Zara)	*Being able to communicate to her* [Dr. Brooks, f, dom]… *directly and transparently and honestly really helped…talking to her. This is what I want. This is what I feel. This is what makes me sad. For her, as a busy person, knowing what you want is much better than reading your mind. And that improved our efficiency.* (Amelia)
Code: Taking/Not taking the time to know the mentee (5 out of 20 mentees)	
Talk personal stuff (Joshua)	*He* [Dr. Gray, m, int] *tries to get to know…the mentee.* (Florian) *Have some conversation …also help the students to explore what they want to do after graduation, I think have the conversation as early as possible is very helpful.* (Quinn)
Code: Active listening (1 out of 20 mentees)	
Not found	*Listening carefully* (Sonja)

Note. The red font indicates a negative aspect. f = female, m = male, dom = domestic, and int = international.

The domestic students described the communication with their mentors as “open,” “clear,” “respectful,” and still continuing to maintain contact after their graduation. Joshua explained that his mentor [Dr. Yao, m, int] would take his time to know him, as they did “talk [about] personal stuff.” International graduates described the communication similarly, as being “clear” and “honest.” Sonja (international) mentioned active listening as an effective strategy: “In the beginning I was really impressed that he [Dr. Benito, m, dom] is listening really, really, carefully what I'm talking.”

Mentoring Approaches, by Dyads

In order to answer research question four, two mentors with differing approaches were considered and presented. The mentoring approaches in two dyads, Dr. Brooks (highly academic) and her students, and Dr. Day (highly psychosocial) and her students, are described below.

Dyad 1: Dr. Brooks, Amelia, and Antonia's Narratives of their Mentoring Experiences

Dr. Brooks, a highly academic mentor, used predominantly academic behaviors (73%) to support the development of her graduate STEM students.

Dr. Brooks: Mentoring Amelia. She worked with Amelia (international) to help her learn analytic skills, build her confidence in research techniques, and provide her with independence and freedom in her research. She found Amelia ambitious, met with her regularly, but wished she had more publications despite her career goals outside of academia.

Amelia: Dr. Brooks' Mentoring. Amelia found Dr. Brooks to be very busy, and hands-off, which matched her personality well. She gave Amelia direction, trusted her to do things on her own, and was protective and encouraged her students. She felt they could communicate directly, transparently, and openly, and that Dr. Brooks was very interested in helping women succeed.

Dr. Brooks: Mentoring Antonia. Dr. Brooks found Antonia (domestic) very talented, organized and highly interested in her research, but perceived her to be less confident in her computing abilities than Amelia and Max. She encouraged her and gave her many opportunities, and felt that Antonia worked extremely hard. She knew Antonia did not want to become a professor, but wished she would be more confident, have more publications, and attend conferences.

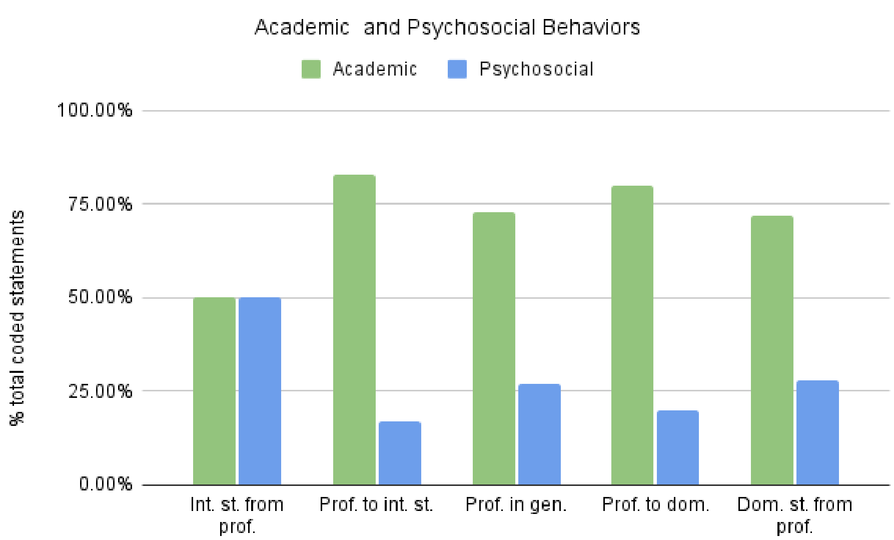
Antonia: Dr. Brooks' Mentoring. Antonia felt that Dr. Brooks tailored the mentoring strategies she used with Antonia, to address her learning disability in reading. She felt that Dr. Brooks wanted people to work on things they were passionate about and enjoy it so they could stay motivated. Antonia found Dr. Brooks was reassuring and she provided opportunities for Antonia to attend conferences, mentor teachers and students, and gave her more time when needed to practice presentations and review her papers. Dr. Brooks had 14 mentees and was often overwhelmed, yet was very good at flying by the seat of her pants; Antonia didn't have a problem with this because she felt they were similar in how they operated.

Dyad 1 Summary: Dr. Brooks, Amelia, and Antonia

When discussing mentoring in general**,** Dr. Brooks most frequently mentioned *academic behaviors*, which constituted 73% of the coded statements (see Figure 2.8).

Figure 2.8

General and Particular Academic and Psychosocial Strategies Dr. Brooks, Amelia (domestic), and Antonia (international) Described



Note. Int.st. means international student, dom. st. domestic student, prof. professor.

Dr. Brooks used *induction* (81.8%), *competence* (9.1%), and *availability* (9.1%) to describe general *academic* behaviors that supported the development of her graduate STEM students. *Psychosocial* behaviors were second in importance, reflecting 38.9% of the total coded statements when discussing mentoring in general. *Communication* was the only strategy Dr. Brooks used to support the development of graduate students.

Dr. Brooks', Amelia's, and Antonia's mentoring experiences are described below. Academic and psychosocial behaviors are reflected similarly in Dr. Brooks' description of her mentoring: 80% of the total coded statements for mentoring the domestic graduate were academic behaviors, while 83.3% of the total coded statements for the international mentee were academic (see Figure 2.8). The only academic behavior used with the domestic student was induction (see Figure 2.9), while with the international student, induction and availability were mentioned (see Figure 2.10). Similarly, for both mentees, Dr. Brooks used induction as she provided feedback and helped them learn skills. Differently, Dr. Brooks tailored unique strategies for the domestic mentee and gave independence to the international graduate.

Figure 2.9

Mentoring Strategies in the Dyad Dr. Brooks-Domestic Student

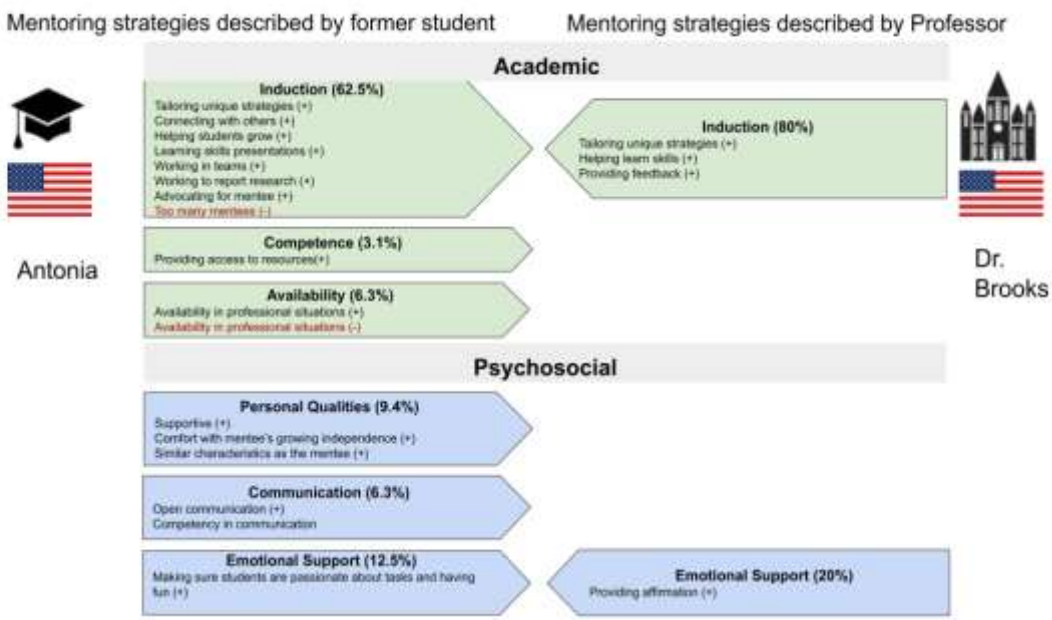
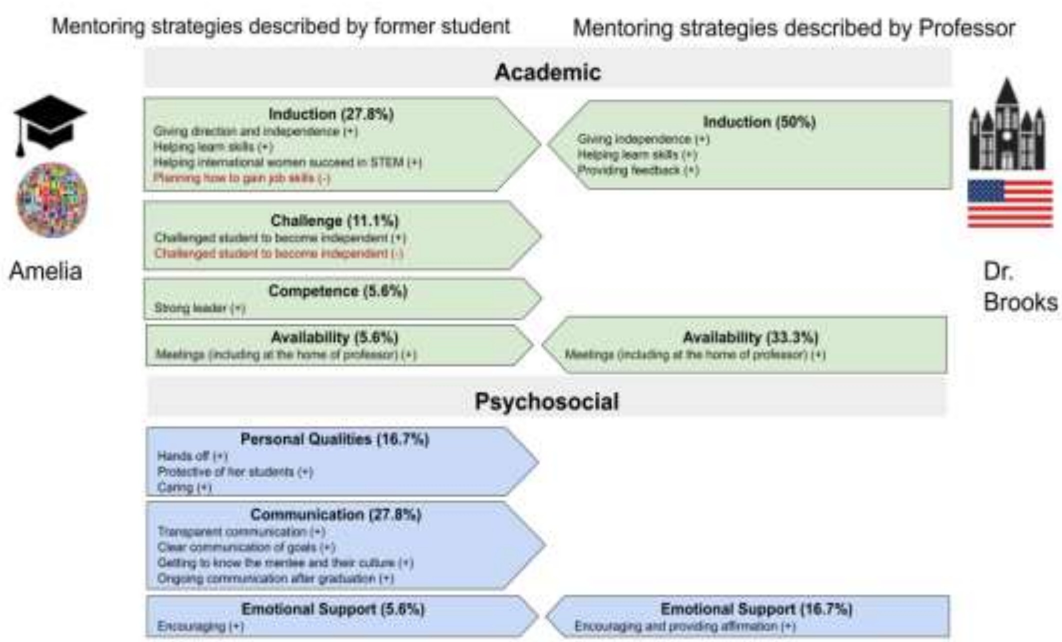


Figure 2.10

Mentoring Strategies in the Dyad Dr. Brooks- International Student



The psychosocial behaviors were not prevalent in Dr. Brooks' mentoring, as it was found in 20%, respectively 16.7% of the total coded statements of the mentoring strategies Dr. Brooks employed for the domestic and respectively international graduates. The only psychosocial behavior Dr. Brooks narrated was emotional support, which was found in both domestic and international mentoring experiences.

Antonia on the Mentoring Received from Dr. Brooks

Similar to her mentor, Antonia's description of her mentoring experiences included mostly academic behaviors (71.9% of the total coded statements), with psychosocial behaviors accounting only for 28.2% (see Figure 2.7). The academic behaviors narrated included induction (62.5% from total coded statements), competence (6.3%), and availability (3.1%). The psychosocial behaviors were comprised of emotional support (12.5%), personal qualities (9.4%), and communication (6.3%).

Amelia on the Mentoring Received from Dr. Brooks

Unlike her mentor, who described mostly academic behaviors she used to support her development as a graduate student, Amelia described receiving evenly academic (50% of the total coded statements) and psychosocial support (50%). The academic behaviors Amelia noticed were induction (27.8%), challenge (11%), availability (5.6%), and competence (5.6%). The psychosocial behaviors Amelia narrated were communication (27.8%), personal qualities (16.7%), and emotional support (5.6%).

Dyad 2: Dr. Day, Thomas, and Musah's Narratives of their Mentoring Experiences

Dr. Day used predominantly psychosocial behaviors (61% of the total coded statements of mentoring she described) to support the development of her graduate STEM students.

Dr. Day: Mentoring Thomas. Dr. Day knew Thomas from when he was doing undergraduate research during a summer program and felt they had a lot of shared experiences (swam, attended a small college, and grew up in the same town). She described Thomas as focused, goal-oriented, successful, and highly motivated. Thomas' dissertation focused on benchwork and education research. Thomas was sometimes burdened with too much assigned work but was willing to ask for what he needed, and Dr. Day supported this.

Thomas: Dr. Day's Mentoring. Thomas perceived Dr. Day as holding high standards and being attentive and responsive to student's needs. In addition, she was a talented writer and connected him with other professionals in the field. They had weekly meetings where she worked with him on improving academic writing and taught him how to write grants. At times, Thomas was frustrated with the slow feedback. He also wished for more career support, especially outside academia. Thomas perceived the mentoring relationship with Dr. Day as reciprocal; not only Dr. Day provided support, but Thomas did also by sharing techniques with her and providing emotional support during COVID-19.

Dr. Day: Mentoring Musah. Dr. Day described Musah as having a tough time during COVID-19, as he could not return home to see his family. She gave him space, provided personal support, changed his timeline, and encouraged connections with students and his faith community. She challenged him to improve his academic writing skills and gave him more feedback than other students. Musah did not always take her advice, but over time, she became more comfortable with his growing independence and allowed him to decide which edits to accept.

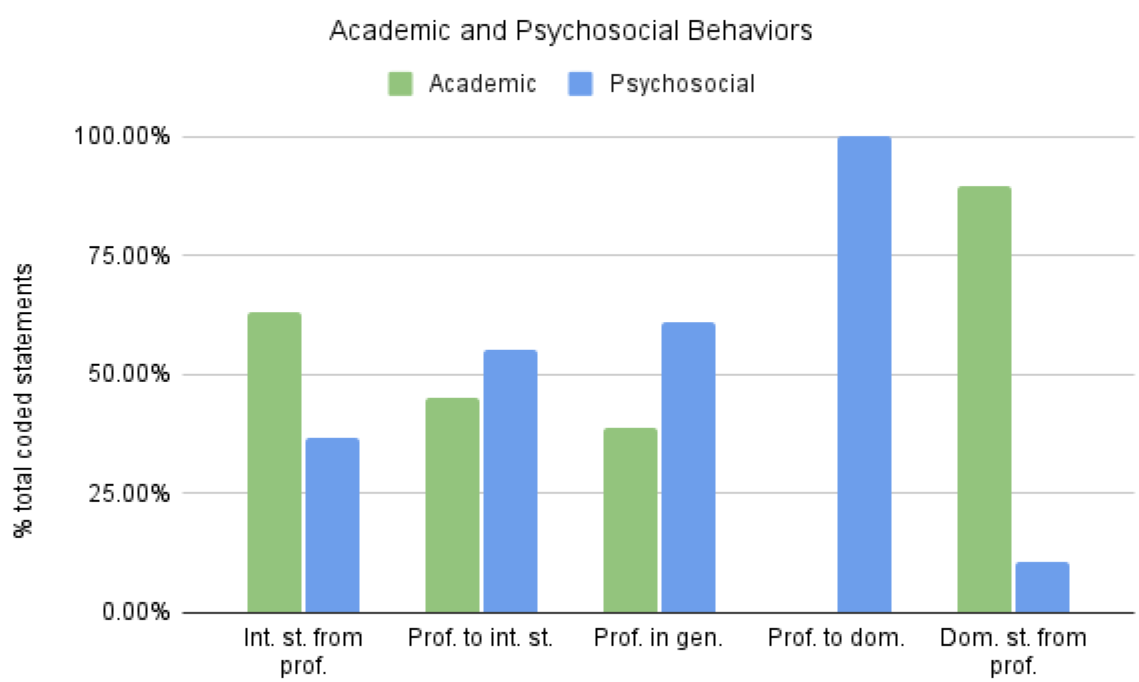
Musah: Dr. Day's Mentoring. He perceived Dr. Day as good at developing and conducting research. She gave him the independence to develop his project, which was studying the experiences of [Asian] international students as they transitioned to PhD programs. She spent much time with Musah and challenged him to improve his writing, which took over one year. Dr. Day was nice, supportive, and encouraging, giving him time to go to his worship place, mentoring him and continuing with advice after graduation. Her support gave him confidence; he couldn't talk highly enough of her and was grateful for everything she did for him.

Dyad 2 Summary: Dr. Day, Thomas, and Musah

When discussing mentoring in general**,** Dr. Day most frequently mentioned *psychosocial behaviors* constituting 61% of the coded statements (see Figure 2.11).

Figure 2.11

General and Particular Academic and Psychosocial Strategies Dr. Day, Thomas (domestic), and Musah (international) Described



Note. Int.st. means international student, dom. st. domestic student, prof. professor.

Dr. Day described psychosocial behaviors that supported the development of graduate STEM students that were coded as *communication* (50%), *personal qualities* (33.3%), and *emotional support* (16.7%). The academic behaviors Dr. Day employed were coded as *induction* and *competence.*

To mentor Thomas, Dr. Day used only psychosocial behaviors (Figure 2.12). To mentor Musah, she used both academic and psychosocial behaviors (Figure 2.13).

Figure 2.12

Mentoring Strategies in the Dyad Dr. Day – Domestic Student

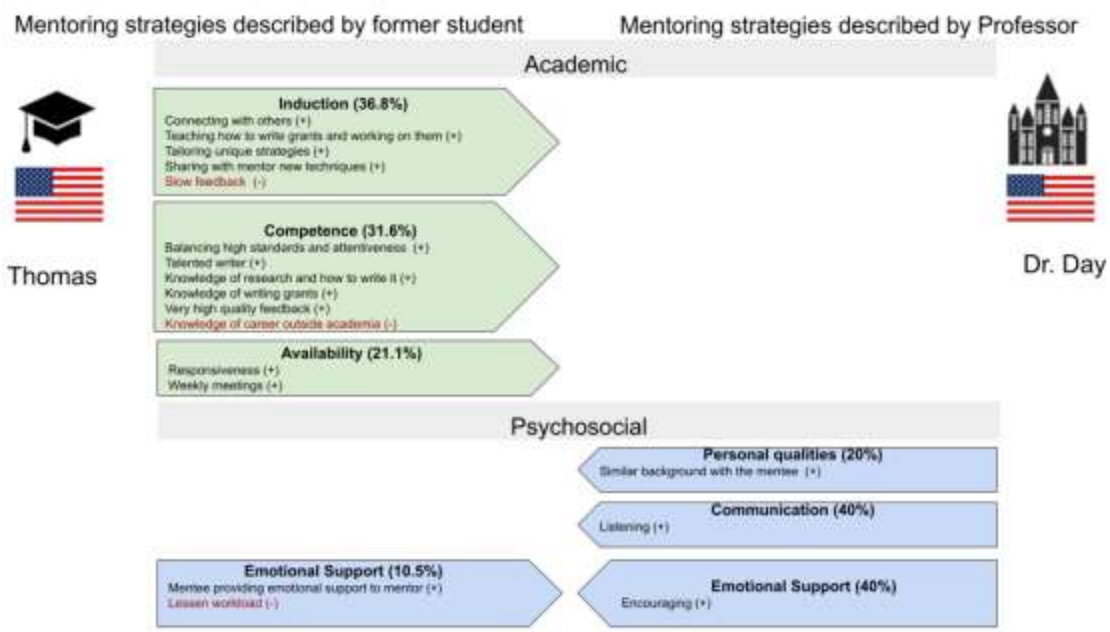
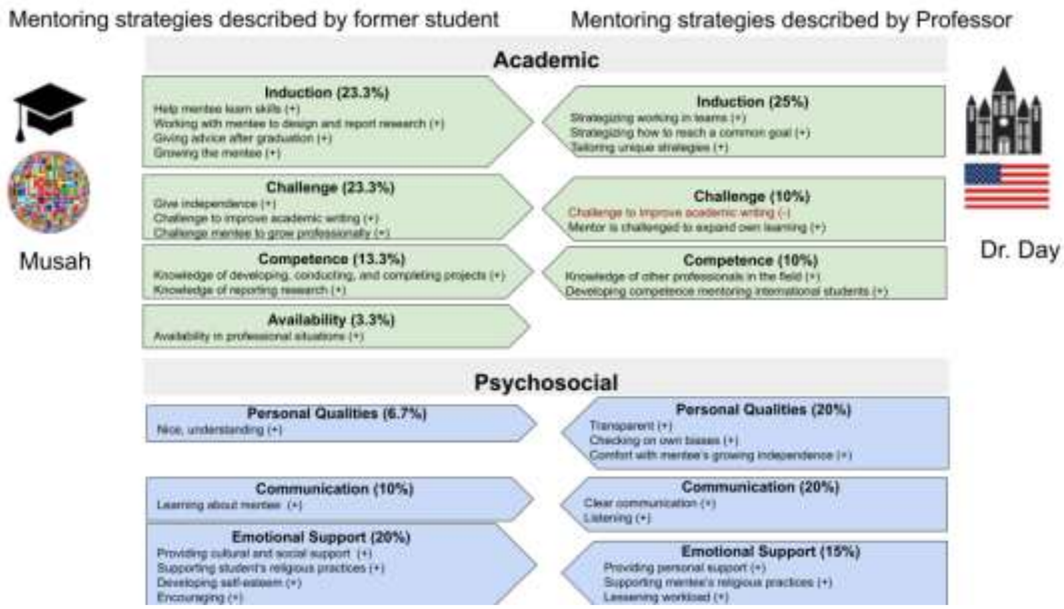


Figure 2.13

Mentoring Strategies in the Dyad Dr. Day – International Student



Personal qualities counted for 20% of the total coded statements of the mentoring Dr. Day used to support Thomas' development as a graduate student. *Emotional support* and *communication* constituted each 40% of the total coded statements of the mentoring. Differently than in the case of mentoring Thomas, to mentor Musah, Dr. Day used both academic and psychosocial behaviors. The academic behaviors counted as 45% of the total coded statements of the mentoring Dr. Day used to support Musah's development and the psychosocial behaviors summed up to 55%. The academic behaviors used were induction (25%), challenge (10%), and competence (10%). These behaviors helped Musah improve his writing skills. The psychosocial behaviors Dr. Day used with Musah were: personal qualities (20% of total), communication (20%) and emotional support (15%).

Thomas on the Mentoring Received from Dr. Day

Unlike his mentor, Thomas described mostly academic behaviors (89.5% of the total coded statements of mentoring received from Dr. Day). The psychosocial behaviors were reflected in 10.5% of the total coded statements. Induction (36.8%), competence (31.6%), and availability (21.1%) are the three subthemes found in Thomas' interview. Emotional support surfaced as the only psychosocial behavior.

Musah on the Mentoring Received from Dr. Day

Musah described mostly academic behaviors (63.3%); the psychosocial behaviors were reflected in 36.7% of the total coded statements of mentoring he received from Dr. Day. All four academic behaviors were found: induction (23.3%), challenge (23.3%), availability (3.3%), and competence (13.3%). The psychosocial behaviors described by Musah were personal qualities, communication, and emotional support.

Limitations

These findings should be considered keeping in mind a few limitations. First the participant professors in this study might be mentors who had primarily positive mentoring experiences with their mentees and therefore recommended them to participate in the interview. Also, the mentees could have a mostly beneficial mentoring relationship. Different mentors and mentees might lead to different findings. Second, only one data source was used. Having more data sources beside the semi-structured interview might lead to more nuanced findings. Third, it is possible that the participants' responses would have been interpreted differently with a different researcher.

Discussion and Conclusions

Research Questions

The purpose of this study was to understand the mentoring approaches perceived by both mentors and mentees. The first research question investigated, overall, the most prevalent academic and psychosocial supports that were described by the mentors and the mentees. The most prevalent themes were academic (induction, 33%; challenge, 13.2%), followed by psychosocial (personal qualities, 16.2%; communication, 12%; emotional support, 11.8%).

Next, research question two addressed the overall mentoring approaches that mentors used to support the development of graduate students. The majority of mentors (75%) in this study described using predominantly academic behaviors to support the development of their graduate STEM students. Induction was the most common theme (M = 40%), followed by challenge (M = 18.5%), availability (M = 8.5%) and competence (M = 3%).

These findings are similar to Sanczyk et al.'s (2021b) study who found that all six STEM faculty participants tended to describe mentoring as giving academic support to their mentees, in the forms of providing guidance to doctoral STEM students, assisting them with research and encouraging them to publish papers, providing resources, connecting them to other professionals in the field, and meeting regularly to keep them on track. The mentors' focus in this study on academic behaviors also resonates with Howell et al.'s (2021) assertion that STEM doctoral faculty "see mentoring more exclusively as the development of science knowledge" (p. 435), as they focused on the importance of molding their mentees into becoming scientists.

The mentors' focus on academic behavior and growing the STEM students into independent thinkers are in line with the National Academies of Sciences, Engineering, and Medicine's views that the "education and training that students receive during their Ph.D.

education should provide them with the ability to conduct original scientific research" (NASEM, 2018, p. 106). Providing opportunities to the mentees to publish research seem important to several mentors in this study. This finding aligns with Leshner and Scherer (2019) who argued that at research intensive universities, faculty members' advancement criteria is heavily inclined toward productivity in conducting and publishing research and obtaining funding.

Five mentors in this study highlighted the importance of tailoring their mentoring to their mentees' unique needs. Although NASEM (2018) expressed clearly that graduate STEM education should have "an increased focus on the needs of students" (p. 18), this tailored mentoring is not common in the literature. Geesa et al. (2020) found that mentors in an EdD educational leadership program at a Midwestern U.S. university tailored their group presentations based on the stage of the mentee in the program.

The third research question focused on how STEM graduate students described their mentoring approach as well as aspects that were supportive of their development. All the domestic and the majority of international graduates (54.5%) reported that their mentor used at least equally or more academic than psychosocial behaviors to support their development as graduate students. Only four out of eleven (36.4%) international STEM graduates described mostly psychosocial behaviors of their mentors. The mentees described their mentors connecting them with others in the field, providing feedback and guidance, and helping them grow as professionals and learn skills. These findings are in line with previous research showing that domestic graduate STEM students see mentors as examples to model and who give them opportunities to grow professionally (Atkins et al., 2020). The mentees were challenged to become independent thinkers, consistent with Atkins et al. (2020) who describe mentors as people encouraging the domestic STEM mentees to pursue independent work while providing them opportunities to do so. This current study contributes to the literature as it includes the experiences of international graduate STEM students. As described in prior literature, the online doctoral mentees valued the timely feedback they received in the education program, as they needed it to make progress in their research (Kumar and Coe, 2017). This current study adds to the body of literature, including the mentoring experiences of in-person doctoral mentees.

The mentees in this study, including underrepresented minority, female, and international students, expressed perceptions of mentoring experiences showing that their mentors considered their unique needs, and provided emotional support that enhanced their confidence and STEM abilities. These findings contrast with those of Sanczyk et al.'s (2021a), whose qualitative study found that twenty-five doctoral STEM students at a predominantly white southeastern U.S. research university (nine were underrepresented minorities) described perceptions of being neglected, misunderstood, and marginalized by their mentors. Sanczyk et al's (2021a) underrepresented minority doctoral STEM students reported perceptions of cracks in the STEM doctoral mentoring due to absence of "social, cultural, and emotional connections between faculty mentors and their doctoral students" (p. 4366). None of the twenty doctoral STEM graduates in this study reported lack of mentors' encouragement; although Thomas (domestic) and Florian (international) wished that their mentors would recognize their emotional struggle with an excessive workload and take steps to lessen it.

The study provides a nuanced understanding of how mentors and mentees feel about their mentoring STEM experiences, toward one another, not generically. This allows the reader insight into their perceptions of the same relationship, from different perspectives. Unlike Sanczyk et al.'s (2021a) findings, this study is revealing by far more positive than negative perceptions of the mentoring experiences the mentors provided and the mentees received.

The fourth research question addressed the experiences of two dyads of the mentoring: between two different graduate STEM mentors and two of their mentees, to understand their approaches, and aspects that were supportive in students' development, or not. Dr. Brooks described her mentoring approach in a similar way when she referred to the domestic and international students. She described mostly academic behaviors. The domestic student described also predominantly academic behaviors, matching her mentor's description, but the international mentee described equal amounts of academic and psychosocial behaviors.

Dr. Day described her mentoring approach differently when referring to her domestic and international student. In relation to the domestic student, she described only psychosocial behaviors. However, the domestic mentee described mostly academic behaviors. Dr. Day described both types of behaviors with the international student, but with a higher emphasis on psychosocial behaviors. The international mentee described mostly academic behaviors.

Eller et al. (2014) found, in their qualitative study of 117 dyads in STEM fields, that mentors and mentees described similarly and reached consensus on key components of effective mentoring relationships. Similar to Eller et al. (2014), some of the mentor-mentee dyads in this study described similarly supportive mentoring approaches. However, the differences revealed through a rich, descriptive study based on individual interviews, the importance of investigating mentoring from the unique and individual perspectives of mentors and mentees on the same relationship. This study adds to the literature by providing insights from both participants in the same mentoring relationship, providing rich qualitative vignettes, and focusing on both international and domestic doctoral students and mentors. It also shows the importance of assessment and dialogue in mentoring as means to better support the development of graduate STEM students.

Connection of Study's Findings to the Frameworks

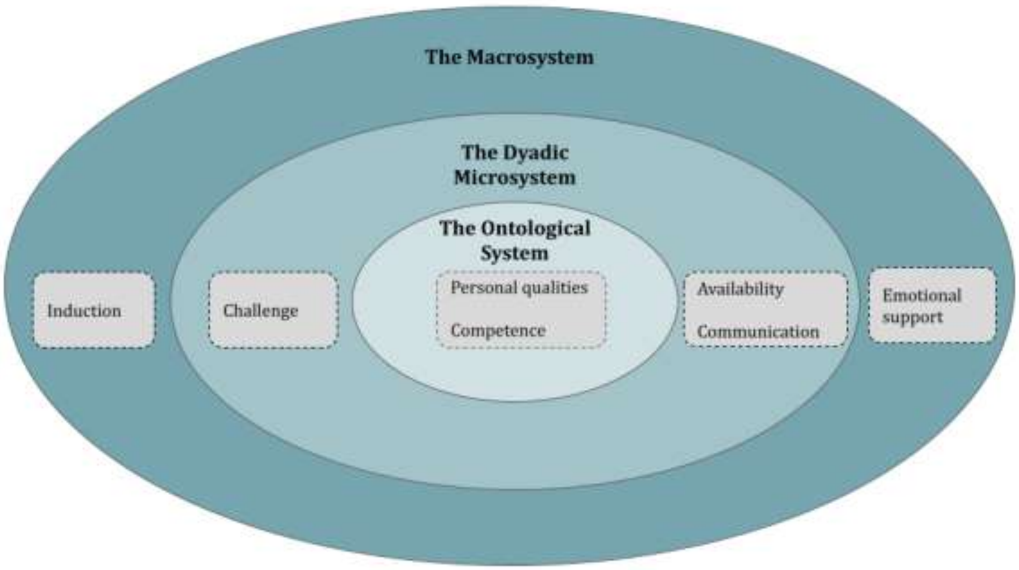
When Yob and Crawford's (2012) published their conceptual theory of mentoring, they called for international students to be included in a future study as well as for investigating whether mentors and mentees agree on what constitutes effective mentoring. Their framework was effective in capturing all of the reported behaviors by the mentors and mentees in this study, which were consistent with academic and psychosocial behaviors, most of which supported the graduate STEM students' development. In the current research, it was noted that some of the behaviors had a negative aspect to the behavior, which at times was described by the mentor or the mentee.

In order to think more about how the mentor and mentee relationship fits into the larger academic and cultural environment, Chandler et al.'s (2011) ecological systems theory was employed. The specific characteristics of the systems were modified to reflect the salient aspects of the graduate student ecological systems. Personal attributes of the individuals, both mentor and mentee, did contribute to the ontological system. By only studying an individual rather than looking at the reciprocal perspectives of the mentor-mentee relationship, it would not be possible to understand the interplay of the ontological system (personal attributes), or show relational characteristics between the mentor and mentee (dyadic microsystem). It would not be possible to understand the macrosystem (norms and practices, cultural differences) that influenced the experiences of the individuals without having rich understandings of how beliefs, abilities, norms, and culture influenced the ecological systems of the graduate experience, due to the thick descriptions in the qualitative data.

Given the findings of this study, there is an opportunity to rethink Chandler et al.'s (2011) ecological systems theory – applied to graduate education, incorporating the interrelationships between mentors and mentees. There are shared constructs between the two frameworks (Figure 2.14). Chandler et al.'s (2011) *ontological system*, the inner circle, could be described by Yob and Crawford's (2012) personal qualities and competence of the mentor and the mentee, as they represent the mentor's and mentee's attributes. The *dyadic microsystem*, the next circle, could be described as 'challenge', which is mostly a mentoring function that stimulates graduate students to grow, and become independent thinkers. The mentor's availability and communication back and forth with graduate students, which are part of the dyadic microsystem, reflect one relational characteristic between mentor and mentee. Induction is reflected into the *macrosystem*, the outermost circle. Mentors induct the mentees into (STEM) departments and fields, provide resources for them, and connect them with other professionals in the field, which depend on institutions, programs, and other people in the field, and are described by particular norms and practices. Chandler et al. (2011) attributed cultural differences to the macrosystem. Mentors and mentees in this study described cultural differences and challenges, and also the support they provided and received to overcome them. Emotional support was placed within the macrosystem, as mentors and mentees come from different countries, cultures, and groups and bring with them varied personal and emotional needs. Providing affirmation and encouragement, and developing confidence and self-esteem are highly dependent on the unique needs of domestic and international students.

Figure 2.14

Shared Constructs between Yob and Crawford's (2012) and Chandler et al.'s (2011) Theories



Note. Yob and Crawford's (2012) academic and psychosocial behaviors are included in gray, dotted-line boxes in Chandler et al.'s (2011) ecological systems theory applied to graduate mentoring.

Recommendations

This study's results provide rich descriptions about mentoring relationships that add to what we know about mentors, and mentoring between international and domestic mentors and mentees at a research-intensive university in the southeastern U.S. The findings lead to a series of recommendations, with the intention of improving the mentoring experiences of domestic and international doctoral STEM students.

Recommendations for Mentees

1. Develop a post-graduation transition plan by exploring career options and seeking job market advice early in the program.

2. Prioritize publishing papers in the program as authorship will help them build a stronger academic portfolio.
3. Incorporate the mentor’s feedback into the research process. Constructive criticism is essential to elevating the quality of research and publications.
4. Exhibit greater independence in the dissertation process, including selecting the dissertation topic.

Recommendations for Mentors

1. Actively introduce mentees to a broader network of professionals, such as other researchers in the field, potential employers, and counselors. These connections will support the academic and psychosocial development of students and guide their career decisions.
2. Initiate conversations about job prospects early in the program and offer job search guidance for academic and non-academic careers.
3. Provide more structured guidance early in the program as the mentees need help in the early stages of their program.
4. Increase availability in professional situations.
5. Prioritize giving timely feedback on written work.
6. Balance mentees’ workloads to avoid situations in which students are burdened by the amount of tasks they are given or choose to have.

Recommendations for Departments, Graduate Schools, and Institutions

1. Limit the number of mentees per professor. A high mentor-to-student ratio can limit the time a mentor can dedicate to the mentee, leading to a negative impact on the development of the graduate student.

2. Integrate job search resources into the doctoral program to ensure that both mentors and mentees have access to information about academic and non-academic career opportunities.
3. Offer formal training on best practices in mentoring as effective mentoring positively impacts students, professors, departments, and institutions.

As with any other relationship, some aspects could be improved to support the development of doctoral STEM students. Mentors experience difficulties mentoring their protegees due to their mentees' role (Eby & McManus, 2004). Also, scientists want more mentorship training, as effective mentoring leads to better research productivity and psychosocial support (Hund et al., 2018). By following the recommendations from this study, departments and institutions can enhance the development of doctoral STEM students by prioritizing mentoring.

Chapter 3: The Development and Validation of the Mentoring Experiences of Graduate Students Survey (MEGSS) with STEM Graduate Students

Abstract

The U.S. system of graduate STEM education is one of the top in the world. The number of graduate STEM students has steadily increased, but there still are high attrition rates. Mentoring is recognized as crucial to support the development of graduate STEM students, yet little is known about how best to support graduate STEM students through mentoring. In this quantitative study, the Mentoring Experiences of Graduate Students Survey (MEGSS) was developed and validated. The survey was distributed to graduate STEM students from a large, public, research-intensive U.S. university. Exploratory factor analysis was conducted to test the validity and reliability of the survey, with 280 responses. A 5-factor, 38-item model was determined with the following subscales: psychosocial support, program completion, research and writing, career expectations, and career support. Findings revealed significant differences in students' perceptions of their mentoring experiences and expected outcomes based on gender identity, stage in the program, and academic discipline. Recommendations for mentors and universities are given to provide more psychosocial support, research and writing, and career support.

Keywords: graduate STEM students, mentoring, exploratory factor analysis, psychosocial support, program completion, research and writing, career expectations, career support.

Introduction

Graduate STEM education contributes to the innovation and scientific advances that give the U.S. a competitive position in the global economy (NASEM, 2018). Graduate STEM students develop knowledge, conduct research, generate publications and become independent thinkers who solve some of the most pressing issues. However, they face many challenges. Studies have found that graduate students are generally unprepared for their writing tasks, especially in doctoral programs (Deshpande, 2016; Zerbe & Berdanier, 2019), and they lack awareness of career options (Thiry et al., 2015).

There are high rates of attrition in graduate STEM programs. Mentors represent one of the most important sources of information and support (Collier & Blanchard, 2024; Thiry et al., 2015) and are key in supporting the development of graduate STEM students (NASEM, 2018; Yob & Crawford, 2012) from both academic and personal perspectives (Antonio & Baek, 2021; Kumar & Coe, 2017). Mentors develop mentees' sense of professional competence (Lechuga, 2011), inspire the mentees to pursue careers (Karalis Noel et al., 2022), or encourage them to persist and succeed in their graduate programs (Janssen et al., 2021). With an increasingly diverse pool of graduate STEM students, there is a call to put the students at the center of the graduate school experience by addressing their individual needs (NASEM, 2018).

Literature Review

Graduate STEM Education

In 2020, the U.S. awarded 42,000 science and engineering doctoral degrees (NSB, 2024b). Sixty-three percent of the master's and fifty-seven percent of doctoral degrees were awarded to domestic students (NSB, 2024b). International graduate students are overrepresented in computer science and engineering, with 60% of the doctoral degree awarded to international students (Miner, 2019; Zwetsloot et al., 2020). Domestic students are overrepresented in life and physical sciences (Miner, 2019). In the health and biological sciences, domestic graduate students account for over two-thirds of the total student population (Zwetsloot et al., 2020).

With an increasing number of international students, there is some debate regarding the fact that they might take the place of domestic students in science and engineering graduate programs. Hegarty (2014) asserted that international students "quite often enroll in programs that are under-enrolled by domestic students and therefore are the lifeline of existence for many programs" (p. 231). Conducting a forecasting analysis for 2011-2025, Sanfilippo et al. (2016) found the present rates of international students' enrollment in science and engineering as favorable. Cutting in half the number of international graduate students might lead to an increase of 10% in the number of domestic students, but at the expense of revenues from education, decreased number of patent submissions, and slimmer scientific novelties (Sanfilippo et al., 2016).

Gender, Race, and Ethnicity

In 2022, 64% of the doctoral STEM degrees in the U.S. were awarded to males, half of those being domestic. Out of the 36% of the doctoral degrees awarded to females, over two-thirds were conferred to domestic graduates (Institute of Education Sciences, 2025). Domestic and international graduate students are not equally represented in STEM fields by gender. Analyzing the responses of 1535 domestic and 787 international graduate students from 74 countries enrolled in physical sciences, mathematics, engineering, and computer sciences, Miner (2019) found that, while there is a difference in male and female enrollment of domestic graduate students in engineering, this is not the case for international students, who are represented similarly. The same author noted that, compared to domestic male students, the number of international male participants in computer science is more than triple. Compared to international men, international women are more likely to be in life sciences disciplines compared to physical sciences (Miner, 2019).

Racial/ethnic minorities are disproportionately underrepresented in graduate STEM programs. In 2019, the U.S. population comprised 13.4% Black and 18.5% Hispanic individuals (U.S. Census Bureau, 2019). In the same year, only 8.1% of the science and engineering doctoral degrees were awarded to Black and 8.4% to Hispanic individuals. White individuals earned 69.1% of the science and engineering doctoral degrees, and Asians 10.6% (NSB & NSF, 2022).

Country of Origin

Most international graduate STEM students studying in the U.S. are from China (36%) and India (13%), followed by South Korea, Turkey, and Taiwan (NCSES, 2025). The country of origin affects international graduate STEM students' intentions to remain in the U.S. after graduation. Chinese and Indian graduates have higher expected stay rates than European and South Korean graduates (NSB & NSF, 2022).

In a qualitative study of 22 science and engineering postdocs, 22 faculty members, and 5 U.S. and United Kingdom administrators, Cantwell and Lee (2010) found that the international postdocs had uneven experiences that depended on their country of origin. The Asian postdocs perceived the most alienation, discrimination, and pressure to perform (Cantwell & Lee, 2010). Also, the faculty members who hired the international postdocs did not have similar expectations of them and attached stereotypes about their country of origin to individual postdocs. Faculty members described the postdocs from North America and Europe as "broad-ranging in thought" and "creative"; the postdocs from developing countries were perceived as "hard-working" and "dedicated." Postdocs from Europe and Australia were labeled "as better trained in theory than Asians were, and thus more prepared to become faculty;" however, East Asians were seen as having better "technical training," and for this reason, they were favored to be hired as postdocs (Cantwell & Lee, 2010, pp. 503-507).

Reasons to Study STEM in the U.S.

STEM workers have higher average median income; in 2019, they earned 67% more than the non-STEM workers (NSB & NSF, 2022). Domestic students perceive the reputation of the university and the completion time as the factors that weigh the most in their selection of graduate programs; international graduate students focus on the variety of courses they can take and their rigor as primary motivators to pursue their education in the U.S. (Graham et al., 2018). Another important factor for international students is the opportunity to work in the U.S. (Furukawa et al., 2013; Graham et al., 2018). Also, international graduate STEM students choose to study in the U.S. for social and personal reasons. Pursuing graduate engineering degrees in the U.S. was found to boost the female and male Indian students' marriage options and to improve the family's social position in Indian communities (Yakabovski et al., 2014).

Enrollment in a master's degree has different purposes for domestic and international students. Domestic students see the master's degree as an avenue to obtain a promotion in their job. In contrast, international graduate students are more likely to seek a doctoral degree in the U.S. after completing a master's degree (Ruthotto et al., 2021). When international graduate students decide to pursue their education in the U.S., they stop their careers (Graham et al., 2018).

Obtaining a Visa

International graduate STEM students need F-1, J-1, or M-1 visas to be admitted into the U.S. and stay for the duration of their program (Granovskiy & Wilson, 2019). There are few options for international graduates to remain in the U.S. after completing their degree: optional practical training, H-1B visa, and lawful permanent residence (Granovskiy & Wilson, 2019). The lawful permanent residence process takes years because of restrictions on the allowed yearly and per-country numbers (Granovskiy & Wilson, 2019). Advisors' knowledge of the process of obtaining and keeping a visa that allows international graduate STEM students to study in the U.S. is critical to the success of their advisees. Cantwell et al. (2018) found that international graduate STEM students felt they depended on their academic advisors from a legal perspective. The National Science Board (2022) emphasizes the need for a "streamlined and expanded visa system" (p. 1) to reduce the barriers to international students studying in the U.S.

Challenges of Graduate STEM Students

Academic writing is a much-needed skill in graduate schools (Berdanier & Zerbe, 2018; Zerbe & Berdanier, 2019). Regardless of country of origin and citizenship status, graduate students are generally unprepared for their writing tasks, especially in doctoral programs (Berdanier & Zerbe, 2018; Deshpande, 2016; Zerbe & Berdanier, 2019). Berdanier and Zerbe (2018) conducted a study on how domestic and international graduate students studying engineering in the U.S. conceptualize and relate to academic writing. Using the survey responses of 210 students, the researchers found that the participants struggled with low self-efficacy in writing processes, perfectionism, and procrastination. However, statistically positive shifts were found between stages in the program and the number of times the students discussed writing with their advisor. Berdanier and Zerbe (2018) concluded that there are multi-layers of writing issues that graduate engineering students encounter and the academic writing support ought to be tailored to the individual.

Academic writing is influenced by student's level of English skills. For international students to study in the U.S., English proficiency tests, such as the TOEFL (Test of English as a Foreign Language), are required. Alves et al. (2015) found that Mexican engineering graduate students had difficulties passing the TOEFL exam, but an intensive summer program helped them improve their scores. However, TOEFL does not measure writing ability. The challenge of reading and writing academic papers in a language different from their mother language, for most of them, required extended time and extra effort (Rodriguez et al., 2024).

For the last three decades, many graduate STEM students have been working as teaching and research assistants in their departments of study, especially in science and technology; many programs depend on them (Cotos & Chong, 2019; Ozturgut, 2013, Reeves et al., 2018). Despite teaching large introductory classes, graduate teaching assistants have little training in pedagogy. The most common training is a short, pre-semester workshop conducted at course, department, or college level (Reeves et al, 2018). In their study of 81 domestic and international graduate STEM students from three universities who were working as teaching assistants, Reeves et al. (2018) examined the role of contextual factors in the efficacy of professional development. They found that even if the professional development was short, the graduate teaching assistants' self-efficacy and pedagogical knowledge increased while their anxiety decreased as a result of their participation in it. However, the changes in graduate teaching assistants' self-efficacy and anxiety varied by workshop (Reeves et al., 2018).

While working as teaching assistants, the international graduate students face cultural and teaching challenges (Avsar Erumit et al., 2020; Rodriguez et al., 2024). In their qualitative study of seven Turkish, South Korean, Indian, Chinese, and Nepalese graduate students, the researchers found the participants experienced cultural challenges in the form of "understanding U.S. humor, customs, values, and beliefs" (Avsar Erumit et al., 2020, p. 251). The linguistic challenges were related to "accent and fluency in speaking, the correct pronunciation of the words, and the differences in science and mathematics jargon across different countries" (Avsar Erumit et al., 2020, p. 251).

Similarly, in their qualitative study of 22 international graduate STEM students at predominantly White U.S. institutions, Rodriguez et al. (2024) found that the participants encountered social and cultural challenges. Challenges included interacting with domestic peers in social situations and the different gestural social norms, such as smiling as a form of respect and not using spoons, forks, and knives when eating, were some of the reported social and cultural experiences. As a result of these challenges, the international graduate STEM students felt isolated; the less culturally represented students expressed more isolation (Rodriguez et al., 2024).

Supports Received

Institutional Support

International graduate students receive many types of support while studying in U.S. academic institutions, with some types being more prevalent than others. Ozturgut (2013) analyzed open-ended survey responses from 53 institutions regarding the best practices used to recruit and retain international students. The researcher found that institutions focus, in general, on the social and cultural support of international graduate students and not as much on their personal and academic support. The author concluded that academic institutions invest more resources such as money, time, and effort in international graduate students' recruitment than in retention. Furthermore, Ozturgut (2013) noted that even if academic institutions successfully bring international graduate students to their campuses, a personal approach to recruiting and retaining them was required for their success, which was lacking.

Yu et al. (2017) investigated how international graduate STEM students perceive the role of libraries. The researchers quantitatively analyzed the responses of 284 international STEM and 1104 international non-STEM graduate students. They found that international graduate STEM students attribute less value to the role of libraries in storing and having available paid resources needed for research and graduate classes and in helping develop research competencies (Yu et al., 2017). The authors recommend that graduate programs include specific training in the graduate coursework to help international students develop their research skills.

Faculty Support

In addition to institutional resources, human resources such as advisors and faculty members are influential in helping international students successfully navigate graduate school (Antonio & Baek, 2021). Faculty members are the people graduate students meet most often on campus and are asked most questions (Ozurgut, 2013). Cantwell and Lee (2018) found that international graduate STEM students experience positive relationships with their advisors. Some of these international graduate students reported that the advisors made them feel like knowledge co-contributors to research and esteemed collaborators (Cantwell et al., 2018). Faculty members are also an essential source of knowledge regarding academic honesty. In a quantitative study of 647 international and domestic graduate STEM students from the University of Florida, Leonard et al. (2015) found that international students received more information from their professors regarding academic honesty than domestic students.

A sense of belonging in the program is vital for a successful experience in graduate studies and completion of the degree, and faculty members play an essential role. In a qualitative study of 12 male electrical engineering doctoral students from China, France, India, South Korea, and Turkey, Antonio & Baek (2021) analyzed how the participants construct their sense of belonging in the program. The authors found that the participants believe that their “advisors are the primary arbiters of their academic standing and performance” and “relationships with advisors are consequential for smooth academic and professional transitions in graduate school” (p. 143). For those international male doctoral students, academic success had the most weight in constructing a sense of belonging; social connections were of secondary importance (Antonio & Baek, 2021). The researchers found that older students reported stronger relationships with faculty members, while newer students reported a lack of responsiveness from faculty members before passing the qualifying engineering exams.

Peña-Calvo et al. (2016) studied how gender and STEM programs influence the perceptions of supports and barriers regarding the career development of 811 sophomore STEM students from Spain. The quantitative data analyses revealed that, in general, engineering students perceived they encountered more faculty barriers and received less faculty support compared to other students in science, mathematics, or technology (SMT) programs. Also, the researchers found that the students reported teaching barriers to be greater than the financial barriers. Peña-Calvo et al. (2016) found that the perceived faculty support, in both engineering and SMT programs, is the most important factor for students’ career expectations.

Wilkins-Yel et al. (2024) studied how graduate STEM advisors help or exacerbate women of color’s perceived barriers in doctoral programs. Eleven Latinx, Native American, Black, Asian American, multiracial female graduate students, postdoctoral fellows, and early career professionals were interviewed. Five participants described that their advisor provided career support, as they received support to attend workshops and conferences, or they were encouraged to obtain certifications outside the program that would enhance their skills and portfolio. However, the researchers found that 10 participants described unsupportive advisor behaviors, including inconsistent support and devaluation of careers outside of academia.

The academic support the graduate STEM students receive is reflected, among other things, in more publications in scholarly journals. Fisher et al. (2019) conducted a study involving 499 graduate STEM students from four California universities that draw highly qualified domestic and international students. The participants were from fields with the greatest representation of minorities (Mathematics, Physical and Computer Sciences, and Engineering). Fisher et al. (2019) aimed to assess, among other factors, progress in the doctoral programs, publication success, and perceived level of preparation. They found that Latino/Hispanic and Native American/Native Alaskan students published at rates similar or higher than Asian and White students. Black students were nearly three times less likely to publish in an academic journal. The researchers found that students' perceived success in the STEM program was the only direct predictor of publication success.

Desired Support

In a qualitative study involving 27 Korean, Chinese, and Vietnamese doctoral students enrolled in electrical and mechanical engineering and chemistry, Park et al. (2018) found that, to develop a professional identity, international graduate STEM students need intertwined types of support, which depend on the skills and experiences the students bring with them. The researchers found that the participants' prior work experiences contributed to developing Asian doctoral STEM students' professional identity, level of knowledge in their field, proficiency in the English language, and socialization with faculty members and colleagues (Park et al., 2018). To better support international doctoral STEM students, close attention should be paid not only to the gain of disciplinary skills but to the "sociocultural context in which they find themselves" (Park et al., 2018, p. 152).

Once they complete their studies, international STEM graduates can pursue careers in academia, government, or industry. The extant literature on graduate studies concentrates mainly on academic career research and not industry jobs (Choe & Borrego, 2019). Industry jobs generally hire one-third of the individuals with engineering doctorates, so students need support on future career undertakings in industry and government, beside academic knowledge (Choe & Borrego, 2019).

Career Plans

The career plans of graduate STEM students vary. Using survey responses from 2,322 domestic and international graduate STEM students in the U.S., Han and Appelbaum (2016) found that 39% of the participants preferred to remain in academia, 31% work for a company, 4.6% work for the government, 2.8% start their companies, and 2.5% work for a non-governmental organization. Compared to international students, the domestic students were less likely to look for a job in a company and more likely to work for the government. Also, 40% of the domestic students preferred to conduct academic research, and 27% favored seeking employment in a company. Han and Appelbaum (2016) found no differences in the percentage of international students who wanted to conduct academic research and those who wanted to work in a company.

Mentoring

Regarding the completion of the program, "the single most important factor in student decisions to continue or withdraw is the relationship with a faculty adviser" (Lovitts & Nelson, 2000, p. 50). Graduate students leave the programs less because of their skills but because of what they experience in graduate school (Lovitts & Nelson, 2000). In a qualitative study of 10 graduate students from Indonesia, Pakistan, the United Kingdom, Germany, Korea, Tanzania, Venezuela, Brazil, Taiwan, and China, Zhai (2004) found that advisors are the third most used resource of international students after family and friends and the international students' office.

Houser et al. (2013) examined how 22 science and engineering students involved in a research experience for undergraduate programs viewed mentoring. The researchers found that "...the relationship with the faculty mentor appears to influence the decision of the students to conduct future research and/or attend graduate school" (Houser et al., 2013, p. 304). In a quantitative study of 719 undergraduate students from a mid-sized Southeastern university, Hawthorne et al. (2022) found that if students experience academic difficulties, they may be more inclined to reach out to their advisor if the advisor manifests an interest in the student's progress, not only in selecting courses (Hawthorne et al., 2022).

On a similar line, in a qualitative study involving 15 Latino faculty members in STEM fields, Lechuga (2011) found that faculty advisors not only perceived themselves "as a source of academic advice and personal support or counsel" (p. 763) but as instructors, employers, and agents of disciplinary socialization for their graduate students from underrepresented groups. The faculty members considered themselves "allies to their students and took a supportive approach in working with them" (Lechuga, 2011, p. 767).

Frequent meetings between advisors and advisees are vital to ensure student support. In a qualitative study of expectations and experience with academic advising of 611 undergraduate psychology students, Young-Jones et al. (2013) found that generally, students who meet frequently with their advisors report more substantial support (Young-Jones, 2013). However, the frequency of meetings is not the same throughout various graduate programs. Marijanovic et al. (2021) found in a qualitative study of 21 first-year international doctoral students that, compared to humanities and social sciences programs, the students in STEM fields interacted more often with their advisors and had more conversations related to future careers. The faculty advisor's experience brings different expectations to the students. While both junior (untenured) and tenured faculty expect graduate students to be able to work independently, take initiative, and have specific discipline skills, the tenured faculty develop abilities to present at conferences and network with others in the field (Lechuga, 2011).

Some studies report that same-race connections were perceived as vital. In a qualitative study involving 16 participants, Barker (2011) examined cross-race advising of Black social sciences and humanities doctoral students with White advisors. While most Black doctoral students and White advisors believed that same-race connections (peer, mentors, or faculty) are essential, the advisor did not have to be from the same race. More so, "the majority of Black doctoral students did not specify a racial preference for their advisor" (Barker, 2011, p. 394).

High expectations of mentoring experiences exist not only for graduates but for undergraduate students, as well. In a study of research experience programs involving 91 domestic and international engineering undergraduate students, Richard and Yoon (2023) found that the participants expected their mentors to provide research and career guidance, psychological support, and cultivate their autonomy when researching independently. The international students perceived their relationship with the mentor as different from those in their home country; they mentioned a culture of openly asking questions and giving advice in the U.S. institution (Richard & Yoon, 2023).

Advising implies academic and interpersonal components. In their qualitative study, the satisfaction and dissatisfaction of advisees with their advisors have been documented by Schlosser et al. (2003). The researchers looked into the experiences of 16 doctoral psychology students, primarily Caucasian women. They found that the differences between satisfied and dissatisfied graduate students focused on interpersonal and academic aspects, such as research being part of the advising relationship, discussing program requirements, and receiving career guidance. Satisfied graduate students felt that the advisor encouraged them to participate in conferences, felt comfortable talking about their professional and personal lives, expected collegial and supportive relationships, and conflict was treated openly and therefore strengthened the advising relationship (Schlosser et al., 2003). Unsatisfied students felt that their advising relationships lacked all the aspects that the satisfied students had identified. Satisfied students met individually and regularly with their advisors, while the unsatisfied students met infrequently and only once or twice per semester.

In a similar line of research, a study of 537 doctoral students, Rose (2005) found that international graduate STEM and non-STEM students prefer mentors who are "interpersonally involved in the student's life, compared to domestic students" (p. 74). The author noted that the educational experiences of international graduate students are not similar to those of their domestic counterparts due to the difficulty of adapting to a new culture (Rose, 2005). Using survey responses from 4010 graduate students from humanities, social sciences, and physical and biological sciences, Noy & Ray (2012) found that race and gender were important when analyzing how graduate students perceived their relationship with the advisor. The researchers found that students of color perceived their advisors as “less respectful of their ideas” (Noy & Ray, 2012, p. 898) compared to White students. Women had the perception of receiving more support than male students, and “they may actually be advantaged in graduate mentorship” (Noy & Ray, 2012, p. 898). However, the women of color had the most disadvantages in the support of advisors.

Mentor support varies by residency and enrollment in the graduate program. Collier and Blanchard (2024) conducted a quantitative study of domestic (n = 526) and international (n = 121) graduate students, of which 55% were in STEM programs at 23 U.S. universities. The researchers reported that international graduate students felt their mentor support was greater than did domestic students. Master’s students perceived less mentoring support than doctoral students. Part-time students reported fewer opportunities to participate in research and write manuscripts for publication than full-time students. The graduate STEM students generally felt their mentors cared more about their well-being than non-STEM majors (Collier & Blanchard, 2024).

Theoretical Frameworks

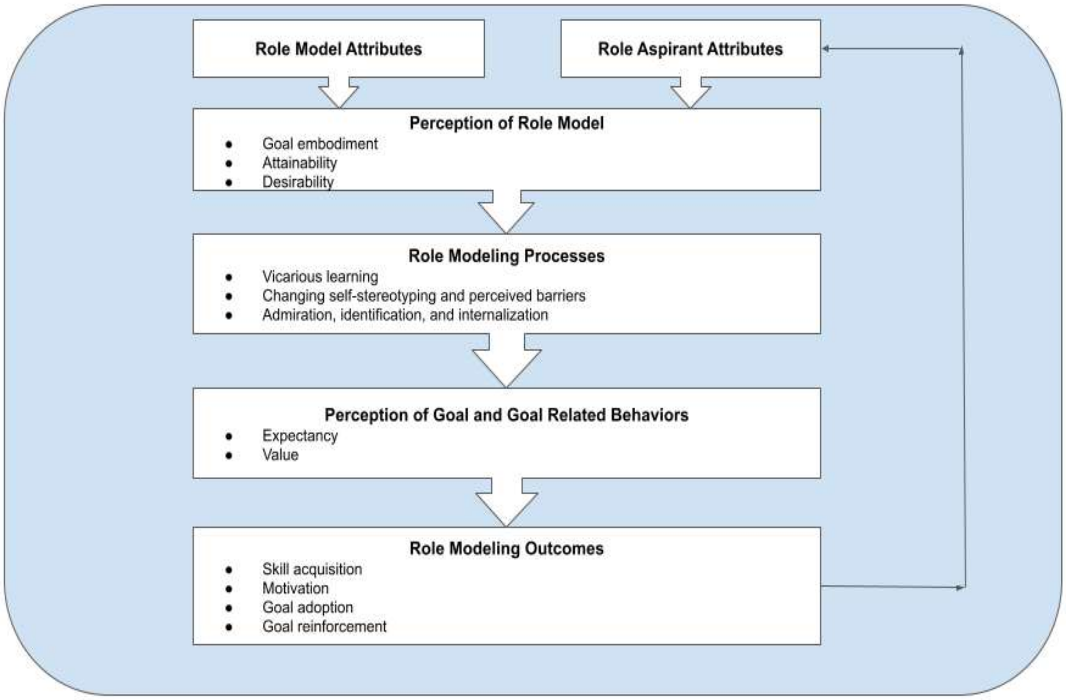
Two frameworks guided this study: the Motivational Theory of Role Modeling (Morgenroth et al., 2015) and Yob and Crawford’s (2012) conceptual theory of mentoring. These frameworks together provide a more cohesive understanding of mentoring than each individual framework would do by connecting the mentoring behaviors described by Yob and Crawford (2012) with the perceptions of role models and role modeling processes as detailed by Morgenroth et al. (2015) in their theory.

The Motivational Theory of Role Modeling (Morgenroth et al., 2015) is a theoretical framework that describes a role model, such as a mentor, as an individual whose behaviors serve as a guide for others, such as a graduate STEM student. Role models have been shown to have a positive impact on role aspirants (e.g., Fried & MacCleave, 2009; González-Perez et al., 2020; Passi & Johnson, 2016). Specifically, Passi and Johnson (2016) reported that role models supported the growth of medical students by developing their professional identities and influencing their career choices.

Morgenroth et al. (2015) described role models as “individuals who influence role aspirants’ achievements, motivation, and goals by acting as behavioral models, representations of the possible, and/or inspirations” (p. 468). The framework highlights the viewpoint of the role aspirants, such as graduate STEM students, by linking the role model attributes (success and competence) and role aspirant attributes (pre-existing goals) with the perception of role model, role modeling processes, perceptions of goals and goals related behaviors, and resulting outcomes (Figure 3.1).

Figure 3.1

Overview of the Motivational Theory of Role Modeling (Adapted from Morgenroth et al., 2015)



Morgenroth et al. (2015) introduced four propositions in their theory to explain how role models help role aspirants achieve outcomes. (1) Identified goal embodiment shapes expectancy, motivation and goals by initiating vicarious learning. (2) Identified goal embodiment and identified attainability combine to shape expectancy, motivation, and goals by altering self-stereotyping. (3) Identified goal embodiment and identified attainability combine to shape expectancy, motivation, and goals by altering identified external barriers. (4) Identified desirability shapes value, motivation, and adoption of new goals by initiating personal identification, internalization, and admiration (Morgenroth et al., 2015, pp. 472- 477).

The second framework is Yob and Crawford's (2012) conceptual theory of mentoring. Yob and Crawford (2012) conducted a review of research and professional literature. They found four inquiry directions in mentoring doctoral students: successful mentoring in general, mentoring of doctoral dissertations, mentoring in online environments, and the relative importance of mentoring behaviors. The findings were grouped into two domains: academic and psychosocial behaviors. In the academic domain, four attributes were found: mentor's competence, availability, induction of mentees into the field and their professions, and challenge. The psychosocial domain included three attributes: the mentor's personal qualities, communication, and emotional support.

Drawing on Existing Survey Measures

No existing validated surveys measured the mentoring experiences of domestic and international doctoral STEM students. This study aimed to develop a valid and reliable instrument to measure domestic and international graduate STEM students' mentoring experiences. This instrument development was built on an existing mentorship survey (Fedesco et al., 2023; University of Georgia, 2025). Fedesco et al. conducted an iterative pilot test and evaluation of the mentorship assessment. Twelve pairs of life sciences doctoral students and their research advisors at a research-intensive U.S. university completed the survey. Semi-structured interviews were conducted with seven students and six advisors to gather feedback to improve the mentorship assessment. A second round of interviews was conducted with seven new pairs of students and advisors. Also, 11 international students were interviewed to explore their experience with the mentorship assessment but did not complete the survey.

Fedesco et al.'s (2023) and University of Georgia's (2025) mentorship assessment consists of 21 career and 19 psychosocial support questions, measured on a 5-point Likert scale and two open-ended questions. The career and psychosocial questions assessed the support the graduate students felt they received from their advisors and the support the advisors perceived they gave to their students. The two open-ended questions referred to mentorship aspects that helped work together and ideas of what could be done to improve the work together. The responses to these closed and open-ended questions were shared with the graduate student and advisor as summary statistics. Five confidential closed and open-ended questions about the satisfaction with the mentorship relationship were asked, but the answers were not shared with the participants.

Research Questions

The goal of this study was to develop a valid and reliable instrument to measure graduate STEM students' perceptions of their mentoring experiences and underlying factors influencing differences in their perceptions.

1. Is the Mentoring Graduate STEM Students Survey a valid and reliable instrument for measuring graduate STEM students' perceptions of their mentoring experiences that were supportive of their development?
2. What are the differences in graduate STEM students perceptions' of their mentoring experiences:
   a. Based on gender?

      H1: Female students will have more negative experiences with the measured mentoring factors (i.e., less psychosocial and career support).

   b. Based on citizenship status?

      H2: International graduate STEM students will have more negative experiences with the measuring mentoring factors (i.e., career expectations and career support).

   c. Based on enrollment status?

H3: Part-time students will have more negative experiences with the measured factors (i.e., research and writing, career expectations, and career support).

d. Based on academic discipline?

H4: The mentoring experiences of graduate students regarding the measured factors (i.e., research and writing, program completion, career support, and career expectations) will differ.

3. Will the constructs of the survey have an impact on graduate STEM students' program completion and career expectations?

H5: The composite scores for psychosocial support, research and writing, and career support will have a significant impact on students' composite scores for program completion in a regression model.

H6: The composite scores for psychosocial support, research and writing, and career support will have a significant impact on students' composite scores for career expectations in a regression model.

Methods

Scale Development

The survey developed in this study was guided by Hinkin's (1998) stages of scale development: item generation, questionnaire administration, and initial item reduction.

Item Generation

The findings from the qualitative study presented in Chapter 2 informed the development of the survey (Appendix K). Items for the mentoring survey were taken from Fedesco et al. (2023) and University of Georgia (2025) and modified based on study 1's participants' interviews. In all items, the term "advisor" was replaced with "mentor." Five of the 21 career support items were excluded, as they did not appear in the participants' interviews. Five new items were included in the academic/career support part. Eight of the 19 psychosocial support items were excluded, and two new items were included. Ten items related to program completion and career outcomes were included. A total of 44 academic and psychosocial items, nine demographic questions, and one open-ended response formed the survey. The survey items were evaluated with a 5-point Likert scale; *strongly disagree* was represented by 1, *disagree* by 2, *neither agree nor disagree* by 3, *agree* by 4, and *strongly agree* by 5.

To assess the face and content validity (Taherdoost, 2016), ten domestic and international doctoral STEM and STEM education students were given the survey to read through and fill out while taking notes on the items. Also, the survey was given to one survey expert and one professor of STEM education to check for confusing and leading questions. Their responses to the items were analyzed to identify any issues with item content. The feedback was used to improve the items and their order.

Questionnaire Administration

For the survey, convenience sampling (Mertens, 2019) was employed, as the participants were graduate STEM students from a large, public, research-intensive university in the southeastern United States where the researcher attends school. The dean of the graduate school was contacted to help with the contact information of all the graduate STEM students in thesis master's and doctoral programs. The graduate school dean provided a list of 2888 emails, but only 2739 were kept, as some fields were in STEM education, teacher education, and learning sciences.

The survey was distributed through Qualtrics. Invitations to participate in the survey were sent out in January through February 2025. Survey responses were collected until the end of

February. Three reminders were sent after an average of 7-14 days from the previous reminder for those who had not completed the survey. Three hundred sixty-two survey responses were collected and stored in Qualtrics for analysis. Schafer (1999) asserted that a 5% or less missing rate is unlikely to impact the results significantly. The dataset was cleaned by deleting the responses of participants who didn't agree to participate in the research (n =11) and who failed to complete the survey entirely. Two hundred eighty survey responses were kept, as at least 95% of items were completed, resulting in a survey completion rate of 77.4%.

Initial Item Reduction

For the validation of an instrument, factor analysis is used to reveal its internal structure (Mertens, 2019). Exploratory factor analysis is used when there is little or no prior information about the instrument's latent structure of the instrument, and it is desired to uncover complex patterns and test predictions (Child, 2006; Finch, 2019). To verify the structure of the survey, exploratory factor analysis (EFA) was done using the SPSS software version 29.0.1.0 (2023). Forty-four items were used in the analysis.

Findings

Testing the Validity and Reliability of the Mentoring Graduate Students Survey

Testing the Suitability of Data Set for Factor Analysis

To begin to address research question one, what is the validity and reliability of the Mentoring Graduate Students Survey (MEGSS), an exploratory factor analysis (EFA) was planned. Before conducting EFA, the suitability of the data set was tested for factor analysis. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity were conducted to determine the suitability of the data set for factor analysis. To be suitable for EFA, the KMO ought to be above 0.50, and Bartlett's Test of Sphericity significant ($p < 0.05$)

(Yong & Pearce, 2013). The KMO was 0.956, and Bartlett's Test of Sphericity had a significance of less than 0.01. The data set was suitable for factor analysis.

Factor Extraction and Rotation

Factor analysis posits that the observed measures are affected by underlying common factors and unique factors (Yong & Pearce, 2013). Two common extraction methods are Maximum Likelihood and Principal Axis Factoring. Maximum Likelihood is more suitable for confirmatory factor analysis (Yong & Pearce, 2013). The Principal Axis Factor method produces factors and is used for factor extraction. Oblique rotation is used when factors are considered to be correlated (Yong & Pearce, 2013). Oblimin and Promax are common oblique rotation techniques; Oblimin is used to simplify the structure, while Promax is used for large datasets (Yong & Pearce, 2013). The Oblimin rotation with Kaiser Normalization was used as the dataset contained 280 survey responses.

Retention and Other Analysis

To determine the number of significant factors, the *Total Variance Explained* table was used (Yong & Pearce, 2013). There were six factors with eigenvalues greater than 1 (see Figure 3.2).

Figure 3.2

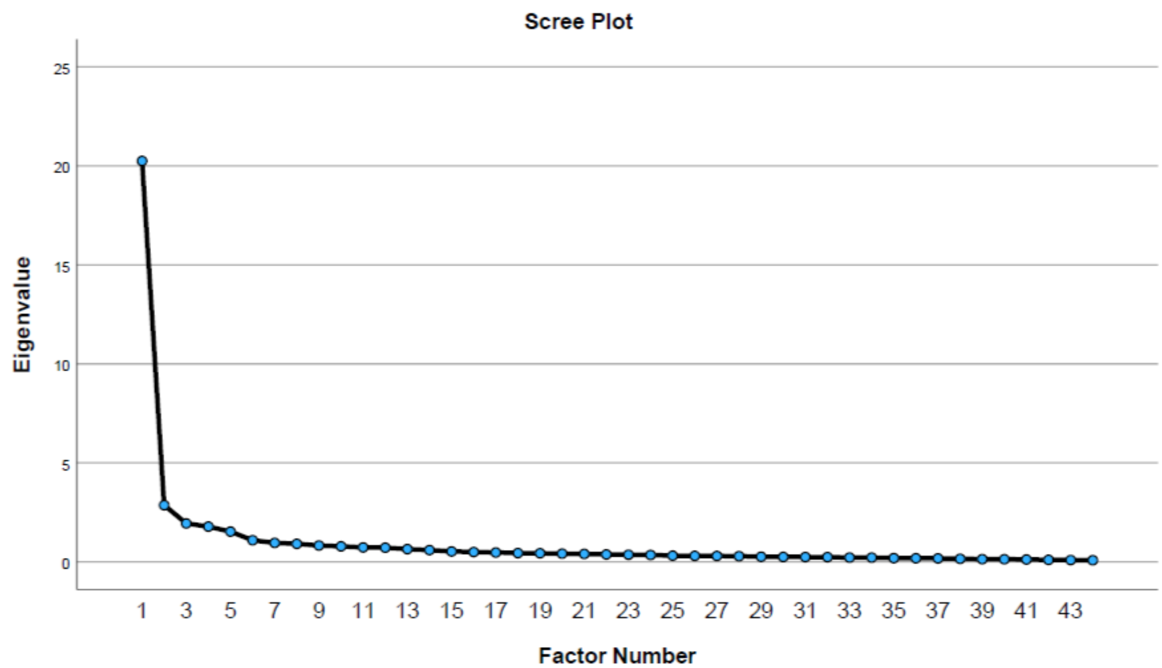
Truncated SPSS Output for the Total Variance Explained for Extracted Components

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	20.245	46.011	46.011	19.892	45.210	45.210
2	2.866	6.513	52.524	2.504	5.692	50.902
3	1.943	4.416	56.940	1.553	3.529	54.430
4	1.784	4.055	60.995	1.442	3.278	57.709
5	1.531	3.479	64.474	1.129	2.565	60.274
6	1.094	2.487	66.961	.692	1.573	61.847
7	.961	2.184	69.145			
8	.912	2.073	71.218			
9	.828	1.883	73.101			
10	.786	1.786	74.887			
11	.733	1.665	76.552			

The scree test is composed of eigenvalues and factors and is reliable if the sample size is greater than 200 (Yong & Pearce, 2013). The sample size was 280. The scree plot indicated that the data have six components (see Figure 3.3).

Figure 3.3

SPSS Output for Scree Plot



The variance in the observed variables that is accounted for by a common factor is the communality or common variance (Child, 2006). Variables with low communalities (less than 0.20, which means that 80% is unique variance) are eliminated since the focus is to explain variance through common factors (Child, 2006; Fabrigar et al., 1999; Yong & Pearce, 2013). There were no items with communalities below 0.20, so no items were excluded.

Factors can be identified by the largest loadings (Yong & Pearce, 2013). Factor loadings above 0.4 are assumed to be stable (Guadagnoli & Velicer, 1988), and factor loadings less than 0.33 imply that the items ought to be suppressed (Field, 2009). There were no factor loadings in the component matrix less than 0.33. One item (*I am experiencing an acceptable level of stress)* did not load on any factor and was eliminated. Next, cross-loading values were analyzed. Cross-loading values greater than 0.32 on multiple factors ought to be removed (Costello & Osborne, 2005). Starting with the highest cross-loading values, items were removed one by one. After each individual removal, EFA was conducted again, and the cross-loadings were re-analyzed. Six items were eliminated through this process (Table 3.1).

Table 3.1

Questions Eliminated in EFA

Item	Reason for Elimination
I am experiencing an acceptable level of stress.	Not loading on any factor
My mentor provides the right amount of support.	cross loading
I am building strong professional relationships.	cross loading
My mentor works with me to set clear expectations on our mentoring relationship.	cross loading
My mentor and I communicate effectively.	cross loading
My mentor motivates me.	cross loading

A factor should have at least 3 variables (Tabachnick & Fidell, 2019). The sixth factor had only 2 variables and therefore, the survey was reduced to five subscales. A 5-factor, 38-item model was determined from the EFA. The following five subscales were included: 1) *psychosocial support*, 2) *program completion,* 3) *writing and research*, 4*) career expectations*, and 5) *career support*. The five subscales ranged from 3 to 14 items. Factor loadings ranged between 0.897 and 0.353 (Table 3.2). Tabachnick and Fidell (2019) recommend a minimum threshold of 0.32 to identify significant factor loadings. Three items (*I expect to obtain a desired job, I expect to achieve my career goals,* and *I feel prepared for my career***)** had negative loadings (-0.897, -0.840, and -0.556). The loadings' signs indicate the direction of the correlation; therefore negative loadings suggest that the variable is related in the opposite direction from the factor and as the factor increases, the variable decreases (Asnawi et al., 2012; De Vaus, 2013, Yong & Peace, 2013). The negative loading values were explained as a lack of expectation to obtain a job and achieve career goals and a lack of feeling prepared for a career.

Table 3.2

Pattern Matrix

Factor 1	**Psychosocial Support**	**Loading**
psych1	My mentor cares about me as a whole person, not just as a researcher.	0.798
psych2	My mentor is friendly to me.	0.784
psych3	My mentor has reasonable expectations for my workload.	0.761
psych4	My mentor is supportive of my personal identity.	0.753
psych5	My mentor is understanding of my needs as a graduate student.	0.730
psych6	My mentor is someone I trust.	0.722
psych7	My mentor encourages me.	0.693
psych8	My mentor acts in my best interest.	0.614
psych9	My mentor and I feel comfortable talking about things other than research.	0.613
psych10	My mentor gives me an appropriate level of independence.	0.580
psych11	My mentor advocates for me when necessary.	0.554
psych12	My mentor serves as a role model for me.	0.533
psych13	My mentor works with me to align our expectations on our mentoring relationship.	0.428
psych14	My mentor helps me secure the resources I need for academic success.	0.353
	Factor 2 Program Completion	
progr1	I expect to complete my thesis/dissertation.	0.897
progr2	I expect to graduate.	0.824
progr3	I am productive in my academic writing.	0.484
progr4	I am productive in my research.	0.475
progr5	I expect to achieve my masters/doctoral program milestones in a timely manner.	0.458
	Factor 3 Research and Writing	
res1	My mentor helps me improve my scientific writing.	0.726
res2	My mentor provides me timely feedback.	0.667
res3	My mentor helps me write my research for publication.	0.663
res4	My mentor works with me to set research goals.	0.643
res5	My mentor provides me useful feedback.	0.621
res6	My mentor is available when I need them.	0.567
res7	My mentor helps me prepare to present my research.	0.495
res8	My mentor keeps up with my development.	0.464
res9	My mentor provides me with information about resources relevant to my work.	0.447

Table 3.2 (continued)

	Factor 4 Career Expectations	
carexp1	I feel prepared for my career.	-0.897
carexp2	I expect to obtain a desired job.	-0.840
carexp3	I expect to achieve my career goals.	-0.566
	Factor 5 Career Support	
carsupp1	My mentor helps me develop professional relationships with others in the field.	0.680
carsupp2	My mentor provides guidance on career development.	0.661
carsupp3	My mentor provides useful information about various career paths inside academia.	0.658
carsupp4	My mentor provides useful information about various career paths outside academia.	0.621
carsupp5	My mentor provides opportunities for me to learn about grant proposal writing.	0.455
carsupp6	My mentor takes time to learn about my career goals.	0.397
carsupp7	My mentor challenges me to grow and develop professionally.	0.376

The factor correlation matrix (Table 3.3) showed that the highest correlation was 0.584 between factors 1 (psychosocial support) and 5 (career support). Cohen (1998) suggests that a large correlation is represented by a correlation coefficient of 0.50 or higher, moderate by values close to 0.3, and weak for correlation coefficients of 0.10 and below. The correlation between most factors is moderate, with three large correlations: factors 1 and 6, factors 3 (research and writing) and 6 (career support), and factors 1 (psychosocial support) and 3 (research and writing).

Table 3.3

Factor Correlation Matrix

Factor	**Psychosocial Support**	**Program Completion**	**Research and Writing**	**Career Expectations**	**Career Support**
Psychosocial Support	1	0.217	0.545	-0.277	0.584
Program Completion	0.217	1	0.276	-0.302	0.243
Research and Writing	0.545	0.276	1	-0.281	0.552
Career Expectations	-0.277	-0.302	-0.281	1	-0.247
Career Support	0.584	0.243	0.552	-0.247	1

The eigenvalues for the 5-factor model ranged between 16.650 and 1.006 and explained 60.177% of the variance in the data. Next, after determining the factors and corresponding items, Cronbach's alpha, a common statistics for internal consistency, was used to determine the reliability of the factors. The Cronbach's alpha values of 0.70 are acceptable, and 0.80 or greater are preferred (Cortina, 1993). The alpha values ranged between 0.80 and 0.96, suggesting reliability in the scales. The 5-factor model has Cronbach's alpha values that are considered good for all five factors (Table 3.4).

Table 3.4

Cronbach's Alpha for 5-Factor Model

Factor	Number of Items	Eigenvalues	Explained Variance (%)	Cumulative Explained Variance (%)	Cronbach's Alpha
Psychosocial Support	14	16.650	43.816	43.816	0.96
Program Completion	5	2.349	6.182	49.998	0.80
Research and Writing	9	1.500	3.948	53.946	0.91
Career Expectations	3	1.362	3.584	57.531	0.81
Career Support	7	1.006	2.647	60.177	0.89

Differences in Graduate STEM Students' Perceptions of Mentoring

The second research question addressed students' perceptions of mentoring. This was investigated through the analyses of a wide range of self-reported demographic factors in relation to their survey results.

Demographic Statistics

Demographic statistics were collected to find the gender, race, ethnicity, citizenship status, full-time/part-time, stage in the program, number of years working with the mentor, program of study, type of program (thesis masters or doctoral), and academic discipline (Table 3.5). The participants self-reported the demographic information. Most of the survey respondents were male (51.43%), White (51.07%), doctoral (99.6%), domestic students (56.4%), and enrolled in engineering programs (43.6%). Most of the students were full-time (95.7%), worked for 3 years with their current mentor (24.6), and were in the late stage of the program (working on dissertation/thesis, 46.4%).

Table 3.5

Self-Reported Graduate STEM Student Demographic Information

Gender	**Total (*N* = 280)**	**Percent (%)**
Male	144	51.4
Female	127	45.4
Non-binary	8	2.9
Prefer to describe	1	0.4
Racial identity		
American Indian or Alaskan Native	1	0.4
Asian	60	21.4
Black or African American	17	6.1
Middle Eastern	9	3.2
Indian	29	10.4
White	143	51.1
Prefer to self-describe	21	7.5
Ethnic Identity		
Hispanic or Latino/a	22	7.9
Not Hispanic or Latino/a	241	86.1
Prefer to self-describe	17	6.1
International Status		
International	122	43.6
Not international	158	56.4
Enrollment Status		
Part time	12	4.3
Full time	268	95.7
Level of Graduate Program		
M.S. degree (thesis)	1	0.4
Ph. D. (doctoral thesis)	279	99.6
Stage of the doctoral/master’s program		
Early (beginning coursework)	55	19.6
Middle (finishing coursework)	95	33.9
Late (working on dissertation)	130	46.4

Table 3.5 (continued)

Number of years working with the mentor		
1	65	23.2
2	58	20.7
3	69	24.6
4	49	17.5
5	21	7.5
6	9	3.2
7+	9	3.2
Academic Discipline		
Agriculture and/or Natural Resources	38	13.6
Biological and/or Biomedical Sciences	32	11.4
Computer and/or Information Sciences	20	7.1
Engineering	122	43.6
Geosciences, Atmospheric Sciences, and Oceanic Sciences	11	3.9
Mathematics and/or Statistics	18	6.4
Physical Sciences	25	8.9
Other	14	5

Survey Items Analyses

The most widely and powerful methods to test the normality of data are the Shapiro-Wilk test if the sample size is less than 50 and the Kolmogorov-Smirnov test, if the sample size is greater than 50 (Gupta et al., 2019; Orca, 2020). The sample size was $N = 280$. Kolmogorov-Smirnov (KS) test was used to test for normality. The data were not normally distributed, as proven by the significance sig. < 0.001. Other methods to test the normality are skewness and kurtosis, but they cannot be used alone to decide on the data normality (Orcan, 2020). Also, there is no agreement on which values indicate normality (Orcan, 2020). For example, Lei and Lomax (2005) recommend that if the absolute values of skewness and kurtosis are less than 0.1, the data show slight nonnormality, values between 1.0 and 2.3 indicate moderate nonnormality, and values beyond 2.3 reveal severe nonnormality. The values included in Table 3.6 show that the data were not normally distributed.

Table 3.6

Descriptive Statistics for Survey Items

Item	*N*	*M*	*SD*	*Sign. value for KS test*	Skewness	Kurtosis
psych1	280	3.91	1.139	< 0.001	-1.161	0.640
psych2	280	4.25	0.898	< 0.001	-1.509	2.745
psych3	280	3.79	1.110	< 0.001	-1.022	0.508
psych4	280	4.07	0.893	< 0.001	-1.117	1.087
psych5	280	3.85	1.114	< 0.001	-0.930	0.220
psych6	280	4.05	1.155	< 0.001	-1.173	0.506
psych7	280	4.04	0.998	< 0.001	-1.250	1.542
psych8	280	3.89	1.070	< 0.001	-0.944	0.422
psych9	280	3.73	1.144	< 0.001	-0.898	0.064
psych10	280	4.16	0.942	< 0.001	-1.232	1.333
psych11	280	4.00	1.016	< 0.001	-1.322	1.752
psych12	280	3.68	1.226	< 0.001	-0.698	-0.458
psych13	280	3.52	1.097	< 0.001	-0.611	-0.239
psych14	280	3.91	1.042	< 0.001	-1.123	0.988
progr1	280	4.40	0.769	< 0.001	-1.577	3.518
progr2	280	4.51	0.683	< 0.001	-1.729	4.725
progr3	280	3.46	0.891	< 0.001	-0.534	0.013
progr4	280	3.74	0.872	< 0.001	-0.874	1.004
progr5	280	3.83	0.972	< 0.001	-1.064	1.062
res1	280	3.80	1.085	< 0.001	-0.774	-0.016
res2	280	3.74	1.139	< 0.001	-0.882	0.048
res3	280	3.68	1.099	< 0.001	-0.651	-0.140
res4	280	3.94	1.049	< 0.001	-1.016	0.422
res5	280	4.00	0.989	< 0.001	-1.238	1.472
res6	280	4.04	0.950	< 0.001	-0.805	-0.01
res7	280	3.92	0.970	< 0.001	-0.911	0.556
res8	280	3.77	1.015	< 0.001	-0.793	0.161
res9	280	4.03	0.967	< 0.001	-1.152	1.296
carexp1	280	3.38	1.034	< 0.001	-0.309	-0.415
carexp2	280	3.86	0.890	< 0.001	-0.715	0.649
carexp3	280	3.93	0.826	< 0.001	-0.595	0.386
carsupp1	280	3.78	1.153	< 0.001	-0.880	0.018
carsupp2	280	3.41	1.068	< 0.001	-0.496	-0.271
carsupp3	280	3.32	1.150	< 0.001	-0.411	-0.536
carsupp4	280	3.18	1.146	< 0.001	-0.232	-0.707
carsupp5	280	3.11	1.236	< 0.001	-0.116	-0.993
carsupp6	280	3.75	1.148	< 0.001	-0.893	0.025
carsupp7	280	3.93	0.992	< 0.001	-1.054	0.938

Item analyses were carried out to determine significant differences in item responses for different subgroups organized by self-reported demographic characteristics. The validated survey items failed to show normality when tested with the Kolmogorov-Smirnov test. Therefore, the Kruskal-Wallis test, a non-parametric ANOVA test with Bonferroni corrections for pairwise comparisons, was used to look for significant differences in survey items between different subgroups ($p < 0.05$). Sample sizes equal or above 5 are suitable for the Kruskal-Wallis test (Ostertagová et al., 2014).

Gender

Means were compared to assess differences across gender. Differences related to psychosocial support, research and writing, and career support were found (Table 3.7). The Kruskal-Wallis test showed that there was a significant difference for item psych 7 (H (3) = 13.648, p = 0.03); students who identified as nonbinary reported that their mentor encouraged them more compared to males and females. Regarding psych10 (H (3) = 12.753, p = 0.005), a significant difference was found between males and females; male students felt that their mentor provided them with a more appropriate level of independence compared to female students. Regarding psych11 (H (3) = 18.668, p < 0.001), a significant difference was found between male and female students and between female and nonbinary students; female students felt that their mentor advocated for them less compared to male and nonbinary students.

Kruskal-Wallis test showed that there was a significant difference for res4 (H (3) = 10.881, p = 0.013) between female and non-binary and between male and non-binary students; the nonbinary students reported that their mentor worked with them more to set research goals compared to male and female students. Regarding res5 (H (3) = 9.916, p = 0.019), a significant difference was found between female and nonbinary students; nonbinary students felt that their mentor provided more useful feedback. Regarding res9 (*H* (3) = 14.421, *p* = 0.02), a significant difference was found between female and nonbinary students; the nonbinary students reported that their mentor provided more information about resources relevant to their work compared to female students. Regarding carsupp1 (*H* (3) = 8.315, *p* = 0.040), the nonbinary students reported that their mentor helped them more to develop professional relationships with others in the field. Regarding carsupp4 (*H* (3) = 14.273, *p* = 0.003), a significant difference was found between male and nonbinary and between female and nonbinary students; nonbinary students reported that their mentor provided more opportunities to learn about grant proposal writing compared to male and female students; female students reported the least amount of opportunities to learn about it.

Table 3.7

Mean Scores of Significant Items by Gender

	Male (*n* = 144)		**Female (*n* = 127)**		**Nonbinary (*n* = 8)**		**Prefer to self describe (*n* = 1)**	
Item	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
psych7	4.03*	1.013	3.98*	0.984	**5.00***	**0.00**	3.00	N/A
psych10	**4.28***	**0.904**	4.00*	0.976	4.75	0.463	3.00	N/A
psych11	4.15*	0.993	3.77*	1.100	**4.88***	**0.354**	4.00	N/A
res4	3.93*	1.069	3.89*	1.033	**4.88***	**0.354**	3.00	N/A
res5	4.05*	0.985	3.91	1.00	**4.75***	**0.463**	3.00	N/A
res9	4.08*	0.993	3.91	0.935	**4.88***	**0.354**	3.00	N/A
carsupp1	3.81*	1.142	3.68*	1.174	**4.75***	**0.463**	4.00	N/A
carsupp4	2.93*	1.181	3.24*	1.250	**4.50***	**1.069**	3.00	N/A

Note. * denotes significant relationship ($p < 0.05$). Bolded items represented groups reporting a greater perception of a factor than other groups. Comparison groups are described in the text.

Citizenship Status

Items analysis did not show many statistical differences between international and domestic students. Independent-Samples Mann-Whitney U test, a non-parametric alternative to the independent t-test, when data is not normally distributed, revealed significant differences only regarding the career expectation (carexp1), *U* = 10909.00, *p* = 0.048, *n1* = 122, *n2* = 148. International students (*n* = 122, *M* = 3.24, *SD* = 1.021) perceived they were less prepared for their careers compared to domestic students (*n* = 158, *M* = 3.49, *SD* = 1.033). The mean scores indicate slightly above-neutral responses.

Enrollment Status

The Independent-Samples Mann-Whitney U test did not show any significant differences between part-time and full-time students' perceptions of the mentoring they received (*U* = 1744.500, *p* = 0.600, *n1* = 12, *n2* = 268).

Stage in the Program

The Kruskal-Wallis test showed significant differences for four items in the psychosocial support factor. For one item, the early-stage students reported more positive perceptions of psychosocial support than the other groups of students; for the other three, they reported less support (Table 3.8). Regarding psych1 (*H* (2) = 6.357, *p* = 0.042) between early and late-stage program students, the early-in-the-program students perceived that their mentor cared more about them as a whole person, not just as a researcher compared to late-stage students. Regarding psych3 (*H* (2) = 7.564, *p* = 0.023), there was a statistical difference between early and late-stage students; the late-stage students reported that their mentor had more reasonable expectations of their workload compared to early-stage students. Regarding psych12 (*H* (2) = 11.059, *p* = 0.04), there was a statistical difference between early and late-stage students; the late-stage students perceived their mentor as more of a role model for them than the early-stage students. Regarding psych13 (*H* (2) = 13.242, *p* = 0.01), there were statistical differences between early and middle and early and late-stage in the program students; the early-stage students reported that their mentor worked with them less to align their expectations on the mentoring relationship compared to middle and late-stage students.

One statistical difference was found for one item, progr1, in the program completion factor (H (2) = 7.042, p = 0.030). The early-stage students reported that they were more likely to complete the thesis/dissertation than late-stage students. There were statistical differences for three items in the research and writing factor. Regarding res2 (H (2) = 6.853, p = 0.032), there was a statistical difference between the early and late-stage students' perceptions of the mentor providing timely feedback; the late-stage students reported receiving more timely feedback than the early-stage students. Regarding res6 (H (2) = 11.916, p = 0.003), there were statistical differences between early and late-stage and between early and middle-stage students; the early-stage students reported less mentor availability compared to the other groups. Regarding res9 (H (2) = 9.062, p = 0.011), statistical differences were found between early and late-stage students; the early-stage students reported that their mentor provided less information about resources relevant to their work than late-stage students.

There were statistical differences in three items in the career support factor. Regarding carsupp1 (H (2) = 8.264, p = 0.016), there were statistical differences between early and late and early and middle-stage students; early-stage students felt that their mentor helped them more to develop professional relationships with others in the field compared to the other two groups. Regarding carsupp4 (H (2) = 7.192, p = 0.027), there was a statistical difference between early and late-stage students; early stage students reported less opportunities that their mentor provided to learn about grant proposal writing than the late-stage students. Regarding carsupp7 (H (2) = 11.909, p = 0.003), there were statistical differences between early and middle and between early and late-stage students; the early-stage students reported that their mentor challenged them less to grow professionally compared to the other groups.

Table 3.8

Mean Scores of Significant Items by Stage in the Program

	Early (*n* = 144)		Middle (*n* = 127)		Late (*n* = 8)	
Item	***M***	***SD***	***M***	***SD***	***M***	***SD***
psych1	**4.00***	**1.348**	3.97	1.131	3.97*	1.139
psych3	3.25*	1.138	3.82	1.105	**3.79***	**1.110**
psych12	3.42*	1.311	3.69	1.223	**3.68***	**1.226**
psych13	3.50*	1.314	**3.52***	**1.089**	**3.52***	**1.097**
progr1	**4.67***	**0.651**	4.38	0.773	4.40*	0.769
res2	3.33*	1.435	3.76	1.124	**3.74***	**1.139**
res6	3.92*	1.240	**4.04***	0.937	**4.04***	**0.950**
res9	3.83*	0.937	4.03	0.969	**4.03***	**0.967**
carsupp1	**3.83***	**1.115**	3.77*	1.157	3.78	1.153
carsupp4	2.92*	1.311	3.12	1.235	**3.11***	**1.236**
carsupp7	3.67*	0.985	**3.94***	**0.993**	3.93*	0.992

Note. * denotes significant relationship ($p < 0.05$). Bolded items represented groups reporting a greater perception of a factor than other groups. Comparison groups are specified in the text.

Academic Discipline

The Kruskal-Wallis test showed some significant differences between academic disciplines in one item in the psychosocial factor (psych2), one in the program completion (progr5), two in research and writing (res3, res6), one in career expectations (carexp2), and one in career support (carsupp5) (Table 3.9). Regarding the psych2 item (H (7) = 15.779, p = 0.027), there were statistically significant differences between Agriculture and Computer/Information Sciences students. The Computer/Information Sciences students reported that their mentor was friendlier to them than did the Agriculture/Natural Resources students.

Regarding progr5 (H (7) = 18.118, p = 0.011), there was a statistical difference between Biological/Biomedical Sciences and Math/Statistics students. The Math/Statistics students reported that they had higher expectations of achieving their doctoral milestones. There was a statistical difference in res3 (H (7) = 20.991, p = 0.04); the Computer/Information Sciences students reported that their mentor helped them more to write their research for publication compared to Biological/Biomedical Sciences students. Also, a statistical difference in res6 (H (7) = 16.837, p = 0.018) was found; the Math/Statistics students felt that their mentor was more available to them compared to Physical Sciences students. Regarding carexp2 (H (7) = 14.499, p = 0.043), the Computer/Information Sciences students felt that they were less expecting to get a desired job when compared to the other group of disciplines. Regarding carsupp5 (H (7) = 16.938), p = 0.018), the Agriculture/Natural Resources students felt that their mentor provided less opportunities for them to learn about grant proposal writing compared to Biological/Biomedical Sciences students.

Table 3.9

Mean Scores of Significant Items by Academic Discipline

Item	Ag/Nat Res (*n* = 38) *M (SD)*	Bio/Biom (*n* = 32) *M (SD)*	Comp/Inf (*n* = 20) *M (SD)*	Eng (*n* = 122) *M (SD)*	Geo/At/Oc (*n* = 11) *M (SD)*	Math / Stat (*n* = 25) *M (SD)*	Phy (*n* = 25) *M (SD)*	Other (*n* = 14) *M (SD)*
psych2	3.71* (1.063)	4.00 (1.047)	**4.20* (0.768)**	4.13 (0.918)	4.27 (0.786)	4.50 (0.618)	3.60 (0.866)	3.93 (1.141)
progr5	3.82 (1.062)	3.34* (1.181)	4.00 (0.725)	3.78 (0.983)	4.09 (0.539)	**4.44* (0.616)**	3.84 (0.746)	4.14 (0.949)
res3	3.47 (1.133)	3.28 *(1.250)	**4.30* (0.979)**	3.76 (0.971)	3.82 (1.079)	4.06 (0.998)	3.68 (1.282)	3.00 (1.109)
res6	3.71 (1.063)	4.00 (1.047)	4.20 (0.768)	4.13 (0.918)	4.27 (0.786)	**4.50* (0.618)**	3.60* (0.866)	3.93 (1.141)
carexp2	3.68 (0.962)	3.75 (0.718)	3.55* (0.887)	3.89 (0.916)	3.82 (0.982)	4.00 (0.767)	3.96 (0.841)	**4.50* (0.760)**
carsupp 5	2.71* (1.334)	**3.81* (1.061)**	3.20 (1.152)	3.11 (1.274)	3.27 (0.905)	2.72 (0.826)	3.00 (1.155)	3.07 (1.439)

Note. * denotes significant relationship ($p < 0.05$). Bolded items represented groups reporting a greater perception of a factor than other groups. Comparison groups are specified in the text. Ag/Nat Res means Agriculture/Natural Resources. Bio/Biom means Biological/Biomedical Sciences. Comp/Inf means Computer/Information Sciences. Eng means Engineering. Geo/At/Oc means Geologic/Atmospheric/Oceanic Sciences. Math/Stat means Mathematics/Statistics. Phy means Physical Sciences.

Regression Analysis of Composite Scores

To begin to address research question three, composite scores were calculated for each latent construct (i.e., psychosocial support, program completion, research and writing, career expectations, and career support) by calculating the average scores of the subscales' items (Table 2.10). The composite score for psychosocial support was determined by averaging the graduate STEM students' responses for psych1 through psyc14. For program completion, the composite score was determined by averaging the scores for progr1, progr2, progr3, progr4, and progr5. The same process was used to determine the composite scores for all five subscales.

The individual items were measured with a 5-point Likert scale, with 5 representing strongly agree, 3 neutral responses, and 1 strongly disagree. All of the composite mean scores for the five subscales for psychosocial support were between a neutral response (3) and agree (4) (Table 3.10). The highest values were for program completion (3.99) and psychosocial support (3.92). The lowest value was for career support (3.50).

Table 3.10

Composite Scores for the Five Subscales

Subscale	***M***	***SD***	**95% Confidence Interval**	
Psychosocial Support	3.92	0.87	3.82	4.02
Program Completion	3.99	0.62	3.91	4.06
Research and Writing	3.88	0.79	3.79	3.97
Career Expectations	3.73	0.76	3.63	3.82
Career Support	3.50	0.87	3.39	3.60

Note. * denotes significant relationship ($p < 0.05$).

The composite scores were used in two regression analyses to determine the relationship of psychosocial support, research and writing, and career support to program completion and, respectively, to career expectations.

Regression of Latent Constructs on Program Completion

Based on the regression model (Table 3.11), the psychosocial and career support were not statistically significant. The research and writing latent construct was found to be statistically significant. The Pearson correlation between program completion and research and writing was 0.4, which is considered a moderate correlation. If the research and writing composite score would increase by 1 point, the program completion score would increase by 0.22 points. The latent construct of research and writing can be interpreted as a supportive factor for program completion. In the model, the value of the intercept was 2.73 for the program completion composite score. If all the other factors were zero or kept constant, graduate STEM students' program completion composite score would be 2.73 (between disagree and neural), reflecting a negative perception of completing the program.

Table 3.11

Regression of Psychosocial Support, Research and Writing, and Career Support on Program Completion

Predictor	**Coefficient**	***SE***	***p***	**95% Confidence Interval**	
Intercept	2.73*	0.18	<0.01	2.38	3.06
Psychosocial Support	0.07	0.07	0.327	-0.07	0.210
Research and Writing	0.22*	0.07	0.002	0.08	0.38
Career Support	0.04	0.070	0.507	-0.086	0.18

*Note.** denotes significant relationship ($p < 0.05$)

Regression of Latent Constructs on Career Expectations

Based on the regression model (Table 3.12), the psychosocial support and research and writing constructs were not statistically significant. The career support construct was found to be statistically significant. The Pearson correlation value between career support and career expectations was 0.37, indicating a moderate correlation. If the career support would increase by 1 point, the career expectation composite score would increase by 0.18. The latent construct of career support can be interpreted as a supportive factor for career expectations. In the model, the intercept value was 2.25 for the career expectation composite score. If all the other factors were zero or kept constant, graduate STEM students' program completion composite score would be 2.25 (slightly above disagree), reflecting a negative perception of finding a career.

Table 3.12

Regression of Psychosocial Support, Research and Writing, and Career Support on Career Expectations

Predictor	Coefficient	*SE*	*p*	95% Confidence Interval	
Intercept	2.25*	0.22	<0.01	1.81	2.69
Psychosocial Support	0.10	0.09	0.26	-0.76	0.28
Research and Writing	0.12	0.09	0.19	-0.06	0.29
Career Support	0.18*	0.09	0.04	0.01	0.34

*Note.** denotes significant relationship ($p < 0.05$).

Limitations

Due to the convenience sample, all of the survey respondents were all from a large, public, research–intensive, university in the U.S. where the researcher attends graduate school. The sample had a larger percentage of graduate students who were White, male, engineering, domestic, and full-time. Therefore, findings may have been different if the sample were different. A survey response rate of around 70%, as recommended by Johnson and Christensen (2008), was not achieved, and was lower than the response rate of 44.1% found by Wu et al. (2002) in their education-related research meta-analysis of online survey's response rate.

Discussion

Validity and Reliability of the Mentoring Experiences of Graduate STEM Students

Exploratory factor analysis was conducted to validate the survey, with 280 responses from one public university. A 5-factor, 38-item model was determined with factors ranging from three to fourteen. Cronbach's values between 0.80 and 0.960 indicated the survey's reliability. The following subscales were determined: psychosocial support, program completion, research and writing, career expectations, and career support.

At the time of this study, there were no validated surveys to address the mentoring experiences of graduate STEM students. This survey provides a more nuanced understanding of mentoring experiences that support the development of graduate STEM students (Yob & Crawford, 2012). These include psychosocial support (subscale 1), academic support (subscale 3, research and writing, and subscale 5 career supports), but also outcome expectations of the students such as program completion (subscale 2) and career expectations (subscale 4). The outcome variables (program completion and career expectations) were items that were added to original survey items, in order to investigate whether perceptions of the quality of the mentoring led to different expectations of career outcomes or program completion.

Differences in Graduate STEM Students' Perceptions of their Mentoring Experiences

The survey responses of different subgroups of graduate STEM students varied, indicating perceived differences in the psychosocial support, research and writing, and career support they received from their mentors. Also, there were differences in the graduate STEM students' expected outcomes in program completion and career expectations.

Differences in Graduate STEM Students' perception of their Mentoring Experiences Based on Gender

It was hypothesized (RQ 2a) that female students will have more negative experiences with the measured mentoring factors; that is, less psychosocial and career support. Based on the item analysis, hypothesis one was supported. Female students experienced less psychosocial support, research and writing, and career support. The female students reported that their mentor advocated less for them compared to the other two groups, were given less independence, received less information about resources relevant to their work, and had fewer opportunities to learn about grant proposal writing and develop professional relationships in the field. These findings are aligned with Collier and Blanchard's (2024) findings that female students in STEM fields perceived less mentor support.

Nonbinary students were a small sample of the population (n = 8), yet they perceived more psychosocial, research and writing, and career support compared to female and male students. In all cases of significant differences (see Table 2.7), their mean score responses were between 4.50 (agree) and 5.00 (strongly agree), indicating that they felt strong mentor support. All nonbinary students agreed strongly with the fact that the mentor encouraged them. This finding is important to retention in STEM, as students who do not identify as cisgender remain in STEM fields at a rate that is approximately 10% lower than their male and female counterparts (Maloy et al., 2022).

Differences in Graduate STEM Students' perception of their Mentoring Experiences Based on Citizenship Status

It was hypothesized in research question 2b that international graduate STEM students would have more negative experiences with the measured mentoring factors; that is, career expectations and career support. The findings revealed only one significant difference for international students: they reported less career expectations compared to domestic students. This finding is consistent with Steele et al.'s (2015) findings that international students are unfamiliar with U.S. norms and rules.

Han and Appelbaum (2016) reported that 74% of international graduate students come to study in the U.S. to improve their career outlook, and 48% of them wish to remain in the U.S. for future job opportunities. Therefore, the findings of this study suggest that more needs to be done to support their career opportunities. Surveying 249 graduate engineering students, Choe and Borego (2019) found that while the international doctoral students were highly interested in pursuing careers in academia, industry, and government, they were more likely to indicate a higher likelihood of an academic career compared to the domestic students. Given the desire of international students' high interest in remaining in the U.S. for jobs and the findings of this study that they were not sure about their career opportunities, it seems that there were deficits in communication of this information.

Differences in Graduate STEM Students' Perceptions of their Mentoring Experiences Based on Enrollment Status

It was hypothesized in research question 2c that part-time students would have more negative experiences with the measured factors, i.e., research and writing, career expectations, and career support. This hypothesis was not supported. There were no significant differences in any of the measured factors, in contrast with other studies that reported differences between the experiences of part and full-time students (i.e., Collier & Blanchard, 2024; Gardner & Gopaul, 2012). Collier and Blanchard's (2024) study found that part-time students reported less access to information and opportunity in STEM programs. Gardner and Gopaul (2012) interviewed 10 part-time doctoral STEM students. They found that while they received support during their doctoral journey, it was not recognized as coming from their advisors but from their partners, children, and places of employment. These part-time doctoral students experienced a lack of availability of campus resources and a lack of understanding of their situation.

Differences in Graduate STEM Students' Perceptions of their Mentoring Experiences Based on Stage in the Program

Early-stage students reported higher scores for a total of three items in the psychosocial and career support and program completion. They perceived that their mentor cared more about them as a whole person, not just as a researcher, but was less available to them, received less timely feedback and information about resources relevant to their work, and were challenged less to grow professionally. They reported that they were more likely to complete the thesis /dissertation than late-stage students and received more help to develop professional relationships with others in the field. This current study addressed the literature gap on how mentoring could support the retention of early-stage STEM students in their programs. Studies involving early-stage graduate STEM students were focused on academic reasons for leaving the program. Morris et al. (2019) conducted a quantitative study involving first-year engineering students. They found that the top three reasons they left the program were academic difficulty, too much effort required, and a lack of interest.

Late-stage students reported higher scores for one item in the psychosocial support factor and two in the research and writing. They felt that their mentor had more reasonable expectations of their workload, received more timely feedback, worked with them to align their expectations on the mentoring relationship, and provided more information about resources relevant to their work. They perceived their mentor more as a role model. These findings are in contrast with Collier and Blanchard (2024), who found that the late-stage students experienced less mentor support, less access and opportunity, and less persistence.

Differences in Graduate STEM Students' Perceptions of their Mentoring Experiences Based on Academic Discipline

It was hypothesized in research question 2d that there will be differences in all the measured factors based upon academic discipline. This was not supported. There were statistically significant differences in only one item from each of the following factors: psychosocial support (friendlier mentor), program completion (higher expectations of achieving the doctoral milestones), career expectations (expecting to obtain a desired job), and career support (opportunities to learn about grant proposal writing). Also, there were significant differences in two items in the research and writing factor: the mentor helping to write the research for publication and the mentor being available.

Computer/Information Sciences students reported having a friendlier mentor than Agriculture/Natural Resources students, receiving more help from their mentor to write their research for publication compared to Biological/Biomedical Sciences students, but they were less expecting to obtain a desired job compared to other groups. Mathematics/Statistics students reported higher expectations of achieving the doctoral milestones compared to Biological/Biomedical Sciences students. They perceived that their mentor was more available to them compared to Physical Science students. Biological/Biomedical Sciences students felt their mentor provided more opportunities for them to learn about grant proposal writing.

These findings are important as, even if strong similarities between STEM disciplines exist, each STEM program has unique disciplinary aspects (Reinholz et al., 2019). Reinholz et al. (2019) analyzed the similarities and differences among the cultures of several STEM disciplines: Biology, Chemistry, Mathematics, and Physics. They found that similarities and differences exist in structures, symbols, power, and people. Understanding the uniqueness of each department is important to better support graduate STEM students.

Regression Analysis of Composite Scores

This study aimed to investigate what survey variables would have an effect on students' outcomes expectations, using regression analyses to address research question three. Two hypotheses were tested. First, it was hypothesized that the composite scores for psychosocial support, research and writing, and career support would have a significant impact on students' composite scores for program completion. The regression model indicated that only research and writing significantly impacted students' expected program completion. To achieve the program milestones, complete the thesis/dissertation, and graduate was dependent on the perceived research and writing support the mentor provided to the mentee. This finding is consistent with Collier and Blanchard's (2024) study results, that students' persistence in the program is impacted by mentor support.

The second hypothesis was that the composite scores for psychosocial support, research and writing, and career support would have a significant impact on the career expectations' composite score. The regression analysis revealed that only the career support the mentor provided significantly impacted the graduate STEM students' career expectations. If the mentor provided guidance on career development, took time to learn about the student's career goals, and provided information about various career paths inside and outside academia, the mentee perceived that they would achieve their career expectations.

This finding was found to be important by Harshman (2020), who conducted a literature review and found that doctoral chemistry students are "overly specialized in their training" but "ill-prepared" (p. 259) for nonacademic careers and teaching positions. Despite progress in the last decade, diversifying the U.S. STEM workforce remains a national priority and challenge (Fry et al., 2021). This suggests that graduate STEM students would be more confident about finding a desired job if they learned more about their career goals earlier in graduate school, as well as information about a variety of careers, while connecting them with other professionals in the field.

Connection of Study's Findings to the Frameworks

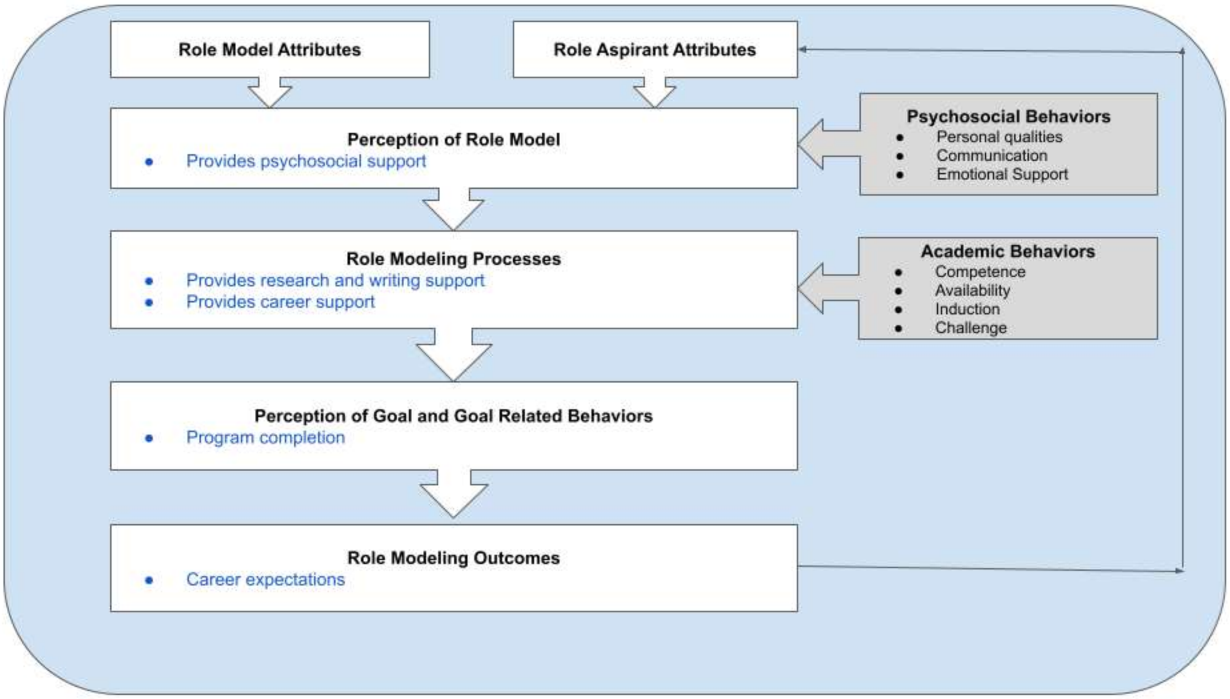
Two theoretical frameworks were used in this study: Yob and Crawford's (2012) conceptual theory of mentoring and Morgenroth et al.'s (2015) theory of role modeling. Yob and

Crawford's (2012) conceptual theory was used to guide the design of the Mentoring Experiences of Graduate Students Survey (MEGSS), validated as a part of this study. The psychosocial factor, consisting of 14 items, aligned with Yob and Crawford's psychosocial domain of mentor's behaviors and characteristics: personal qualities, communication, and emotional support. The research and writing factor, consisting of 9 items, and the career support, consisting of 7 items, aligned with the academic domain of the mentor's behaviors and characteristics: competence, induction, challenge, and availability. This study expands the framework to consider whether good mentoring leads to desired outcomes for students. These items made up the subscales program completion and career expectations.

Mentors are role models for their mentees. In their theory of role modeling, Morgeronth et al. (2015) described the role models. In this case, graduate STEM students' mentors served as behavioral models, representations of the possible, and inspirations. When acting as role models, the mentors focused on the mentee's acquisition of skills and provided research and writing, and career support. The mentors helped the mentees improve their scientific writing, prepare the research to be presented, provided timely and useful feedback and information about useful resources and careers, challenged the mentees to grow, and were available. All these academic behaviors that Yob and Crawford (2012) described as competence, availability, induction, and challenge, as well as the outcome variables added for this study - program completion and career expectations - can be aligned with Morgenroth et al.'s (2015) role modeling processes (Figure 3.4), based on the findings of this study.

Figure 3.4

Alignment between Yob and Crawford' (2012), Outcome Variables from MEGSS, and Morgenroth et al.'s (2015) Frameworks



The mentors in this study exhibited psychosocial behaviors (Yob & Crawford, 2012); the graduate STEM students generally perceived the mentor as encouraging the mentees, advocating for them, and displaying personal qualities such as trust, being a role model, being friendly, understanding, and giving independence. After the survey findings, Yob and Crawford's psychosocial behaviors were aligned with Morgenroth et al.'s (2015) *perception of role models* as attainable and desirable (see Figure 3.4)..

The mentors in this study exhibited academic behaviors (Yob & Crawford, 2012); these twenty graduate STEM students generally perceived the mentor as being available to them, helping them improve their scientific writing and research, challenging them to grow professionally, providing timely and useful feedback, helping them develop professional relationships, and providing information about various careers inside and outside academia. After the survey results were analyzed, these academic behaviors of providing research and writing and career support were aligned with Morgenroth et al.'s (2015) *role modeling processes*.

The program completion factor was aligned with Morgenroth et al.'s (2015) perception of *goals and goal-related behaviors,* following survey analyses. Program completion items reflected students' perceptions of their goals, and included: expect to achieve program milestones in a timely manner, complete the thesis/dissertation, and graduate. Items such as being productive in research and academic writing reflected students' perceptions of goal-related behaviors. The career expectations factor was aligned with Morgenroth et al.'s (2015) *role modeling outcome,* after the survey items were analyzed. The three items, feeling prepared for a career, expecting to obtain a desired career and achieve career goals embodied role modeling outcomes, which were not an original part of Morgenroth et al.'s role modeling theory or Yob and Crawford's (2012) mentoring framework.

In this study, the two frameworks and the additional outcomes from the MEGSS were brought together to highlight complex aspects of mentoring. Yob and Crawford's (2012) conceptual framework highlighted the academic and psychosocial behaviors of mentors. These academic and psychosocial behaviors were aligned with Morgenroth et al.'s (2015) *perception of role models,* and *role modeling processes.* Role modeling processes explored in this study include psychosocial support, research and writing, and career support. The theory of role modeling included *perception of goals and goal-related behavior,* which has been aligned with MEGSS program completion aspects. *Role modeling outcomes* in the theory of role modeling has been aligned with the MEGSS career expectations items. Therefore, the theory of role modeling has now been explicitly tied to students' perceptions of the role of a graduate student mentor, and the goals and outcomes that result from that mentoring.

Conclusions and Recommendations

This project developed, distributed, and validated the Mentoring Experiences of Graduate Students Survey (MEGSS) to graduate students in STEM fields. Item analyses revealed statistically significant differences between varied groups of graduate STEM students regarding their perceptions of psychosocial support, research and writing, and the career support they received from their mentors. In many instances, it mattered who you were - your gender, the stage of your degree, your program, and your citizenship status - how you perceived your mentorship. This suggests that there is a lot of variation in the experiences of graduate STEM student mentoring, and much of that is linked to who you are and who your mentors are.

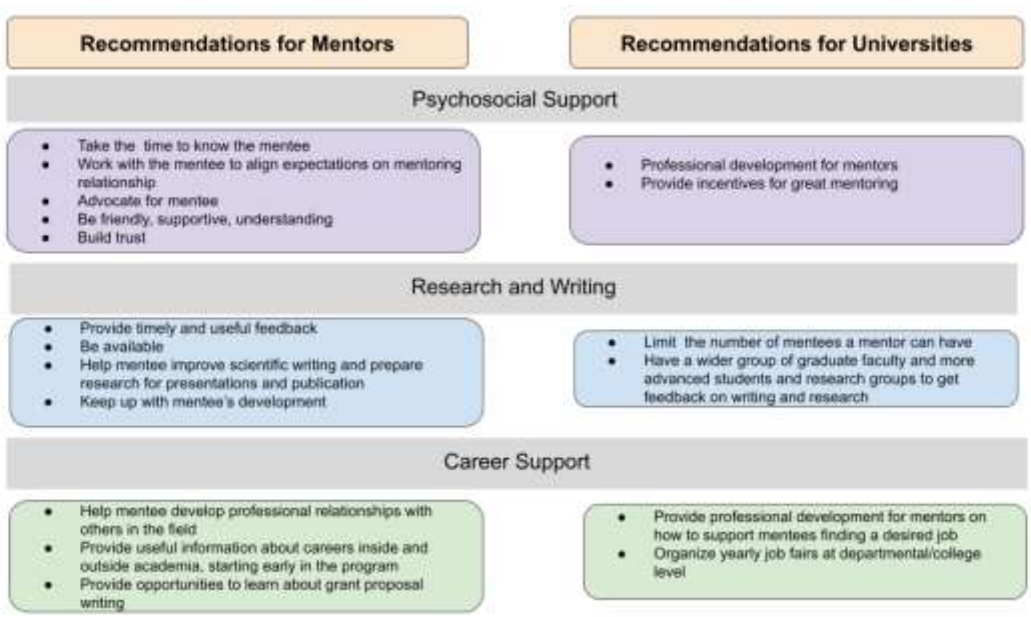
Overall, regression analyses revealed that only research and writing statistically influenced the program completion for the entire group of participants, while the psychosocial and career support did not influence it. Similarly, only career support statistically affected the entire group's career expectations; the psychosocial and research and writing support did not influence career expectations. That is, despite differing perceptions of aspects of mentoring related to academic and psychosocial support, the factors that were most salient to positive outcomes (e.g., program completion aspects and career expectations) were related to positive perceptions of experiences of research and writing and career supports. Although many psychosocial aspects are enjoyed and considered desirable by students and mentors, they were not predictive of expected outcomes in this study.

Recommendations

Findings from the Mentoring Experiences of Graduate Students Survey (MEGSS) with graduate STEM students highlight areas where students need additional support based on demographic characteristics (e.g., gender) and program characteristics (e.g., stage in the program, academic discipline). Based on these findings, recommendations for mentors and universities regarding psychosocial support, research and writing, and career support are offered to bolster graduate STEM students' development (Figure 3.5).

Figure 3.5

Recommendations for Mentors and Universities Programs



Psychosocial Support

Considering the psychosocial support the graduate STEM students perceived as needed, it would be beneficial for mentors to take the time to know the mentees, work with the mentee to align expectations on the mentoring relationship, exhibit personal qualities such as friendly, caring, supportive, and understanding of their needs as graduate students, and build trust.

Colleges and departments could organize professional development for mentors to share successes and struggles and learn specific strategies to support the mentees better, as different STEM disciplines have different structures, symbols, power, and people. Future regression models focusing on specific subgroups (i.e., female, international students in Physical Sciences) may reveal significant effects of the latent constructs.

NASEM (2018) recognized that faculty are rewarded and nominated for tenure and promotion at most research universities based on the number of publications and grant funding. Even if evaluations of teaching quality and mentoring activities exist and are gathered together, they count less in the faculty's evaluation. Universities can provide incentives and awards for quality mentoring and consider them to a greater extent in the overall faculty evaluation.

Research and Writing

The regression analysis revealed that the composite score for research and writing statistically impacted the composite score for program completion. The attrition rates in graduate STEM programs remain high (Bahnson & Berdanier, 2023; Sowell et al., 2015). One way to improve retention is by offering graduate STEM students more support regarding research and writing. Mentors can provide timely and useful feedback, be available, and help students improve their scientific writing and prepare it for presentations and publications. The number of mentees, if too high, limits the amount of time the mentor can dedicate to working with one mentee and providing feedback on written work. The universities could limit the number of mentees a mentor can have so professors do not become overburdened by a too high number of students.

Career Support

The regression analysis revealed that the composite score for career expectations was statistically dependent on the career support composite score. The U.S. needs to improve graduate STEM education by addressing the unique needs of its students (NASEM, 2018) and improve the STEM workforce by diversifying its pool. The mentors can, from early in the program, learn about mentees' career goals and provide useful information about careers inside and outside academia. Also, the mentors can help the graduate STEM students develop professional relationships with others in the field. The universities can organize yearly department or college-level job fairs so that the students can learn about possible job opportunities and connect with others inside and outside academia.

Future use of the survey - for STEM and beyond STEM majors - can provide insight to departments and colleges about the perceived psychosocial, research and writing, and career support, along with students' perceptions of program completion and career expectations. Identifying areas that lack support can allow departments and colleges to better support the development of their graduate STEM students.

CHAPTER 4: Conclusions, Implications, and Recommendations

Conclusions

Graduate STEM education attracts domestic and international students and has the potential to lead to appealing career jobs, advance technology and innovation, and find solutions to pressing and complex problems. Graduate STEM students face a multitude of challenges, and mentoring is a key way to support the development of graduate STEM students. Despite higher attrition rates, little has been known about how to best support graduate STEM students through mentoring.

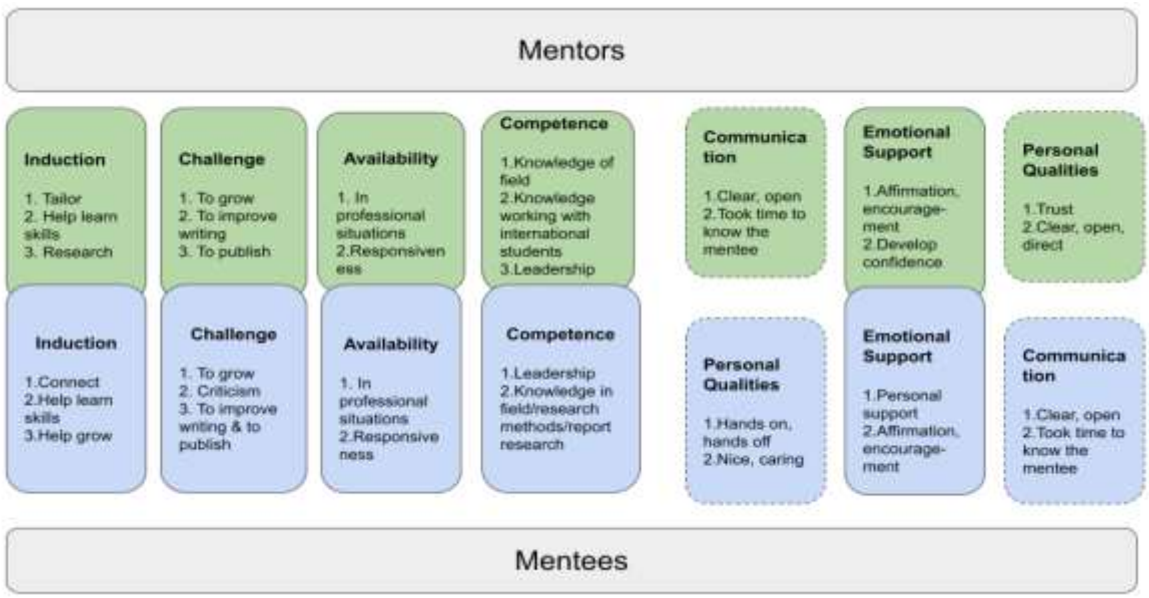
Two studies were conducted as a part of this dissertation to understand the mentoring experiences of graduate STEM students. A qualitative study involving interviews of STEM professors and their former doctoral students (recent graduates) provided insights into the mentoring experiences from both the perspectives of mentors and mentees. In the second study, the Mentoring Experiences of Graduate Students Survey (MEGSS) was developed, distributed, and validated to domestic and international graduate STEM students from a large, public, southeastern, research-intensive university. Exploratory factor analysis was used to test the validity and reliability of the survey, and descriptive and regression analyses were conducted. Based on the findings, recommendations were made to better support the development of graduate STEM students.

Qualitative Study

This study sought to explore the mentoring experiences of STEM mentors and their former doctoral mentees. Eight professors and twenty former mentees, domestic and international, were interviewed. Yob and Crawford’s (2012) academic and psychosocial behaviors were used to code the transcripts deductively. It was found in this first study that, overall, the mentors and mentees described similar mentoring approaches that supported their development. (Figure 4.1)

Figure 4.1

Academic and Psychosocial Behaviors Mentors and Mentees Described



Note. Behaviors described by mentors are in green, and mentoring behaviors described by mentees are in blue. The academic and psychosocial behaviors are presented in order from left to right, from most to least prevalent. The numbered behaviors and the associated examples are presented in order of how prevalent they were described by the mentors (in green) or the mentees (in blue). The mentoring approaches included in dotted-line boxes are described in a different order of prevalence by mentors and mentees.

Academic Behaviors

Academic behaviors were the most prevalent in mentors' and mentees' descriptions of mentoring experiences. For both groups, induction was the most common approach. Within induction, the mentors described tailoring unique strategies, helping mentees learn skills, and working on designing, conducting, and reporting research as the top three approaches to mentor, while the mentees described connecting with others in the field, helping the mentee to learn skills, and helping the mentee to grow as the most common. The second most common academic behavior was challenge, for both groups. The mentors described challenging mentees to grow, to improve academic writing, and to publish papers as the top three approaches; the mentees most often described being challenged to grow, provided with constructive criticism, and challenged to improve academic writing and to publish. The third most common mentoring approach was availability. Within availability, both groups described the same approaches: being available in professional situations, and responsiveness. The fourth academic approach described by mentors and mentees was the competence of the mentor. Within competence, mentors described having knowledge in the field and knowledge of working with international students as the most common, while the mentees most often described mostly their mentors having leadership skills, knowledge in their field, competence in research methods, and reporting research. All the participants were from a research-intensive public university. It seems likely that both groups of mentors and mentees described academic behaviors as the most prevalent because the doctoral programs are heavily oriented toward gaining highly specialized knowledge in a specific field, and professors' and students' success is related to the quality of their research and the number of publications (NASEM, 2018).

Psychosocial Behaviors

Overall, psychosocial behaviors were described less than academic behaviors by both mentors and mentees. Also, their prevalence was different for mentors and mentees. The most common behavior described by mentors was communication, the second was emotional support, and lastly, personal qualities. In contrast, mentees most often described personal qualities, followed by emotional support, and communication. However, both groups' most common communication approaches were clear and open communication and the mentor taking time to get to know the mentee. Within emotional support, the mentors described providing affirmation and encouragement and helping students to develop confidence and self-esteem as the most common approaches. The mentees described their mentors providing personal support and affirmation and encouragement as the most prevalent. Within personal qualities, the mentors described trust and being clear, open, and direct as the most common, while the mentees most often described their mentor as being hands-on, hands-off, nice, caring, and understanding as the most common. It is possible that psychosocial behaviors were described less because graduate STEM education in the U.S. is focused on advancing STEM innovations and less on the students' psychosocial needs (NASEM, 2018).

Two (out of eight) professors (Dr. Powell and Dr. Day), both domestic, overall described mostly psychosocial behaviors. One professor (Dr. Powell) described that most students can do the work but might need motivation to persist in the program, while the other professor (Dr. Day) emphasized the importance of listening to the mentees and taking time to get to know them. It is possible that both professors had experienced that students' persistence and success in a STEM program were heavily dependent on psychosocial support. Six out of the eleven international graduate STEM students described mostly academic behaviors of their mentors; four described mostly psychosocial. The international students are selected to study in the U.S. graduate STEM programs based on their rigorous academic qualifications and many of them have research experience before coming to the U.S. (Ruiz, 2014). However, they face language, cultural, and social challenges and are away from their families while studying in the U.S. (Han & Appelbaum, 2016). Therefore, for nearly a third of them, the psychosocial support they received from their mentor might have been perceived as more important than academic support (Collier & Blanchard, 2024).

Quantitative Study

The Mentoring Experiences of Graduate Students Survey was developed and distributed to students from a large, public, research-intensive university. Exploratory factor analysis was used to test the validity and reliability of the survey with 280 responses. The majority of the respondents were male (51.43%), White (51.07%), doctoral (99.6%), domestic students (56.4%), and enrolled in engineering programs (43.6%). Most of the students were full-time (95.7%), had worked for 3 years with their current mentor (24.6%), and were in the late stage of the program (working on dissertation/thesis, 46.4%).

A 5-factor, 38-item model was determined with factors ranging from three to fourteen items. The following scales were determined: psychosocial support, program completion, research and writing, career expectations, and career support. Reliability testing led to Cronbach's alpha values ranging from 0.80 to 0.96. The results of the survey highlighted variations in the perceived support received from the mentor and in the students' outcomes related to program completion and career expectations.

Differences by Demographics and Characteristics

Female students perceived less psychosocial, research and writing, and career support. This result is possibly due to the persistent underrepresentation of women in STEM fields (NSB, 2024a). There were no statistical differences found in the perceptions of international and domestic students, except that international students felt less prepared for their careers. Also, there were no statistically significant differences in the perceptions of part-time and full-time graduate STEM students. Their stage in the program revealed statistical differences. The late-stage students reported the most psychosocial, research and writing, and career support, followed by early-stage students. The middle-stage students reported the least support. It is possible that the early-stage students perceived more support from their mentors as a result of induction into the field, selecting courses to enroll in, and meeting program deadlines and requirements. The late-stage students perceived more support as they were heavily immersed in designing, conducting, and reporting their dissertation research. The middle-stage part of the program might be the phase where mentors need to provide more psychosocial, research and writing, and career support, as that is when time is lost due to the uncertainty of research direction, questions, and methods and perceptions of negative mentoring depend on the graduate STEM students' stages of development (Tuma et al., 2021). Providing more support to middle-stage students might lead to more research productivity in publications, a major goal of graduate students and their mentors (NASEM, 2018).

There were differences between different academic disciplines. Mathematics and Statistics graduate students reported the most research and writing support, and program completion expectations. Computer/Information Sciences students reported the most psychosocial and research and writing support. These findings suggest that there is variation in the experiences of graduate students in different STEM fields, as Reinholz et al. (2019) found that STEM fields differ in terms of structure, power, and people.

Regression Analysis of Latent Constructs

Two regression analyses were conducted. The first analysis revealed that research and writing support positively influenced program completion. Psychosocial and career support did not significantly impact program completion. The second analysis revealed that career support positively influenced career expectations. Psychosocial support and research and writing did not significantly impact career expectations. Despite differing perceptions of aspects of mentoring support, the factors that were most critical to positive program completion and career expectations outcomes were related to positive perceptions of experiences of research and writing and career supports. Many psychosocial aspects are appreciated by students and mentors, but they were not predictive of expected outcomes in this study.

Theoretical Frameworks

Three theoretical frameworks were used in the two studies in this dissertation: Yob and Crawford's (2012) conceptual theory of mentoring, Chandler et al.'s (2011) ecological systems theoretical framework, and Morgenroth et al.'s (2015) theory of role modeling (Figures 4.2, 4.3, 4.5).

Figure 4.2

Conceptual Framework of Mentoring (Re-drawn from Yob and Crawford, 2012)

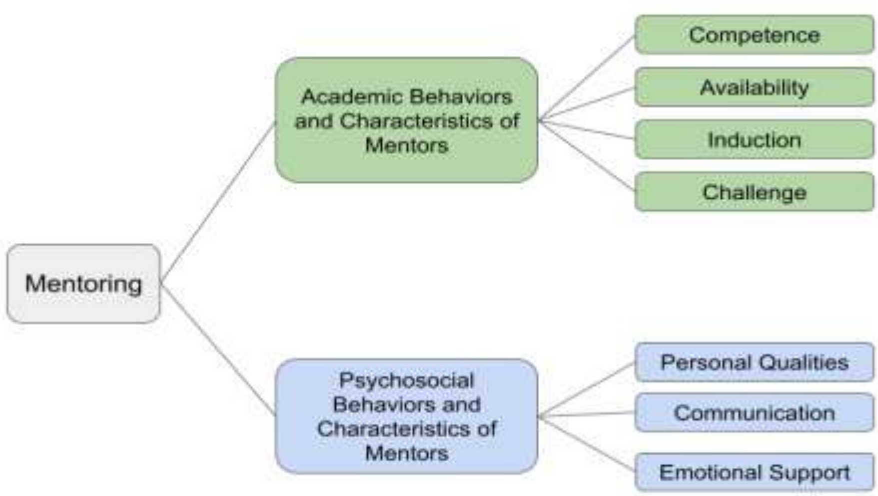
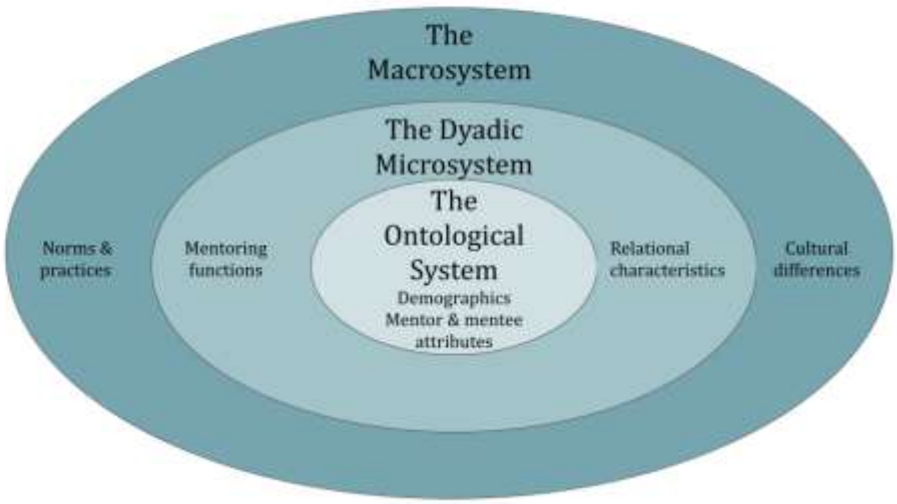


Figure 4.3

Ecological Systems Theory (Re-drawn and Modified with Mentoring Constructs, from Chandler et al., 2011)



Shared Constructs between Yob and Crawford's (2012) and Chandler et al.'s (2011) Frameworks in the Qualitative Study

When thinking about graduate mentoring as an ecological system, the mentor attributes described by Yob and Crawford could be reimagined within that system. As shown in Figure 4.4, Chandler et al.'s (2011) inner circle, the ontological system, was adapted by the author to include Yob and Crawford's (2012) personal qualities and competence of the mentor, reflecting the mentor's attributes. The next circle, the dyadic system, was described by challenge, a mentoring function in Yob and Crawford's framework that helps graduate students to grow, become independent thinkers, and advance their knowledge in the field. Also, in the dyadic system, the availability and communication aspects of Yob and Crawford are used to reflect the relational characteristics between mentor and mentee in the ecological systems model. The outermost circle, the macrosystem, could be described by Yob and Crawford's induction. Mentors induct the mentees into STEM fields, provide resources for them, and connect them with other professionals in the field, which depend on institutions, programs, and other people in the field and are described by particular norms and practices. Chandler et al. (2011) attributed cultural differences to the macrosystem. Emotional support is a part of the macrosystem, as mentors and mentees come from different countries, cultures, and groups and bring with them varied personal and emotional needs. Providing affirmation and encouragement and developing confidence and self-esteem are highly dependent on the domestic and international students' unique needs.

Figure 4.4

Shared Constructs between Yob and Crawford's (2012) and Chandler et al.'s (2011) Theories

Note. Yob and Crawford's (2012) academic and psychosocial behaviors are included in gray, dotted-line boxes in Chandler et al.'s (2011) ecological systems theory.

Frameworks in the Quantitative Study

As depicted in Figure 4.6, Yob and Crawford's (2012) psychosocial behaviors were absorbed by the perception of the mentor as a role model, as the mentors displayed personal qualities, communicated, and provided emotional support to the mentees. Morgenroth et al.'s (2015) role modeling processes absorbed the academic behaviors the mentors displayed, as they were competent and available, inducted mentees to the field, challenged them to grow and learn skills, and provided research and writing, and career support.

Figure 4.5

Motivational Theory of Role Modeling (Adapted from Morgenroth et al., 2015)

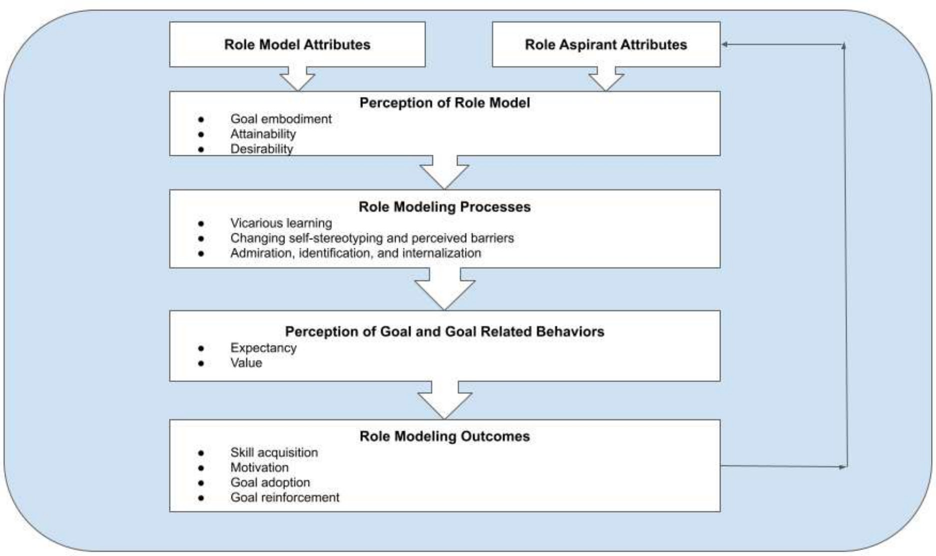
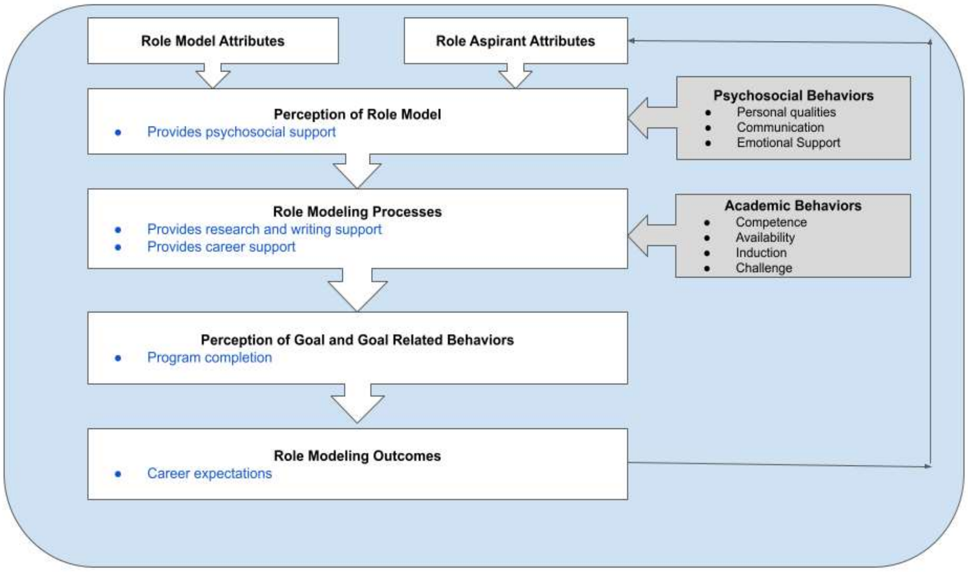


Figure 4.6

Shared Constructs between Yob and Crawford's (2012) and Morgenroth et al.'s (2011) Theories

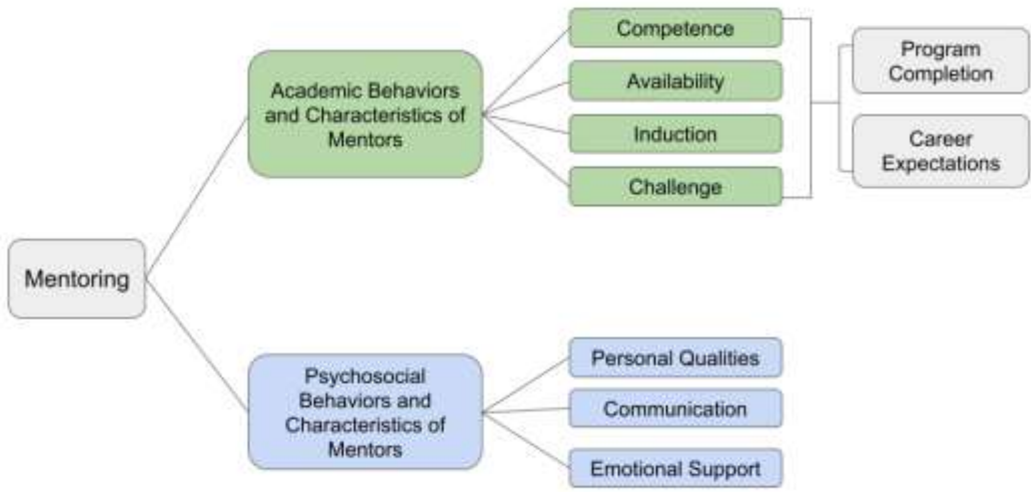


Note. Yob and Crawford's (2012) academic and psychosocial behaviors are included in gray boxes in Morgenroth et al.'s (2011) theory of role modeling.

The findings of the MEGSS also lead to a suggested modification to Yob and Crawford's (2012) framework. Graduate STEM students' perceptions of the program completion and career expectations outcomes were dependent on Yob and Crawford's (2012) academic behaviors (research and writing and career support) their mentors provided (see Figure 4.7). The psychosocial behaviors from Yob and Crawford's conceptual theory of mentoring did not seem to play a significant role in students' outcomes.

Figure 4.7

Yob and Crawford's Framework and Mentees' Outcomes



Note. The mentees' outcomes are program completion and career expectations.

Implications

From the first study, it was learned what mentoring approaches the mentors used to support the development of graduate STEM students. Academic behaviors were the most prevalent from mentors' and mentees' perspectives. Without the survey study, we would not have learned the program completion and career expectations outcomes. From the regression analysis, it was found that the program completion outcome was positively impacted by the research and writing support the mentors provided. The more research and writing support a mentor provided, the more the graduate STEM students felt they would complete the program. Also, the regression analysis revealed that career expectations were positively influenced by the career support the mentor provided. The more career support a mentor provided, the more the graduate STEM students felt that they were prepared for a career, would obtain a desired job, and achieve their career goals.

One of the differences in the studies is that for the qualitative study, graduate professors and their students volunteered to take part, and knew their former students would be interviewed. In the quantitative study, graduate STEM students completed the survey voluntarily, but they knew their professors would not be privy to their feedback. Thus, it seems likely that the qualitative study was more likely a 'best case' situation detailing the experiences of STEM graduate students who received mentoring with involved, caring professors. It also seems likely that the mentoring experiences of the participants in the survey study came from a wider range of mentoring experiences, and that study may have revealed a more 'typical' experience with mentoring.

Recommendations

Conducting the qualitative study and administering the Mentoring Graduate Students Survey with STEM graduate students led to very different but complementary information, providing a more expansive as well as nuanced understanding of the mentoring experiences of graduate STEM students. Universities could provide training to assist faculty with learning and sharing the best mentoring practices. Professional development on mentoring would be beneficial to both mentees and mentors, as students perceived mentors as one of the most important resources for their success in graduate school (Collier & Blanchard, 2024) and faculty reported lack of mentoring raining but a need for it (Hund et al., 2018; Stolzenberg et al., 2019). Also, universities could provide incentives and awards for quality mentoring and consider mentoring to a greater extent in the overall faculty evaluation, tenure, and promotion. STEM graduates who were participants in the qualitative study recognized that their mentor had a high number of mentees, which greatly limited the mentor's availability and the feedback they received. Programs and departments could limit the number of mentees a faculty member has so that more availability would exist for mentors' professional needs, and more timely feedback would be offered to them. Another option would be to make postdoctoral fellows an active member of a mentor 'team' to add to the individuals who are providing research advice and writing feedback to graduate students. To evaluate its quality and provide feedback to both mentors and mentees, mentoring assessments could be done once per semester, and aggregate or individual feedback could be shared with the mentor and the mentee, to improve the relationship and support the development of graduate STEM students.

The graduate STEM students expressed a need for more career support throughout the program. This is consistent with Harshman's (2020) finding that doctoral students feel ill-prepared for their careers. Universities could provide more opportunities for students to learn more about careers inside and outside academia as early in the program as possible. Programs and departments could invite research partners from academic institutions, industry, or government to participate in yearly presentations and job fairs so that graduate STEM students could learn more about academic and non-academic career opportunities. By making these experiences a part of graduate education and graduate research and teaching assistantships instead of something students are supposed to do 'on their own,' it would expand graduate students' access to career pathways.

To support graduate STEM students' development, the mentors could actively introduce mentees, from early in the program, to a broader range of professionals, such as other researchers in the field, collaborators, and potential employers. Making funding for conference travel a high priority within departments could support these experiences, consistent with recommendations by Collier and Blanchard (2024). Increased availability in professional situations, timely feedback on written work, and balanced workloads for the mentees were ways that STEM graduates felt would have helped them to be more successful. Regression analysis revealed that the research and writing factor was a predictor of program completion, and this is an important consideration in light of the high attrition rates in graduate STEM programs (Bahnson & Berdanier, 2023; Sowell et al., 2015). STEM graduates in this dissertation study reported that more guidance and hand-holding were needed in the early and middle stages of the program when they were in the designing and beginning of conducting phases of their research. They felt that precious time was lost in finding the direction of their research, and their mentor's advanced expertise and connections with others in the field would have been greatly helpful in increasing their productivity.

Mentees could seek more opportunities to improve their academic writing at university and college levels. Constructive criticism is essential to strengthen the quality of academic writing, and incorporating the mentor's feedback in written work is crucial. International graduate STEM students could seek more opportunities to improve their English skills; attending workshops or listening to podcasts could be ways to strengthen their oral and written skills. To build a stronger academic portfolio, the mentees could prioritize publishing papers. Also, mentees could develop and share with the mentor a post-graduation plan and seek job market advice from early in the program. Making all of these activities a typical part of graduate education instead of an 'add on' to be done in one's free time could greatly enhance graduate student outcomes.

Each mentee is unique, and taking the time to know the mentee and their goals is essential to find the best ways to support their development. Collier and Blanchard (2024) found that female graduate STEM students who are in the late stage of the program reported less mentor support, more microaggressions due to gender, and less persistence in the degree. Their findings resonate with this study. However, Collier and Blanchard (2024) found that nonbinary graduate students perceived experiencing microaggressions in the program due to their gender, and therefore, it was an inhibitory factor for their success. Still, this current study found that nonbinary students experienced strong mentor support. There is a need to address the unique needs of graduate STEM students as the pool of students changes (NASEM, 2018). This study's survey included one open-response where the participants could share more about their mentoring experiences. Future research can explore what other mentoring supports and barriers different genders, stages in the program, and academic discipline students described. This future research has the potential to offer more insight into the particular needs of students and fill in the gap of finding ways to address the uniqueness of graduate STEM students. The development of a student is dependent not only on their ontogenetic characteristics but also on the micro and macrosystem (Chandler et al., 2011). Quality mentoring of graduate STEM students is essential to support the development of a more diverse and inclusive STEM graduate school experience, improve attrition, and ultimately strengthen the STEM workforce.

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APPENDICES

Appendix A

Mentor (Faculty Member) Interview

Thank you for agreeing to participate in this interview. I am interested in your mentoring experiences with your former international (or domestic) graduate student(s). Your responses will be kept confidential. I would like to record you. A professional transcriptionist will change this recording into a transcript. I will analyze the transcripts of the interviews. Your personal identifiers (name, country of origin, name of mentee, etc.) will be removed before any analysis of data will occur. If, during the interview, you want to stop, we will. Do you have any questions before we begin? Do I have your permission to record this interview? I am going to start recording now.

1. Please tell me your name and country of origin.

2. What is your STEM field?

3. I will show you one definition of mentoring.
   Mentoring is "the activity of guiding, advising, or counseling a learner" (UNESCO International Centre for Technical and Vocational Education and Training, n.d.). The mentor provides academic and psychosocial support, employing a variety of behaviors and characteristics such as being competent and available, inducting mentees to the field and other professionals and challenging the mentees, displaying personal qualities and communication skills, and providing emotional support (Yob & Crawford, 2012).
   Is this how you see mentoring, or do you see mentoring differently?

4. What do you consider important or effective mentoring strategies?

   For the next questions, think about Person X who was your main research advisee when you respond. Do you have that person in mind?

5. What mentoring strategies did you use to support the development of Mentee X?

6. What challenges did you encounter while mentoring your international mentee? Did you consider any of them to be different than when mentoring a domestic student? Please explain.

7. How did you overcome those challenges?

8. Name and describe 1-3 aspects of your mentor experience that enhanced your work with student X.

9. What are 1-3 things Student X could have done/or did to be (more) successful as a graduate student?

That was my last question. Is there anything that I did not think to ask that will be useful to better understand your mentoring experiences? Thank you for taking your time to answer my questions. Your responses are critical to my study. If you have any questions, please contact me.

Appendix B

Mentee (Former Graduate Student) Interview

Thank you for agreeing to participate in this interview. I am interested in your mentoring experiences as an international or domestic graduate student while studying STEM in the U.S. Your responses will be kept confidential. I would like to record you. A professional transcriptionist will change this recording into a transcript. I will analyze the transcripts of the interviews. Your personal identifiers (name, country of origin, name of mentor, etc.) will be removed before any analysis of data will occur. If, during the interview, you want to stop, we will. Do you have any questions before we begin? Do I have your permission to record this interview? I am going to start recording now.

1. Please tell me your name and country of origin.

2. What is your STEM field?

3. I will show you one definition of mentoring.
   Mentoring is "the activity of guiding, advising, or counseling a learner" (UNESCO International Centre for Technical and Vocational Education and Training, n.d.). The mentor provides academic and psychosocial support, employing a variety of behaviors and characteristics such as being competent and available, inducting mentees to the field and other professionals and challenging the mentees, displaying personal qualities and communication skills, and providing emotional support (Yob & Crawford, 2012).
   Do you see mentoring similarly or differently from this definition? Please explain.

4. What do you see as important or effective mentoring strategies?

   For the next questions, think about a person who was your main research advisor when you respond. Do you have that person in mind?

5. How would you describe your research advisor's mentoring approach?

6. What mentoring strategies did they use to support your development?

7. Name and describe 1-3 aspects of your mentee experiences that enhanced your work with this Professor.

8. Please think back on your mentoring experiences as an international or domestic graduate STEM student. Has distance after graduation changed your perceptions on the mentoring that you received? Please explain.

9. What challenges did you encounter, if any, while being advised by your faculty research mentor?

10. Did you overcome these challenges? If so, how?

11. What are 1-3 things your mentor could have done to help you be more successful as an international graduate STEM student?

That was my last question. Is there anything that I did not think to ask that will be useful to better understand your mentoring experiences? Thank you for taking your time to answer my questions. Your responses are critical to my study. If you have any questions, please contact me.

Appendix C

Dr. Benito, Maria, Sonja, Jack, Roman, and Luna's Mentoring Experiences

Dr. Benito

Effective mentoring is a cycle where the mentor discusses objectives and activities with the mentee, the mentee attempts to do them, and then the mentor provides feedback. The mentor helps the mentee develop the research, meet the program requirements, develop their writing and presentation skills, and ensure their research aligns with their career goals. Also the mentor ensures there is a plan for approaching potential employers. Dr. Benito changed his mentoring in response to the student's needs. The international students were better prepared for research, and more driven, responsible, and committed to their research, while the domestic ones seemed to be distracted, and didn't spend as much time on their research.

Dr. Benito: Mentoring Maria

Maria (international) was chosen to work on one of Dr. Benito's project based on her academic transcripts. They met once or twice a week to discuss research, experiments, and procedures. Maria was independent, self-motivated, driven, and a pleasure to have as a graduate student. Dr. Benito did not have to challenge her. They would read a proposal together, and Maria would know the next step. He gave her the resources she needed and opportunities to make presentations, attend conferences, and submit to high-level journals. She was confident in her abilities.

Maria: Dr. Benito's Mentoring

Trust is the most important in mentoring based on open communication and asking questions without fear. Maria had two mentors, with different personalities, yet they were complementary. Her main research mentor was Dr. Benito. He was friendly, nice, supportive, hands-on and tracked every student. He focused on technical advising and was good at managing students, full of imagination, but having too many ideas, and wanting to do it all. Initially, she was overwhelmed and had to filter through his ideas. He put pressure to publish papers, was very good at managing funds, and provided all the resources she needed. She felt that there was a lot of pressure on the international students who had to work harder than domestic students. She was unprepared for the cultural differences and found the transition from university to the workforce very tough, with racism present in the male-dominated workforce.

Dr. Benito: Mentoring Sonja

Communication with Sonja (international) was a little bit harder in the beginning than with Maria, but they communicated effectively. Sonja needed more direction than Maria, as she was less sure of herself and needed Dr. Benito to tell her the next steps. She was self-driven, working hard, and responsible. Sonja did a great job with reports, conferences, and papers.

Sonja: Dr. Benito's Mentoring

Dr. Benito's mentoring style was perfect for her. She was impressed at the beginning with how carefully he was listening to what she was saying. Dr. Benito pointed out the things that needed to be improved, which she appreciated. Dr. Benito never forgot to encourage Sonja and his other mentees. Dr. Benito helped her improve her manuscripts and presentations. She experienced a language barrier, especially at the beginning of her doctoral studies. Dr. Benito was kind of fast for Sonja. Her graduate school experience was great.

Dr. Benito: Mentoring Jack

Jack (domestic) was very independent and successful, but his attention was not always on the research, as other activities distracted Jack from his research. Jack wanted to start a small business during his graduate studies. Dr. Benito had to ensure that Jack was focused on the research project; he needed to push him and keep him going in the same straight line. Jack was a good presenter and published a lot. He was very good at networking and had many good job opportunities to pick from.

Jack: Dr. Benito's Mentoring

Dr. Benito established high levels of expectations in terms of quality and rigor and helped the mentee overcome his weaknesses. There were one-on-one interactions, with a lot of feedback given. Dr. Benito enabled Jack to set a course and an idea and chose his research approach. He encouraged, taught, helped, and challenged Jack to achieve a high level of rigor in understanding the science and communicating the research. Jack believed it was really hard to be a graduate student and to be pushed to the level that Dr. Benito pushed his students. Dr. Benito expressed some empathy towards the challenge, but Jack wished for more. Jack also thought pointing the student to counseling or other emotional support resources would have been helpful to him.

Roman: Dr. Benito's Mentoring

Note: Roman was interviewed after Dr. Benito's interview.

Dr. Benito was a good, open, and supportive mentor. His relationship with Dr. Benito was a friendship, as he trusted his mentor to tell him personal issues. When Roman asked to participate in conferences, Dr. Benito helped him get departmental scholarships. Dr. Benito would give him the best recommendation letters when looking for a job after graduation. They met once or twice weekly to set goals. Dr. Benito let Roman manage his time. Dr. Benito's mentoring approach was relaxed, which Roman appreciated, but everything needed to be ready by the deadline. When he needed a vacation, Dr. Benito would give him time to relax with his family. Dr. Benito organized social gatherings at home. Roman wished he would know from the beginning of the doctoral program that the university offered several certificate programs that he could get but did not. He also wished to have been involved in other research projects and teams so that he could collaborate with others and publish articles together.

Luna: Dr. Benito's Mentoring

Note: Luna was interviewed after Dr. Benito's interview.

Luna (international) had weekly or bi-weekly meetings with Dr. Benito when she got feedback, or they brainstormed. He was not micromanaging and gave Luna space to develop her ideas and propose new research approaches. Dr. Benito connected her with different industrial partners and other people from her country or international students. He provided academic and personal support to Luna. He was open and close to his students. He organized celebrations in his house. He provided the equipment she needed in the lab to explore her ideas. Dr. Benito was not good at giving good feedback, as he never reached out to tell her she did great. She wished she would be pushed to attend more conferences to present her research. Dr. Benito was a great support during her job search. He put her in contact with people, and she got her job because of his contacts.

Appendix D

Dr. Gray and Florian's Mentoring Experiences

Dr. Gray

Dr. Gray was from South America. Mentoring was a self-discovery learning experience. Trust was vital in mentoring. He was protective and available, trained his mentees to communicate and think fast and pushed them to do things they were not doing before. He identified their strengths and weaknesses and designed professional development to help them improve. His students worked hard. Dr. Gray organized retreat meetings with the whole team once per year to plan the research. He looked for self-motivated, creative mentees who wanted to change the world. Dr. Gray enjoyed working with his students.

Dr. Gray: Mentoring Florian

Florian challenged Dr. Gray with questions such as, 'Why are you doing this? It doesn't make sense.' To help Florian understand, Dr. Gray explained the background and the constraints of the research project or the project administration. Florian quickly overcame the challenges associated with speaking and writing English. Florian was described by Dr. Gray as a student who was amazing and nothing short of.

Florian: Dr. Gray's Mentoring

Florian described mentoring as a relationship depending on the needs of mentees and found it difficult for a mentor to check all the boxes. He appreciated a business-like oriented mentoring in which he felt comfortable with the personal relationship. Dr. Gray was business oriented and getting things done was a priority for him. He was supportive and tried to get to know the mentee. They followed a similar path as Dr. Gray was an immigrant in STEM and became good friends. He was good at connecting Florian with other people, exposed him to different scenarios, pushed him out of his comfort zone, and helped with job seeking. Dr. Gray asked Florian for more things than he could deliver. Florian wished for more free time.

Appendix E

Dr. Soleil, Zara, and Sebastian's Mentoring Experiences

Dr. Soleil

Dr. Soleil grew up in Europe. She emphasized clear expectations, goals, and regular re-evaluations to ensure they align with the student's development. Transparency, weekly meetings, and providing constructive criticism were also important. She praised the students, and had high standards and a hard time making compromises regarding the quality of work. She shared with her students that she didn't like to provide completely ignored feedback, although she respected students' independence and insights. She provided opportunities for students to deepen their knowledge and tailored the mentoring to the student's strengths and needs.

Dr. Soleil: Mentoring Zara

Zara (domestic) had great networking skills and was a former teacher and a people but not a theoretical person. Dr. Soleil exposed her to various projects to build confidence and higher level communication skills and improve her methodological work. Zara took advantage of the many opportunities provided by her mentor and expanded them, but she spread herself thin because she handled too many projects. Zara would make mistakes, and instead of realizing that her results cannot be and going back to find the mistakes, she would try to find an explanation for why they made sense.

Zara: Dr. Soleil's Mentoring

Zara described Dr. Soleil as the strongest woman, available, effective, straightforward, and reliable, offering her more than mentoring. They both had children, and this shared experience brought them close together. Zara considered her friend. Dr. Soleil gave Zara feedback and directions, helped her build a foundation in mathematical research, recommended her for awards, and ensured enough funding to attend conferences. Zara admired her mentor and wished for more social activities involving people from Dr. Soleil's lab.

Dr. Soleil: Mentoring Sebastian

Sebastian (international) was very meticulous, overly polite, and not a people person. He worked better by himself than in teams but was good at explaining. She gave him opportunities to be a teaching assistant, and he learned new techniques that he used later to build his research. His written skills were a challenge, and she wished Sebastian had listened to podcasts to improve his English.

Sebastian: Dr. Soleil's Mentoring

Dr. Soleil gave Sebastian freedom, valued his work and emotional state, provided support in times of family crisis, and was concerned about his progress. He sometimes wished for better modes of communication, but after talking with her, they changed the mode of communication. She helped him develop the skills needed for research. They met weekly to plan and work on projects. He wished he would finish a project and publish a paper before starting a new one; working on multiple projects simultaneously helped him learn skills but stressed Sebastian and made him feel he did not make adequate progress most of the time. He thought that courses or seminars to develop academic writing skills might have been helpful at the beginning of the program for international students.

Appendix F

Dr. King, Collin, and Jon’s Mentoring Experiences

Dr. King

Dr. King (international) used a project-based approach to mentoring; the students were junior scholars fully involved in interdisciplinary research projects. To mentor Collin and Jon (international), she strongly encouraged them to read and understand more about their field, be social, communicate with others, and create social networking at conferences. Collin and Jon were hard-working, with intrinsic motivation and resilience. International students were generally more stressed because of visa issues or their need for financial support.

Dr. King: Mentoring Collin

Collin joined Dr. King's research project during data collection and analysis. He was more social than Jon and tended to reach out professionally better to conferences. Dr. King wished he would be more interdisciplinary and read different literature about methodologies of various fields.

Collin: Dr. King’s Mentoring

Collin received strong academic support. He was inducted into the field and learned from peripheral participation. Dr. King had passion and dedication; she was competent, supportive, and available and provided instant responses. She balanced his independence and gave guidance. Dr. King provided detailed feedback on the manuscripts. The doctoral program was a guided discovery experience. He did not know anyone when he came to the United States to join the program. To overcome the challenges, Collin talked with people, went to counseling services on campus, and took breaks from work by going to movies and the beach. He enjoyed the program, as he was in a supportive program with a supportive community.

Dr. King: Mentoring Jon

Jon joined the doctoral program when Dr. King's technology project was in the design phase. He had an established network from his original country and tended to stay with his network. She wished he would be more interdisciplinary and read more about methodologies of various fields.

Jon: Dr. King's Mentoring

Emotional support was essential to Jon. Dr. King was an outstanding, punctual, strict, but very supportive mentor. She fully supported him financially, emotionally, and career-wise. They had weekly and bi-weekly meetings. She spent much time on research design, data collection, and writing. She expanded his ability to conduct research, handle complex tasks, solve problems, and multitask. Early in the program, she gave him opportunities to observe and replicate, and positive feedback and encouraged him to find independent research pathways under her grant project. Later in the program, she would give him harsh feedback; every section had to be improved: the language, research data collection, and academic writing. The foremost challenges Jon experienced were the language and culture differences, as Asian students are hierarchical and cautious when discussing things.

Appendix G

Dr. Yao, Christian, John, Quinn, and Joshua's Mentoring Experiences

Dr. Yao

Dr. Yao (international) emphasized the importance of understanding what a mentee wants to achieve in the doctoral program. The international students spent more time in the lab and were more interested in research than domestic students. He helped them improve their English skills. Writing skills were challenging for international and domestic students. Dr. Yao organized monthly social activities; they played volleyball and kayaking or had gatherings at home.

Dr. Yao: Mentoring Christian

Christian (domestic) wanted to work in industry; his father was an engineer in the same field. He was easy to talk with and had a strong attitude about research. He was a good family person, married early, and had two young sons. Dr. Yao accommodated his family life. Christian's research in his first year did not succeed, but he gained expertise and skills. His research was repivoted, and he got interesting results. Dr. Yao connected him with other professionals in other fields. When looking for a job, Dr. Yao helped him with negotiation strategies that led to a higher salary.

Christian: Dr. Yao's Mentoring

Dr. Yao had a good balance between freedom and micromanaging. He was a very good mentor and a person with big ideas who liked to brainstorm. He was respectful, kind, and very structured in his approach to organized meetings. He was very honest and accurate regarding his development as a researcher. Dr. Yao helped Christian improve himself and was flexible regarding the schedule. The flexibility relieved some of Christian's stress of being a parent and a doctoral student simultaneously. Dr. Yao organized dinners at his house every summer and around Thanksgiving, where he invited his students. He showed interest in Christian's family life. Dr. Yao imposed a structure on the research conducted in his lab, had many connections, and networking helped him advance his research. He wished for more micromanaging in the first three quarters of his first year.

Dr. Yao: Mentoring John

John (domestic) came into the program with a perfect GPA. He gave up his spot in a highly prestigious institution and joined the lab because he was interested in Dr. Yao's research. John was very smart, fun to talk with, and hands-on in the lab. John's research project was very challenging, but he understood and did many things without Dr. Yao telling him what to do. Dr. Yao provided technical input when John asked him. John published two or three papers with Dr. Yao. John took six months off and did an internship in a federal agency, analyzing data, which strongly impacted his career choice.

John: Dr. Yao's Mentoring

Dr. Yao had an open door and was hands-off, flexible, and available. He would give general guidance on the science behind his research, but he wasn't an expert on John's project. John experienced trial and error in his project, and it was hard to find good advice. Dr. Yao connected him with people. They had biweekly meetings. He helped John with presentations. Dr. Yao had exciting research ideas and how to approach them. John felt energized at the end of their meetings, which enhanced his work and motivation. Their personalities were very compatible, and they always had easy discussions. John wished for more research direction at the beginning. He also wished Dr. Yao would connect him more aggressively with experts who could help with his project or with people who might help him with the job search.

Dr. Yao: Mentoring Quinn

Dr. Yao spent time with Quinn (international) to improve her English skills. Dr. Yao and Quinn spoke the same mother language. She spent much time in the lab, worked well, helped other junior members, and carried Dr. Yao's research lab. They published five papers together and became friends. She baked very well; sometimes, she would bake for Dr. Yao's kids' birthdays. Dr. Yao spent more time with Quinn conducting research than with Christian and John because he knew the research Quinn conducted exceptionally well.

Quinn: Dr. Yao's Mentoring

The most important strategies were communication, trust, frequent one-to-one meetings, and giving advice. When she experienced challenges, she trusted her mentor and asked him for help. He gave her positive feedback, encouraged her, and acknowledged her progress. Every year, once or twice, Dr. Yao organized gatherings for his team at his house. His guidance and mentoring were invaluable to her. Quinn wished they would talk more about how she should prepare for a career and possible career options.

Joshua: Dr. Yao's Mentoring

Note: Only Joshua's experience is narrated because he was interviewed only after Dr. Yao.

Dr. Yao gave Joshua (domestic) free space to explore, set up frequent check-ins and multiple weekly meetings to discuss research, class progress, personal stuff, and a list of to-do things. Joshua wanted to become a professor of undergraduate students. Dr. Yao supported this. They wrote grants as early as his first year. The writing and teaching skills prepared him for his career. They had similar personalities. Most of the challenges he encountered were related to research not working. Dr. Yao was a father figure to him and provided a nurturing relationship.

After graduation, Dr. Yao continued to text him about different grant opportunities or to serve on a review panel.

Appendix H

Dr. Powell, Gabriel, and Maria's Mentoring Experiences

Dr. Powell

Dr. Powell (domestic) believed a mentor should help mentees grow academically or personally and adapt to each student's needs. Growing the mentees into independent thinkers was a difficult process, as sometimes the doctoral students felt they needed to be told what to do. Dr. Powell felt a power differential exists between mentors and mentees, and mentors must be aware of it. He described Maria (international) and Gabriel (domestic, underrepresented) as some of his top and easier mentees he worked with.

Dr. Powell: Mentoring Gabriel

Gabriel was one the fastest doctoral students, driven, and had a difficult experience with his Master's advisor. Gabriel needed to know that he was valued and would have the opportunity to do the research he thought he should. Gabriel laid out tests, created good research questions, designed experiments, and worked diligently. Dr. Powell helped him develop his research and gain knowledge in the field. Gabriel felt that some of his coworkers treated him unfair due to his race. Dr. Powell provided support and helped Gabriel manage through the racial discrimination. He wished Gabriel had published more, but he moved quickly in the program and focused mostly on his dissertation. Dr. Powell felt frustrated with him, but at the end of the doctoral program, he learned that Gabriel had a learning disability in writing that he didn't disclose.

Gabriel: Dr. Powell's Mentoring

The most important mentoring strategies for Gabriel were trust, providing a foundation for the mentee to make mistakes and be able to correct them, and balancing a firm hand and a compassionate side. Dr. Powell provided tailored mentoring and was good at teaching Gabriel how to be independent. Gabriel was unfamiliar sometimes with the program and Dr. Powell taught him how to observe and manage the politics of the environment and how to respond externally. Also, Dr. Powell taught him to capitalize on the smaller things that added to a diversified portfolio. Dr. Powell provided a safe environment. He was hands-off, and sometimes Gabriel needed to find him to get help. Dr. Powell always asked him questions such as ‘What do you think?’ which Gabriel found challenging for his personality but gave him a strong foundation.

Dr. Powell: Mentoring Maria

Maria was organized, driven, and mature. As a lab manager, she made sure people got what they needed. Dr. Powell made sure she learned to say ‘no’ sometimes in a professional way to help and work with others constantly instead of focusing on getting her work done. She was willing to take on challenges while conducting her research. He made sure to keep encouraging her and to make her ask questions beyond the technical service aspect. He wished Maria had looked for a better transition plan after graduation and helped less other people so she could focus more on her next steps.

Maria: Dr. Powell’s Mentoring

Dr. Powell was hands-off. She had a trusted relationship with him. Dr. Powell always asked her, “How are you doing? How are you feeling? Are you okay?” He was also focused on Maria’s deep understanding of science. He would have deeper, honest conversations with Maria; she described him as a friend. Dr. Powell connected Maria with different science departments so she could extend her knowledge. Dr. Powell was a father-like figure and available. She wished she would have been more prepared during graduate school for the cultural differences in the workforce. She found the transition from university to job very tough, as she experienced racism in the male-dominated workforce.

Appendix I

Dr. Day, Thomas, and Musah's Mentoring Experiences

Dr. Day

Dr. Day was an energetic middle-aged professor who grew up in the U.S. She emphasized the relationship of mentoring and the importance of building trust. She believed each mentee was unique and, therefore, took time to understand their interests, strengths, and ways she could support them.

Dr. Day: Mentoring Thomas

Dr. Day knew Thomas from when he was doing undergraduate research during a summer program and felt they had a lot of shared experiences (swam, attended a small college, and grew up in the same town). She described Thomas as focused, goal-oriented, successful, and highly motivated. Thomas' dissertation focused on benchwork and education research. Thomas was sometimes burdened with too much assigned work but was willing to ask for what he needed, and Dr. Day supported this.

Thomas: Dr. Day's Mentoring

Dr. Day had high standards and was attentive and responsive to student's needs. She was a talented writer and connected him with other professionals in the field. They had weekly meetings. She worked with him on improving academic writing and taught him how to write grants. At times, Thomas was frustrated with the slow feedback. He wished for more career support, especially outside academia. The mentoring relationship with Dr. Day was reciprocal; not only Dr. Day provided support, but Thomas did also. He shared techniques with her and provided emotional support during COVID-19.

Dr. Day: Mentoring Musah

Musah had a tough time during COVID-19, as he could not return home to see his family. Dr. Day gave him space, provided personal support, changed his timeline, and encouraged connections with students and his faith community. She challenged him to improve his academic writing skills and gave him more feedback than other students. Musah did not always take her advice, but over time, she became more comfortable with his growing independence and allowed him to decide which edits to accept.

Musah: Dr. Day's Mentoring

Dr. Day was good at developing and conducting research. She gave him the independence to develop his project, which was studying the experiences of [Asian] international students as they transition to PhD programs. She spent much time with Musah and challenged him to improve his writing. Writing a manuscript took over one year; Dr. Day was nice, supportive, and encouraging, so Musah did not lose his confidence. She supported his religious practices and gave him time weekly to go to the worship place. She was a great mentor and gave him advice after graduation. Musah couldn't talk highly enough of her and was grateful for everything she did for him.

Appendix J

Dr. Brooks, Max, Amelia, and Antonia's Mentoring Experiences

Dr. Brooks

Dr. Brooks (domestic) highlighted that mentors must advocate for their mentees and help them see how their actions are connected to their goals and career and personal needs. She spent time with the mentees to get to know them and understand their motivations and goals. Mentoring should be tailored to each student. Clear and open communication of expectations, setting and resetting the expectations, frequency of meetings, what kinds of work the mentees should bring to the meetings, and what kind of connections the mentees expect were important in mentoring. The most efficient way to interact with mentees was around artifacts, as she could provide feedback and guidance. She was straightforward and wished to know more about the international students' educational context.

Dr. Brooks: Mentoring Max

Max (domestic) was one of her first PhD students. He was driven. Dr. Brooks gave Max opportunities to work and build skills in his research interest area and spent time working with him since she did not have many students at that time. She helped Max with research writing.

Max: Dr. Brooks' Mentoring

Dr. Brooks was hands-off. She had a lot of students, so the amount of one-on-one time was lower than average. Max was an older student, married, with a young child, and did not look for emotional support. Max felt he was a good match for Dr. Brooks' high-performing, sink-or-swim lab environment where there was not a lot of hand-holding and the self-driven and motivated students excelled. Dr. Brooks' lab was open, as she created an atmosphere where the students felt comfortable. The professor often hosted game nights at her house. She had funding for him; without it, he couldn’t have completed the program. Max found the amount of freedom convenient, but sometimes he needed help but couldn't get it. Max treated the PhD program like a job. He worked 12 hours daily in the lab, including Christmas. To him, if someone puts so much effort into something, it is hard to fail.

Dr. Brooks: Mentoring Amelia

She worked with Amelia (international) to help her learn analytic skills and build her confidence in research techniques. She gave her a lot of independence and freedom in her research. Amelia was ambitious and booked time to meet with Dr. Brooks every week, as her mentor advised. Dr. Brooks wished Amelia would have more publications, but she didn’t intend to have a career in academia.

Amelia: Dr. Brooks’ Mentoring

Dr. Brooks was hands-off, and that characteristic matched her personality well. She gave Amelia direction and trusted her to do things on her own. She was protective of her students and encouraged them. She was very busy, but they could communicate directly, transparently, and openly. Dr. Brooks had a strong interest in helping women succeed.

Dr. Brooks: Mentoring Antonia

Antonia (domestic) was highly interested in her research and very talented and organized, but she was less confident in her computing abilities than Amelia and Max. Antonia worked extremely hard, and Dr. Brooks encouraged her and gave her plenty of opportunities to engage with technology users. She wished Antonia would be more confident, have more publications, and attend conferences. Antonia did not want to become a professor.

Antonia: Dr. Brooks' Mentoring

A safe space tailored to the individual was essential to Antonia. Dr. Brooks tailored the mentoring strategies she used with Antonia, who had a learning disability in reading. Dr. Brooks wanted people to work on things they were passionate about and enjoy it so they could stay motivated. Dr. Brooks had 14 mentees, and she was sometimes overwhelmed. Antonia needed more assurance than others, and Dr. Brooks reassured her and gave her feedback. She was good at connecting Antonia with people, provided opportunities to attend conferences and mentor teachers and students, and gave her more time when needed. Dr. Brooks worked with her to practice presentations and review her papers. She was very good at flying by the seat of her pants, but Antonia didn't have a problem with it because that's how they were similar.

Appendix K

Survey Questions

In this survey, we ask you questions to help us better understand your experiences with your graduate mentor. By providing additional information about yourself, such as your major, enrollment and discipline, we will be able to uncover the role of demographic factors on your and other graduate students' experiences.
This survey should take you approximately 10 minutes or less.

Demographic characteristics

1. **My academic discipline is**
   Agriculture and/or Natural Resources
   Architecture
   Biological and/or Biomedical Sciences
   Computer and/or Information Sciences
   Engineering
   Geosciences, Atmospheric Sciences, and Ocean Sciences
   Health Professions
   Mathematics and/or Statistics
   Physical Sciences
   Other [Open response]

2. **The level of my graduate program is:**
   M.S. degree (thesis)
   Ph.D. degree (doctoral dissertation)
   Non-thesis degree program [these will be routed to a "Thank you. This survey is only intended for thesis and dissertation granting degrees."]

3. **My enrollment status is:**
   Part time
   Full time

4. **I am in this stage of my doctoral/master's program:**
   Early (beginning coursework)
   Middle (finishing coursework)
   Late (working on dissertation/thesis)

5. **What is your international status?**
   International
   My country of citizenship is__________ [Open response]
   Not international

Please consider your key graduate mentor as you respond to the following items.

For the next questions, please provide a response from the following 5-point Likert scale: strongly disagree, 1; disagree, 2; neither agree nor disagree, 3; agree, 4; strongly agree, 5.

[Career/Academic Support – not labeled on survey]

1. My mentor takes time to learn about my career goals.
2. My mentor is available when I need them.
3. My mentor works with me to set research goals.
4. My mentor helps me improve my scientific writing.
5. My mentor helps me write my research for publication.
6. My mentor helps me prepare to present my research.
7. My mentor provides opportunities for me to learn about grant proposal writing.
8. My mentor helps me secure the resources I need for academic success.
9. My mentor helps me develop professional relationships with others in the field.
10. My mentor provides useful information about various career paths inside academia.
11. My mentor provides useful information about various career paths outside academia.
12. My mentor provides guidance on career development.
13. My mentor challenges me to grow and develop professionally.
14. My mentor provides me with information about resources relevant to my work.
15. My mentor advocates for me when necessary.
16. My mentor has reasonable expectations for my workload.
17. My mentor gives me an appropriate level of independence.
18. My mentor provides the right amount of support.
19. My mentor keeps up with my development.
20. My mentor provides me timely feedback.
21. My mentor provides me useful feedback.

[Psychosocial Support – not labeled on survey]

1. My mentor is someone I trust.
2. My mentor is supportive of my personal identity.
3. My mentor serves as a role model for me.
4. My mentor cares about me as a whole person, not just as a researcher.
5. My mentor is friendly to me.
6. My mentor acts in my best interests.
7. My mentor is understanding of my needs as a graduate student.
8. My mentor and I communicate effectively.
9. My mentor works with me to set clear expectations on our mentoring relationship.
10. My mentor works with me to align our expectations on our mentoring relationship.
11. My mentor and I feel comfortable talking about things other than research.
12. My mentor encourages me.
13. My mentor motivates me.

14. **For how many years (approximately) have you been working with your mentor?**
    1 (or less)
    2
    3

4
5
6
7+

For the following items, focus on your perceptions of your progress in your graduate program.

[Outcomes – not labeled on survey]

1. I am productive in my research.
2. I am productive in my academic writing.
3. I am experiencing an acceptable level of stress.
4. I expect to achieve my masters/doctoral program milestones in a timely manner.
5. I expect to complete my thesis/ dissertation.
6. I expect to graduate.
7. I am building strong professional relationships.
8. I feel prepared for my career.
9. I expect to obtain a desired job.
10. I expect to achieve my career goals.

6. ***My gender identity is:***
Male
Female
Non-binary
Prefer to describe [Open response]

7. ***My racial identity is:***
American Indian or Alaskan Native
Asian
Black or African American
Hawaiian or Native Pacific Islander
Middle Eastern
Indian
White
Prefer to self-describe [Open response]

8. ***What is your ethnic identity?***
Hispanic or Latino/a
Not Hispanic or Latino/a
Prefer to self-describe [Open response]

[Open response]
Are there other things you would like to share about your mentoring experiences? Please, explain.