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Work in Progress: Design and Preliminary Results of a Survey to Explore Relationships Between Faculty Mentoring, Engineering Doctoral Student Psychological Safety, and Work Outcomes

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Abstract

A psychologically safe environment is characterized by people who feel safe to voice ideas and concerns, willingly seek feedback, have positive intentions to one another, engage in constructive confrontation, and feel safe to take risks and experiment (Edmondson, 1999). In academic research environments, faculty mentors have an influential role in cultivating a psychologically safe environment amongst their academic research teams. There is a need to better understand how faculty advisors can cultivate more inclusive, psychologically safe environments in which graduate students feel safe to engage in interpersonal risk-taking, especially in research settings. This project explores the relationships between faculty advisor mentoring and doctoral student psychological safety. We developed a survey consisting of three pre-existing scales, three newly developed scales, four open-ended questions, and demographics questions. Graduate students from two R1 institutions in the US who have been enrolled in their doctoral program for at least one year and currently have a doctoral research advisor were recruited to participate in the survey. This paper presents the design of the survey and preliminary survey results for two of the scales used in the survey. As the first part of a larger mixed-methods study, the survey responses provide insight into the education of graduate-level engineering students and how these doctoral students can be better supported.

Introduction

Faculty advisors are some of the most important people doctoral students interact with during their degree program [1]. They are not only responsible for helping students develop technically as researchers and academics, but they also serve as guiding figures for students' personal and professional development [1]. However, engineering faculty often receive minimal training in providing effective psychosocial support to their students. This can lead to poor research group climates, "chilly" environments for underrepresented groups, and an overall feeling of lack of belonging [2], [3]. These negative outcomes hinder graduate students' ability to meet their academic and professional demands, as well as contribute to the growing mental health crisis [2].

Creating more inclusive, psychologically safe environments in engineering disciplines is necessary to continue conducting innovative research. A psychologically safe environment is characterized by people who feel safe to voice ideas and concerns, willingly seek feedback, have positive intentions to one another, engage in constructive confrontation, and feel safe to take risks and experiment, all of which are inherently risky interpersonal behaviors [3]. Without psychologically safe environments, graduate students may feel discouraged from proposing and implementing innovative research projects.

This study is part of a larger research project seeking to understand psychological safety in the education of graduate engineering students and begin developing solutions that help create more inclusive, psychologically safe environments. This work describes survey results from two of the

pre-existing scales used from 469 engineering graduate students about their relationships with their advisors. The study's results, in combination with results from student interviews that will be conducted later, will help guide the development of strategies and interventions to help develop psychologically safe advising environments for doctoral students in engineering. Training engineering faculty in psychosocial mentoring competencies may help mitigate the negative outcomes that doctoral students are experiencing.

Background

Psychological Safety

Psychological safety has been conceptualized as "an individual's perceptions as to whether [they are] comfortable to show and employ [theirself] without fear of negative consequences to self-image, status, or career" [4]. Psychological safety is an individual perception, but often emerges as a shared belief amongst a team of people. Hence psychological safety has also been defined as the "shared belief held by team members that the team is safe for interpersonal risk-taking" [3].

Psychological safety has been recognized as important across the business world [5], though it has not been studied extensively in academic settings. There is considerable evidence that psychological safety in workplace settings comes with a wide range of benefits, including individual and group learning [6] - [8], individual and team performance [9], [10], creativity [11], [12], work engagement [13], [14], and knowledge-sharing [15] - [17]. Psychological safety has also been found to strongly correlate with innovation in Research and Development teams [18], [19], manufacturing process innovation performance [20], and knowledge creation [21], [22]. All of these positive outcomes align with key goals of doctoral research programs, suggesting that working to increase psychological safety in educational settings for graduate engineering students could lead to environments more conducive to learning and the production of innovative research.

A key predecessor of improved work outcomes through the development of psychological safety has been supportive leadership behaviors [23]. Faculty advisors take on a major leadership role in mentoring doctoral students and greatly impact whether psychological safety is established within their research groups and mentoring relationships. The extent to which a graduate student experiences psychological safety within their mentoring relationships and research groups will likely significantly influence their performance and experience in graduate school. Immersing doctoral engineering students in inclusive, psychologically safe environments that support learning is critical to their success.

Conservation of Resources

This study used the Conservation of Resources (COR) theory as a guiding framework to provide a holistic understanding of how psychological safety develops and influences workplace outcomes. COR theory explains how resources in the workplace (e.g., supportive leadership behaviors) influence the development of psychological safety [24]. Through resource investment and depletion, COR theory explains how psychological safety impacts work outcomes such as

stress, team conflict, team/individual performance/innovation/learning, and work attitudes. COR thus provides a framework to understand how psychological safety influences work outcomes [23].

Psychological safety has primarily been studied in professional work environments. A primary focus of this study is exploring how faculty mentorship impacts the psychological safety and work outcomes of doctoral students in this new context of graduate education. According to COR theory, individuals with access to greater resources are less vulnerable to resource depletion and are more capable of investing their available resources to gain further resources. In this context, it is predicted that supportive faculty mentorship is a critical resource that can support graduate students in obtaining more resources, enabling them to successfully meet their work demands. Graduate students who do not receive supportive mentorship have fewer resources available to meet work outcomes and are more susceptible to negative individual and team outcomes.

Purpose & Research Questions

The purpose of this study is to better understand psychological safety in graduate engineering research groups to develop strategies to better support graduate students in engineering. This study is situated in a larger mixed-methods project that includes both survey and interview data to create a holistic view of how doctoral advisors impact engineering doctoral students' psychological safety. This paper explores results from two of the survey subscales to begin to answer the following question: *What are the relationships between faculty advisor mentoring, doctoral student psychological safety, and the subsequent positive and negative outcomes for doctoral students?*

Methods

Data Collection

Researchers developed a survey consisting of pre-existing scales, a newly developed scale, open-ended questions, and demographic questions. The three pre-existing scales included were: dyadic psychological safety [25], team psychological safety [3], and mentoring competency [26]. Minor adaptations were made to the existing scales to include additional questions related to the topic or to omit items that were less relevant to the graduate student environment. Three scales, mental health and well-being [27], job stress and well-being [28], [29], and psychological safety and work outcomes [30], [31] were developed by researchers with inspiration from other previously developed items and definitions. Table 1 in Appendix A includes the scales, number of questions included, and examples of questions that were asked within that scale. Demographic questions are included in Table 2 in Appendix A.

Five open-ended questions were also included to allow participants to expand upon previous answers and provide additional insights into their relationships with their advisor(s). The questions are included in Table 3 in Appendix A.

The survey was reviewed by a group of graduate students outside of the participant pool across multiple institutions and by our grant's external advisory board. The survey was revised based on feedback to improve clarity and ensure the appropriateness of selected subscales. Once responses to the recommendations from the external feedback sources were implemented, the final survey was administered via Qualtrics and was made available to participants for four weeks. The researchers' Institutional Review Boards approved this study (HUM00230743, #23-901).

Participants

The survey was completed by 469 graduate students from two R1 institutions. Participants were recruited by word of mouth and targeted emails distributed by the institutions. Emails invited students to share about their experiences with their advisors. A $20 gift card was provided as an incentive for completing the survey. Participants were all engineering PhD students who had completed at least one year of graduate school toward their PhD and had a faculty research advisor. Participants' ages had a range of approximately 30 years and an average of approximately 27 years. The number of years each participant had spent so far in their PhD program ranged from 1 year to 9 years, with an average of 3 years. Over half of participants identified as men. Over 40% of participants identified as white and 29.2% as Asian. Less than 6% of participants identified as Hispanic or of Latin origin. Over 38% of participants were international students, and just under 14% of participants identified as first-generation college students. Full participant demographics, including gender, race and ethnicity, enrollment status, and first-generation college student status, are included in Tables 4-8 in Appendix B.

Results

The median survey completion time was almost 18 minutes. Descriptive statistics for responses to two of the scales used in the survey, Mentoring Competency and Dyadic Psychological Safety, are included here.

Mentoring Competency Assessment

The adapted Mentoring Competency Assessment (MCA) used in the survey included 26 questions about how skilled the participant felt their advisors were in different mentorship areas. Responses were given on a Likert-style scale from 1, not at all skilled, to 7, extremely skilled. Participants were asked to only use the "not observed" category for cases where they had no basis for assessment. Table 9 in Appendix C includes each mentorship skill asked about and descriptive statistics for participant responses. Some of the items that participants were asked to rate their advisor on included coordinating effectively with other mentors with whom you work and accurately estimating your ability to conduct research. Figure 1 shows boxplots for responses to each question.

Average responses to all items varied from 4.46 to 5.64. Standard deviations for each item varied from 1.45 to 1.88. Items with lower average response scores tended to have a larger deviation. Median responses tended to be greater than the average. Half of the items had modes of 7, indicating that a large number of participants responded that their advisor(s) were "extremely skilled" in these areas.
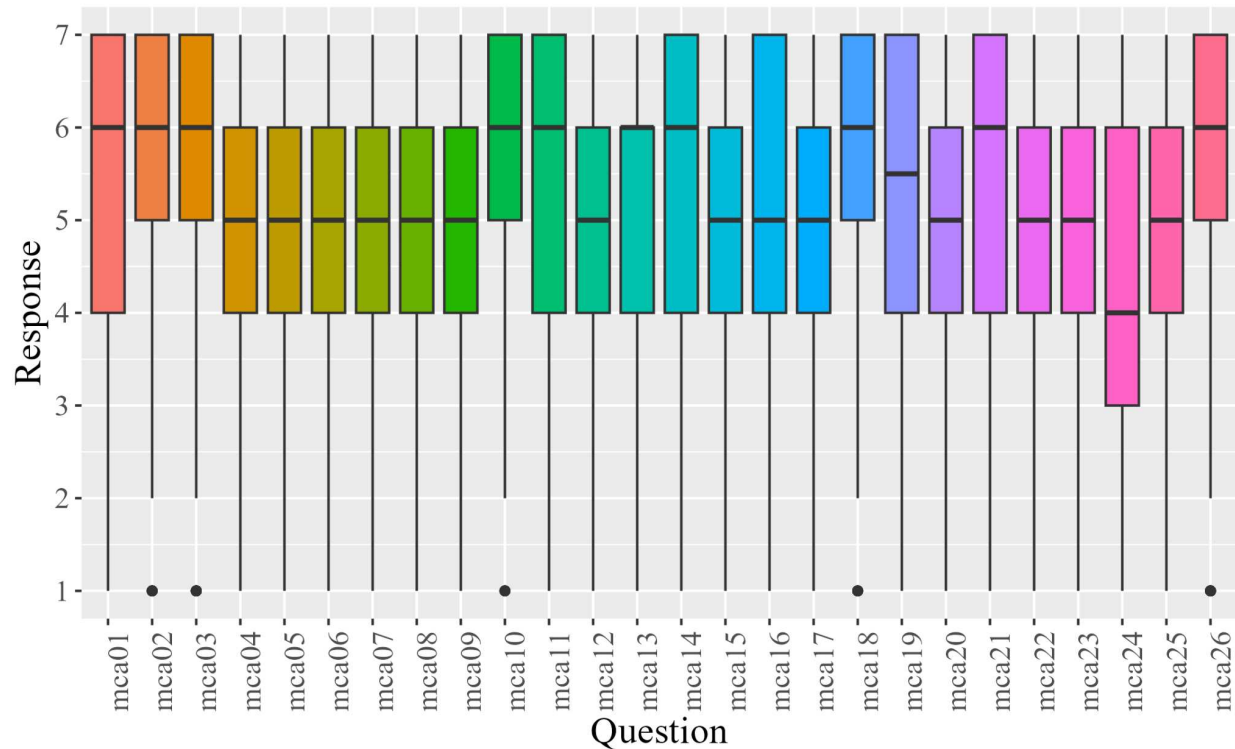
Figure 1. Boxplots showing responses across all participants to each question asked in the Mentoring Competency subscale. All full items are included in Appendix C.

Dyadic Psychological Safety Scale

The adapted Dyadic Psychological Safety Scale used in the survey included 17 statements about how participants felt about their relationship with their advisor. Responses were given on a Likert-style scale from 1, not at all true, to 9, very true. Table 10 in Appendix C includes each statement asked about and the average, standard deviation, median, and mode for participant responses. Some of the items that participants were asked to rate their relationship with their advisor included "My research advisor is interested in me as a person," and "I feel like my research advisor makes decisions for my best interests,". Figure 2 shows boxplots for responses to each statement.

Average responses for all forward-worded items varied from 5.56 to 7.12. Average responses for reverse-worded items varied from 3.86 to 4.36. Standard deviations for each item varied from 1.80 to 2.52. Median responses tended to be less than the average response for reverse-worded questions. The opposite was true for all other items. More than half of the forward-worded items had modes of 9, indicating that a large number of participants responded that the statements were "very true" for their advisor(s).
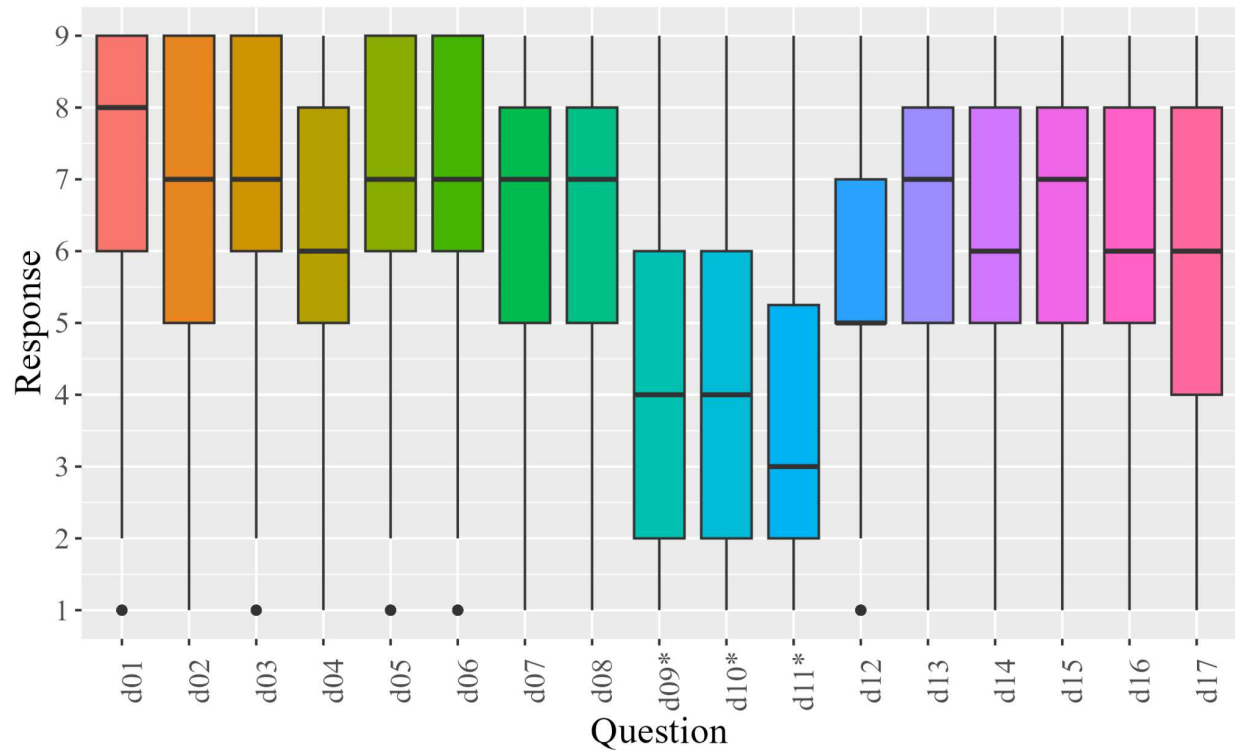
Figure 2. Boxplots showing responses across all participants to each statement asked about in the Dyadic Psychological Safety subscale. Starred items are reverse-worded questions plotted as the raw result. All full items are included in Appendix C.

Discussion

Results from the initial analysis of the first two survey subscales provide early evidence of students' psychological safety in doctoral advising relationships. More in depth analyses of these relationships will be presented in a future paper.

The MCA looked specifically at doctoral advisors' skills when supporting their graduate students. Items that received lower average scores focused on mentoring skills related to communication, coordination, personal relationships, and career planning. This was reflected in the open-response questions, where participants frequently cited these areas as problems or points of stress in their relationships with their advisor(s). Items that received higher average scores focused on research skill building, resource acquisition, feedback, and trust. These areas tend towards some of the more technical aspects of mentoring that advising requires, which engineering doctoral advisors may feel more comfortable with. For example, setting research goals with students may come more naturally for faculty members than helping students prepare for a career outside of academia.

The dyadic psychological safety subscale provided insight into how students feel about their interactions with their advisor(s). When flipped, the reverse-worded questions had the lowest average scores of all items. These items were focused on participants' feelings about challenging their advisors and protecting their feelings. These feelings of fear around damaging their

relationship or standing up to an advisor were frequently cited in responses to the open-ended question about self-advocacy. It seems that students may be fearful of "rocking the boat" and may not possess the psychological safety necessary to self-advocate for themselves in certain situations. The items that received higher average scores referenced advisor intentions, trust, respect, and care. This indicates that doctoral students feel that their advisor(s) are not trying to harm them, and are acting in a way that prioritizes the student as a researcher and a person. It seems like student relationships with their advisor(s) are founded on trust and respect.

These results suggest future opportunities to deeply explore the experiences of doctoral engineering students and identify patterns that may emerge. Engaging with the lived experiences of doctoral students will help guide the development and creation of faculty mentoring resources that will allow these students to thrive.

Limitations & Future Work

A primary limitation of this study is the data collection setting. This study was conducted at two R1 institutions, which means the results likely do not encompass all doctoral student experiences. This work-in-progress paper presented descriptive results from two subscales used in the survey. Future work will include additional analysis of all subscales and the impact of demographic variables, as well as coding of open-response questions. Additionally, interviews with participants will be conducted to offer additional insights into the survey results.

Conclusions

The psychological safety framework provides an opportunity to understand more about the doctoral engineering student experience. The initial survey described here lays a foundation for future studies to help better understand the impact of psychological safety on graduate students in engineering disciplines. The results showed a wide range of experiences with a few key areas in which participants more frequently felt unsupported, providing an opportunity for greater support in these areas through faculty mentorship. Examining both positive and negative student experiences in these areas will allow for the development of mentoring systems to best support the development of graduate student psychological safety in engineering disciplines.

The ultimate goal of this work is to develop a better understanding of graduate student psychological safety in engineering. Supporting engineering doctoral students throughout their graduate careers will not only benefit them personally and professionally, but will impact the future of engineering education for years to come.

Acknowledgments

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Appendix A: Survey Questions

Table 1. Example questions for each scale included in the survey.

Scale	Number of Questions	Example Question	Response Type
Dyadic Psychological Safety [25]	17	Rate to what extent the following statements are true for you: I feel like my research advisor makes decisions for my best interests.	Likert 1-9
Team Psychological Safety [3]	7	Please rate the extent to which you agree with the following statements as they relate to your primary research group: It is safe to take a risk in my research group.	Likert 1-7
Mentoring Competency [26]	26	Please rate how skilled you feel your primary research advisor is in each of the following areas. We understand that you can only speak from your personal experience. Please try to rate a skill whenever possible, reserving the 'not observed' category for cases where you have no basis for assessment: Working with you to set clear expectations of the mentoring relationship	Likert 1-7
Mental Health & Well-Being [27]	6	Please rate the extent to which you agree or disagree with the following statements regarding your overall PhD experience. Mental health is a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community: I feel comfortable discussing my mental health with my research advisor in my PhD.	Likert 1-6
Job Stress [28], [29]	2	Overall, based on your definition of stress, how would you rate your level of overall stress related to the process of getting your PhD?	Likert 1-5
Psychological Safety & Work Outcomes [30], [31]	11	Psychological safety is the extent to which people feel safe to be themselves and express their thoughts, feelings, and ideas without fear of negative consequences, rejection, or humiliation. Please indicate to what extent your psychological safety with your primary research advisor impacts the following outcomes: The quality of my research work	Likert 1-5

Table 2. Demographics questions included in the survey.

Demographic Category	Demographic	Question	Question Type
Advisor	Gender	What is the gender of your main doctoral advisor?	Multiple select; write in option
	Hispanic/Latinx Identity	Does your main doctoral advisor identify as Hispanic, Latino, or Spanish Origin?	Multiple choice
	Race/Ethnicity	What is the racial or ethnic identification of your main doctoral advisor?	Multiple select; write in option
Participant	Field	Which PhD program are you in?	Write in
	Years Enrolled in PhD Program	How many years have you been enrolled in this PhD program?	Numerical write in
	Program Stage	What is your stage of PhD program?	Multiple select
	Enrollment Status	What is your enrollment status?	Multiple choice
	Gender	To which gender identities do you most identify?	Multiple select; write in option
	Age	What is your age?	Numerical write in
	LGBTQ+ Identity	Do you consider yourself to be a member of the LGBTQ+ community?	Multiple choice
	Disability Status	Do you identify as having a disability?	Multiple choice
	Neurodivergent Status	Do you identify as neurodivergent?	Multiple choice
	Household	Which of these people live with you in your household?	Multiple select; write in option
	Hispanic/Latinx Identity	Do you identify as Hispanic, Latino, or Spanish origin?	Multiple choice
	Race/Ethnicity	What is your racial or ethnic identification?	Multiple select; write in option

		Describe the highest level of education obtained by a parent/guardian (if applicable).	Multiple choice; write in option
	Parent/Guardian Education	Describe the highest level of education obtained by a second parent/guardian (if applicable).	
	First Generation College Student Status	Are you a first-generation college student, meaning that none of your parent/s or guardian/s completed a 4-year college or university degree?	Multiple choice
	Financial Security	Please rate your agreement with the following statement: "In the past year, I have felt financially insecure".	Likert, 1-5
	English as a First Language	Is English your first language?	Y/N

Table 3. Open-ended survey questions.

If you had a magic wand and could change one thing to help you feel more psychologically safe (safe to express your thoughts, etc. without fear) with your PhD advisor(s), what would you change?
Describe an experience when your PhD advisor(s) positively impacted your psychological safety (ability to express thoughts without fear) in your research relationships.
Describe an experience when your PhD advisor(s) negatively impacted your psychological safety (ability to express thoughts without fear) in your research relationships.
When have you been able or unable to advocate for yourself and feel heard when you discuss concerns with your advisor?
Is there something else you want to share?

Appendix B: Demographics

Table 4. Participant gender identity counts and percents.

Participant Gender		
	Count	Percent
Agender	3	0.64
Gender Non-Conforming	3	0.64
Man	240	51.1
Non-Binary	6	1.28
Woman	169	36.0
Prefer Not to Answer or N/A	56	11.9

Participants were allowed to select multiple gender identities that best represented them. Percentages will not sum to 100 because of this.

Table 5. Participant racial/ethnic identity counts and percents.

Participant Race/Ethnicity		
	Count	Percent
Asian	137	29.2
Black or African American	21	4.48
Indian Subcontinent	42	8.96
Middle Eastern or North African	17	3.62
Native American/Native Hawaiian or Pacific Islander	4	0.85
White	189	40.3
Prefer Not to Answer or N/A	86	18.3

Participants were allowed to select multiple racial/ethnic identities that best represented them. Percentages will not sum to 100 because of this.

Table 6. Participant Hispanic/Latinx identity counts and percents.

Participant Hispanic/Latinx Identity		
	Count	Percent
Yes	28	5.97
No	389	82.9
Prefer not to Answer or N/A	52	11.1

Table 7. Participant enrollment status counts and percents.

Participant Enrollment Status		
	Count	Percent
In-State	81	17.3
Out of State	153	32.6
International	180	38.4
Prefer not to Answer or N/A	55	11.7

Table 8. Participant first-generation college student counts and percents.

Participant First Gen Status		
	Count	Percent
First-Generation College Student	65	13.9
Not a First-Generation College Student	346	73.8
Prefer not to Answer or N/A	58	12.4

Appendix C: Full Descriptive Statistic Results

Table 9. Descriptive statistics for the Mentoring Competency Scale participant responses.

Identifier	Mentoring Skill	Average	Standard Deviation	Median	Mode
mca1	Active listening	5.25	1.61	6	7
mca2	Providing you constructive feedback	5.56	1.52	6	7
mca3	Establishing a relationship based on trust with you	5.52	1.61	6	7
mca4	Identifying and accommodating different communication styles	4.95	1.67	5	6
mca5	Employing strategies to improve communication with you	4.84	1.71	5	6
mca6	Coordinating effectively with other mentors with whom you work	4.91	1.73	5	7
mca7	Working with you to set clear expectations of the mentoring relationship	5.00	1.73	5	6
mca8	Aligning their expectations with your own	5.02	1.61	5	6
mca9	Considering how personal and professional differences may impact expectations	4.93	1.69	5	6
mca10	Working with you to set research goals	5.50	1.51	6	7
mca11	Helping you develop strategies to meet research goals	5.32	1.60	6	7
mca12	Accurately estimating your level of discipline-specific knowledge	5.16	1.51	5	6
mca13	Accurately estimating your ability to conduct research	5.31	1.45	6	6
mca14	Employing strategies to enhance your understanding of the research	5.22	1.64	6	7

mca15	Motivating you	5.09	1.67	5	6
mca16	Building your confidence	4.97	1.78	5	7
mca17	Stimulating your creativity	5.02	1.64	5	6
mca18	Acknowledging your professional contributions	5.57	1.51	6	7
mca19	Negotiating a path to professional independence with you	5.21	1.59	5.5	7
mca20	Taking into account the biases and prejudices they bring to your mentor/mentee relationship	4.58	1.73	5	4
mca21	Working effectively with mentees whose personal background is different from their own (age, race, gender, class, region, culture, religion, family composition, etc.)	5.31	1.53	6	7
mca22	Helping you network effectively	4.85	1.76	5	7
mca23	Helping you set career goals	4.81	1.76	5	5
mca24	Helping you balance work with your personal life	4.46	1.88	4	4
mca25	Understanding their impact as a role model for you	4.83	1.76	5	6
mca26	Helping you acquire resources (e.g. grants, etc.)	5.64	1.58	6	7

Table 10. Descriptive statistics for the Dyadic Psychological Safety Scale participant responses.

Identifier	Statement	Average	Standard Deviation	Median	Mode
d1	My research advisor has the best intentions toward me.	7.12	2.01	8	9
d2	My research advisor really cares about me.	6.80	2.13	7	9
d3	My research advisor respects my abilities.	6.92	1.94	7	9
d4	My research advisor is interested in me as a person.	6.14	2.32	6	9
d5	I trust my research advisor.	6.87	2.17	7	9
d6	My research advisor would go to bat for me (defend my interests; support me).	6.89	2.11	7	9
d7	I feel like my research advisor makes decisions for my best interests.	6.46	2.17	7	9
d8	My research advisor wants others to support his/her/their ideas.	6.42	1.80	7	5
d9*	At some level I felt I had to tiptoe around my research advisor's feelings.*	4.36	2.46	4	1
d10*	My research advisor will get annoyed at some level if challenged.*	3.95	2.27	4	3
d11*	At some level I feel like my research advisor would be unhappy if I disagreed with him/her/them.*	3.86	2.33	3	2
d12	My research advisor has centered my goals.	5.56	1.92	5	5
d13	My research advisor has helped me meet my goals.	6.32	1.99	7	7
d14	My research advisor solicits my	6.05	2.19	6	6

	feedback.				
d15	I feel safe to be honest with my research advisor.	6.38	2.24	7	9
d16	My research advisor handles interpersonal conflict well.	5.84	2.39	6	5
d17	I admire how my research advisor navigates interpersonal relationships.	5.66	2.52	6	9

The three starred items are reverse-worded from the other items.