Facilitating Engineering Faculty Success: Faculty Development of Graduate Mentoring Practices

Himani Sharma, Arizona State University
Miss Amanda Marie Singer, The Ohio State University

Amanda Singer is a second-year Ph.D. student in the Department of Engineering Education at The Ohio State University. She graduated in 2021 from Michigan Tech with a Bachelor's and Master's of Science in Environmental Engineering. Her current research interests include engineering identity formation, community college engineering education, and mixed methods research.

Dr. Mayra S. Artiles, Arizona State University

Mayra S. Artiles is an assistant professor in engineering at the Polytechnic School of the Ira A. Fulton Schools of Engineering at Arizona State University. Her research expertise includes engineering doctoral education structure, experiences of underrepresented students in doctoral engineering programs.

Dr. Rachel Louis Kajfez, The Ohio State University

Dr. Rachel Louis Kajfez is an Associate Professor in the Department of Engineering Education at The Ohio State University. She earned her B.S. and M.S. degrees in Civil Engineering from Ohio State and earned her Ph.D. in Engineering Education from Virginia Tech. Her research interests focus on the intersection between motivation and identity, first-year engineering programs, mixed methods research, and innovative approaches to teaching. She is the principal investigator for the Research on Identity and Motivation in Engineering (RIME) Collaborative.

Dr. Holly M. Matusovich, Virginia Polytechnic Institute and State University

Dr. Holly Matusovich is the Associate Dean for Graduate and Professional Studies in the College of Engineering at Virginia Tech and a Professor in the Department of Engineering Education where she has also served in key leadership positions. Dr. Matusovich is recognized for her research and leadership related to graduate student mentoring and faculty development. She won the Hokie Supervisor Spotlight Award in 2014, received the College of Engineering Graduate Student Mentor Award in 2018, and was inducted into the Virginia Tech Academy of Faculty Leadership in 2020. Dr. Matusovich has been a PI/Co-PI on 19 funded research projects including the NSF CAREER Award, with her share of funding being nearly $3 million. She has co-authored 2 book chapters, 34 journal publications, and more than 80 conference papers. She is recognized for her research and teaching, including Dean's Awards for Outstanding New Faculty, Outstanding Teacher Award, and a Faculty Fellow. Dr. Matusovich has served the Educational Research and Methods (ERM) division of ASEE in many capacities over the past 10+ years including serving as Chair from 2017-2019. Dr. Matusovich is currently the Editor-in-Chief of the journal, Advances in Engineering Education and she serves on the ASEE committee for Scholarly Publications.

Facilitating Engineering Faculty Advising Success: Faculty Development of Graduate Advising Practices

Abstract

Establishing a positive advising relationship between faculty and doctoral students is a time-consuming and often unacknowledged effort. Previous research has primarily focused on improving student success or faculty productivity, with little attention to the factors that promote or hinder the adoption of student-centered advising practices. We developed a four-part workshop series, "Facilitating Engineering Faculty Advising Success," to improve advising practices for chemical engineering faculty and provide guidance for the successful mentoring of graduate students. The workshops aim to elicit reflections and encourage discussions among faculty to identify their beliefs about mentoring, explore how they align their mentoring practices with their research agenda, and how they define success for their students. This paper describes the development and implementation of the first workshop in the series “Facilitating Engineering Faculty Advising Success: Effective Strategies for Mentoring Graduate Students,” which was offered during the Fall 2022 semester. Emergent themes from participant contributions during this workshop highlighted collective difficulties in navigating and setting appropriate expectations for graduate students, addressing differences in perspective and goals, managing self-doubt as an advisor, and tackling problems outside the traditional roles of a graduate advisor.

Introduction

Cultivating a strong graduate advising relationship is essential for the success and growth of both the graduate student and faculty advisor. Various research studies have demonstrated the importance of strong advising relationships for graduate students, both generally [1, 2] and as a strong predictor for degree completion [3, 4], degree satisfaction [5-6], and career attainment [3, 4]. Similarly, faculty advisors report several benefits from engaging in graduate student advising, including increased research productivity [7], a heightened sense of fulfillment and satisfaction in one’s career, and some minimal external incentives [8]. The importance of fostering this relationship is especially pronounced in graduate science, math, and engineering programs that follow the science advising model [6], where students and faculty work in close partnership and share research responsibilities.

Despite the positive outcomes that these partnerships may afford, establishing positive and mutually beneficial graduate advising relationships requires substantial time and is often hindered by numerous factors [9, 10]. One significant barrier is the lack of recognition and reward for advising in traditional faculty evaluations, which tend to focus on research and teaching activities [9]. Traditional faculty evaluations that prioritize research and teaching activities create an environment where faculty members do not feel motivated to invest their already limited time and energy into advising, thus causing them to view it as more of a service activity than a crucial aspect of their role as educators [10]. Prior research suggests that faculty members are more likely to engage in advising when they see it as an important aspect of their role and when they have opportunities to connect with students in meaningful ways [11]. Additionally, factors such as limited resources or support from the institution, high student-to-

faculty ratios, poor institutional policies, and a lack of understanding of expected advising practices can also hinder the development of effective advising relationships [12].

Although significant research has explored faculty experiences within the advising relationship and the obstacles that prevent engagement in advising, little research discusses the supports that promote and the barriers that prevent faculty from developing and adopting student- centered [13, 14] advising practices that meet both student and faculty members' personal needs. Research on graduate advising has typically taken a unilateral approach, focusing either explicitly on the promotion of student success outcomes [15-19] or faculty productivity [20-22]. Little work has focused on leveraging advising as a mutually beneficial activity that can create value for both faculty and students. To breach this disconnect, support faculty in developing advising relationships that are mutually valuable, and create an environment that engages faculty in conversations about graduate advising, we developed "Facilitating Engineering Faculty Advising Success," a four-part workshop series for chemical engineering faculty which is framed by the 3Cs (connections, curiosity, and creating value) of the Entrepreneurial Mindset (EM) [23] and the goals of the Mentorship 360 initiative [24]. This series was specifically developed to engage faculty in conversation about their advising experiences and to elicit faculty beliefs about effective advising strategies. This paper provides an overview of the development and implementation of the first workshop session, "Effective Strategies for Mentoring Graduate Students," which consisted of interactive activities that were designed to promote discussion and reflection on faculty advising practices and identify challenges that faculty face when advising graduate students.

Prior Research on Advising Relationships

The advising relationship plays a critical role in doctoral student's successful completion of doctoral degrees. Empirical evidence has historically demonstrated a strong correlation between positive advising relationships and degree completion [6, 25-28]. The advisor plays a vital role in guiding the student through the program's requirements, aiding the development of research skills, and facilitating the student's integration into the professional community of their field [17, 29-33]. This fact emphasizes the need for a deeper understanding of the formation and development of advising relationships, particularly within the STEM fields [6, 34, 35].

Advising relationships in STEM, particularly those in engineering, are distinct from other disciplines as the advisor not only acts as a teacher but also as a colleague, supervisor, and co-author [6, 18]. This unique nature of advising relationship often results in a higher degree of interaction between students and faculty, particularly within research groups, where students are socialized into the broader community of their discipline. In engineering, the selection of an advisor is often accompanied by a choice of research group, leading to the development of unique mentoring structures that require advisors to offer mentorship, networking opportunities, and guidance [36-38]. While research has investigated the dynamics of the advising relationship, little attention has been paid to the faculty perspectives in advising [13] or more, specifically, advising practices that engineering faculty employ to support their students' academic growth. A more comprehensive understanding of this unique nature of engineering advising relationships is critical in ensuring mutual success. Through this work, we examine these practices and thus hope

to identify opportunities for mutual benefit to both the student and the faculty, ultimately leading to greater overall academic success.

Program Description

In the engineering education ecosystem, the Kern Entrepreneurial Engineering Network (KEEN) is an organization dedicated to cultivating an Entrepreneurial Mindset (EM) among engineering faculty and students [23]. KEEN includes over 50 universities that are working to instill an EM across the engineering enterprise. KEEN defines an EM through the 3Cs, which include curiosity, connections, and creating value [23]. The workshop series is framed using EM to support faculty advising practices, prompting faculty to consider how they can adapt their advising to create value for themselves and their students, be curious about their research and their students, and aid in building connections for all in their research groups or lab. As such, the aim of the workshop was not to develop an EM within the faculty or their students. The aim was to frame advising using the 3Cs.

Mentorship 360, a multi-university initiative that includes members of KEEN, seeks to improve the mentorship of engineering faculty through the creation of research, frameworks, and resources informed by the EM [24]. The initiative outlines three overarching themes about the goals of their work, which include (1) **instigating** the advancement of faculty mentorship, (2) **connecting** faculty to share professional development opportunities, and (3) **contributing** to the knowledge base about faculty mentorship related to EM. Our work developing and administering these workshops connects to the themes outlined by Mentorship 360 by (1) instigating faculty mentorship by using the 3Cs as a framing for the way faculty view the faculty/student advising relationship, (2) connecting faculty across national universities to build and share experiences around advising and (3) contributing to the knowledge base of effective faculty mentorship.

To identify faculty beliefs regarding effective doctoral advising practices and provide an outlet for practical guidance and support for graduate advisors, we developed a four-part workshop series: Facilitating Engineering Faculty Advising Success (FEFAS) for Chemical Engineering Faculty. We chose to center the workshop series on advising practices in a single engineering discipline as prior studies reflect that faculty approaches to advising are largely shaped by the cultures and practices of individual departments and disciplines [39]. We chose chemical engineering specifically, as prior work by one of the members of our team showed the chemical engineering doctoral programs tend to have the most uniform and structured advising selection process across engineering, simultaneously providing an evidence-based foundation for the context of how these faculty's advising relationships formed and a uniform language around advisor selection for each workshop [13, 40]. The workshop series, which included sessions about effectively identifying, onboarding, and mentoring graduate students and setting students up for success after the Ph.D., was developed to align with the traditional advising cycle. The workshops were intentionally offered throughout the 2022-2023 academic year at times in which the topic of the workshop coincided with timely advising activities. For example, the second workshop in the series, "Effective Strategies for Identifying the Right Graduate Students" was facilitated during the month of November to align with the traditional timing of departmental recruitment activities and graduate application deadlines. Thus, participants engaging in the workshop would either be actively involved in the student identification process or have recently

completed it. The workshop series was designed to promote discussion and reflection on advising experiences, engage faculty participants in conversations about their own experiences as graduate advisors, and elicit their beliefs and motivations pertaining to effective advising practices.

Workshop #1: Effective Strategies for Mentoring Graduate Students

The first session in the workshop series, "Effective Strategies for Mentoring Graduate Students," was held virtually during the Fall 2022 semester and was designed as an open environment in which everyone could engage in dialogue, share their experiences regarding advising, and gain insight from the collective group. The workshop session introduced faculty participants to scaffolded mentoring practices [41] and the different stages of graduate student development [6, 42]. Through several discussion-based activities, this workshop also provided participants with opportunities to be curious about their current mentoring practices and evaluate if these practices effectively created value for students against personal, programmatic, and departmental expectations and measures of success. Thus, the workshop content and activities aimed to elicit faculty discussions pertaining to best practices in graduate advising as well as provide a chance for faculty advisors to share their experiences of advising graduate students, including both successes and challenges, to build connections.

The workshop session was advertised nationally via email within chemical engineering programs across U.S. universities. Seven faculty members with varying backgrounds and advising experiences were selected for the first session to account for the diverse nature of advising practices and experiences as well as capture the complex interactions of gender and race/ethnicity in student-advisor interactions [43, 44]. We intentionally selected a group of participants that were early in their professional careers, targeting faculty advisors that were of assistant and associate standing. Due to the small nature of the field, participant demographics will not be disclosed to protect the identities of the chemical engineering faculty participants.

The workshop session was facilitated by three faculty members in the field of engineering education, who all have researched graduate students, graduate advising relationships, and faculty motivation as well as have their own experience of advising graduate students. Their research background and practical experience added elements of research-based strategies to the information being disseminated and empathy to the faculty in the conversation from a practice angle. Two graduate students also assisted in the facilitation and were able to provide insights from their experiences as current students.

Research Methods

Alongside the practical goal of providing a space to discuss successes and challenges in graduate advising, we also utilized the workshop session as an unstructured focus group to conduct research to uncover faculty beliefs about effective advising practices and challenges. As such, participation in the first workshop session was contingent upon agreement and consent to engage in the associated research activities which included completion of pre- and post- workshop surveys, recording of the workshop conversations, and submission of a current CV. Multiple methods, including qualitative analysis and statistical analytic approaches, were used to identify

patterns within the data collected from the workshop series. However, this paper focuses on exploring salient themes that emerged from the first workshop session, and as a result, a full discussion of overall project methods is outside the scope of this paper. Table 1 provides an overview of demographic information for participants of the first workshop. All seven of the participants were faculty at R1 institutions.

Table 1: Faculty Participant Demographics

Category	No. of Participants
Title	
Assistant	4
Associate	3
Gender (Self-Identified)	
Female	5
Male	2
Race/Ethnicity	
African American /Black	1
Asian/Pacific Islander	1
Caucasian	5
No. of Years at Current Position	
1-3 years	3
4-6 years	1
7-9 years	2
10+ years	1
Primary Work Modality	
Bench Science	3
Computational	3
Experimental & Bench Science	1

The recording of the first workshop session was transcribed and analyzed to identify emergent themes within participant conversations. This high-level analysis focused on identifying recurring issues and concerns raised by participants and clustering them into related themes. This allowed for a better understanding of the main topics of discussion that were discussed at the workshop session. All aspects of the research followed approved IRB procedures.

Findings

Discussions from the first workshop session, Effective Strategies for Mentoring Graduate Students, illuminated several salient themes amongst faculty discussions and reflections about effective graduate student mentoring practices. By being curious about their students and the advising relationship, faculty contributions highlighted collective difficulties about (1) navigating and setting appropriate expectations for graduate students, (2) navigating differences in perspectives and goals, (3) managing problems outside the traditional role(s) of a graduate advisor, and self-doubt. In addition to reflecting on their individual and collective difficulties with these situations, faculty participants discussed their advice for tackling these problems, citing the steps that they or their colleagues facing similar difficulties have taken to successfully

navigate and address these situations. The following paragraphs explore these salient themes in greater detail.

Setting Appropriate Expectations for Graduate Students

Participants discussed the difficulties of setting appropriate expectations for graduate students related to research tasks and degree progress. The following quote from one of our participants illustrates these struggles.

> *"I do a mentoring compact with my students which is pretty informal, I guess, in terms of expectations... there is nothing in there about graduation or what it takes to defend their thesis. It is all about "how do we communicate" and "what should you be doing throughout the year in terms of applying to funding and publishing" ... maybe it is worth re-looking at."*

The difficulties captured within these quotes were common across the participants and align with findings that emerge in the existing literature. In their 2012 work, Bloom and Jordan [45] explore several difficulties that faculty face when setting expectations for their graduate students. These difficulties include balancing academic rigor and student well-being, communicating expectations clearly and effectively, recognizing the limited availability of resources (time, funding, equipment), and maintaining a positive and productive advising relationship. To truly create value within the advising relationship, faculty must work to balance student expectations and needs related to degree progress with research tasks. An appropriate balance will allow both parties to benefit from the advising relationship.

Navigating Differences in Perspectives and Goals

Faculty participants also described challenges in navigating differences in perspectives and goals amongst themselves and their graduate students. This theme was especially salient during one of the workshop activities when participants were discussing how one would navigate a situation in which the advisor suggests a new research approach to the graduate student. In this situation, the student does not want to investigate this new approach as it would potentially add additional time to their degree. In this discussion, one participant suggests:

> "*Sometimes it's hard for us to tell the students what to do because they almost read it as if it's their parent telling them what to do. Maybe it would be a good idea to bring some of their committee in or other faculty who are kind of adjacent… and just say "why don't you go get some feedback on where you're at." From a personal standpoint… I would hope they would realize it's not just me… having high standards like that. This is something that's ... of the community's expectations too."*

Responding to this, another faculty member adds:

> *"I would certainly go for the… committee first… another way to think about this is… if they want to progress in a different direction of the project. Sometimes, if there's enough bandwidth, and this is student dependent, I've let them do both… There are some students that I would never suggest [this] just based on bandwidth capabilities. And so, it will be*

depending on what I think that student can handle and where their frustration is coming from."

These quotes illustrate two different strategies for addressing a situation in which student and faculty perspectives do not match. Both participants agree that leveraging the student's dissertation committee as an outside perspective would be beneficial in encouraging the student to be more curious in their work and not limited to only one approach. However, one participant suggests allowing the student to explore both approaches if one believes the student is capable of taking on additional work. The faculty quotes highlighted above align with the recommendation of open communication and collaborative goal setting between graduate students and advisors as outlined by Mazerolle and coauthors [46]. The suggestion provided by one of the workshop participants of involving the dissertation committee as an outside perspective and allowing the student to explore both approaches demonstrate the importance of seeking mutual understanding, shared commitment, and goal setting between all parties involved in the advising relationship.

Managing Problems Outside the Traditional Role of an Advisor and Self-Doubt

Participants reflected that as graduate advisors, they are often faced with situations that are outside their area of expertise. This disconnect between the advisor's knowledge and capabilities and the student's need for mentorship is depicted in the following quote:

"Something else I wanted to bring up was [the] conversation about … seeking counseling … I know how to suggest counseling for things that are more serious… because … you know I am not equipped to help you with this, but how do you de-stigmatize seeking counseling for questions that are just like "I'm not sure what I want to do with my life," or things that maybe, I don't want to say [are] smaller, because I don't want to like to minimize. But I just want to say, … therapy doesn't have to be I have like a chronic issue that's going to follow me for the rest of my life. Sometimes it's like you need a few sessions to kind of sort things out."

Self-doubt can often arise as advisors strive to provide meaningful guidance and support for their students. A participant noted:

"I'm the advisor, and she's not, and so I've been doubting myself, you know. Am I giving the students too easy of a pass? Am I being too understanding? And then, at the same time, should I be standing up and advocating for students. So, it's quite complicated."

During these times, they have found it especially valuable to have a network of colleagues and peers who are willing to provide advice and perspective. Having access to multiple perspectives through connections has helped them to overcome self-doubt and to make the best decisions for their students [29].

Discussion

This work sought to engage chemical engineering faculty in conversation about their experiences and challenges in advising graduate students. Our preliminary findings reveal that faculty members recognize the challenges associated with establishing mutually agreed-upon

expectations that satisfy both the student's need for support and the challenge necessary for their growth. This observation is consistent with prior research on advising mismatches [30] and student misconceptions regarding the doctoral journey [47]. Despite the prevalence of this challenge, establishing appropriate work expectations is a critical component for the long-term success of the advising relationship [29, 48, 49] in particular for engineers due to the science model of advising [50]. By proactively managing expectations and establishing mutual agreements, faculty and students can anticipate and address the challenges inherent in navigating differences in perspectives and goals, thereby mitigating early departures [30, 47].

Our preliminary findings also shed light on the issue of self-doubt and delineating boundaries with respect to problems outside of the advising relationship, demonstrating faculty awareness of graduate student mental health concerns. Extensive research in recent years has highlighted the prevalence of mental health issues in graduate students [51-53], including the field of engineering [54, 55]. Our preliminary findings contribute to the existing literature by revealing the awareness of faculty members regarding this issue and documenting the initial effective responses within the advising relationship through our program.

Conclusion and Future Work

Establishing a strong advising relationship is a time-consuming endeavor that is essential in developing successful post-graduate professionals. Previous research on doctoral advising has primarily taken a unilateral approach with limited exploration of advising practices and strategies that are both student-centered and create value for faculty. This paper describes the development and implementation of the first workshop in the four-part series, “Facilitating Engineering Faculty Advising Success for Chemical Engineering Faculty,” which seeks to engage graduate advisors of chemical engineering students in discussions regarding effective advising practices. Specifically, this work was framed by the 3Cs (curiosity, connections, creating value) and sought to enhance the work of Mentorship 360 by instigating faculty mentorship, connecting faculty across national universities, and contributing to the knowledge base of effective faculty mentorship. A high-level analysis of participant contributions from the first workshop in the series revealed several salient themes in faculty discussions and reflections. These included collective difficulties in setting appropriate expectations for graduate students, navigating differences in perspectives and goals, managing self-doubt, and addressing problems outside the traditional role(s) of a graduate advisor. The student-advisor relationship allows both the advisor and the student to act as catalysts for growth in terms of both professional and personal development.

The work presented within this paper is only the preliminary results of a larger body of research seeking to identify and characterize mutually beneficial graduate advising practices. Future work will include the analysis of transcripts from all four of the workshop sessions (Effective Strategies for Mentoring Graduate Students, Effective Strategies for Identifying the Right Graduate Students, Effective Strategies for Identifying the Right Graduate Students, and Effective Strategies for Onboarding New Graduate Students) and pre-post survey responses from participants using multiple methods to illuminate patterns regarding graduate advising practices. Faculty beliefs about effective advising practices will also be examined across the lifespan of the workshops. This research will advance the extant literature by providing a deeper understanding

of the motivating factors and personal beliefs that guide faculty decisions when it comes to providing meaningful advising experiences. Such information can be useful for faculty members, department chairs, and academic institutions to improve advising for doctoral students and for institutions and programs to develop more effective mentoring strategies for future advisors.

Acknowledgment

The authors acknowledge The Kern Family Foundation's support and collaboration through the Kern Entrepreneurial Engineering Network (KEEN) and the Mentorship 360 Initiative for contributing to this work. The research team would also like to thank the faculty participants who generously shared their time, insights, and experiences for this project.

References

[1] B. L. Bernstein, "Managing Barriers and Building Supports in Science and Engineering Doctoral Programs: Conceptual Underpinnings for a New Online Training Program for Women," *JWM*, vol. 17, no. 1, 2011, doi: 10.1615/JWomenMinorScienEng.v17.i1.40.

[2] S. Noy and R. Ray, "Graduate Students' Perceptions of Their Advisors: Is There Systematic Disadvantage in Mentorship?," *The Journal of Higher Education*, vol. 83, no. 6, pp. 876–914, 2012, doi: 10.1080/00221546.2012.11777273.

[3] M. King, Ed., *Ph.D. completion and attrition: analysis of baseline demographic data from the Ph.D. Completion Project*. Washington, D.C: Council of Graduate Schools, 2008.

[4] N. Fabert, P. D. Marilyn Cabay, M. B. Rivers, M. L. Smith, and B. L. Bernstein, "Exaggerating the Typical and Stereotyping the Differences: Isolation Experienced by Women in STEM Doctoral Programs," presented at the 2011 ASEE Annual Conference & Exposition, 2011, p. 22.660.1-22.660.16. Accessed: Apr. 09, 2023. [Online]. Available: https://peer.asee.org/exaggerating-the-typical-and-stereotyping-the-differences-isolation-experienced-by-women-in-stem-doctoral-programs

[5] B. Lovitts, *Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study*. Rowman & Littlefield Publishers, Inc, 2001. [Online]. Available: https://rowman.com/ISBN/9780585383644/Leaving-the-Ivory-Tower-The-Causes-and-Consequences-of-Departure-from-Doctoral-Study

[6] C. Zhao, C. M. Golde, and A. C. McCormick, "More than a signature: how advisor choice and advisor behaviour affect doctoral student satisfaction," *Journal of Further and Higher Education*, vol. 31, no. 3, pp. 263–281, Aug. 2007, doi: 10.1080/03098770701424983.

[7] M. A. Hollingsworth and R. E. Fassinger, "The role of faculty mentors in the research training of counseling psychology doctoral students," *Journal of Counseling Psychology*, vol. 49, pp. 324–330, 2002, doi: 10.1037/0022-0167.49.3.324.

[8] S. Knox, L. Schlosser, N. Pruitt, and C. Hill, "A Qualitative Examination of Graduate Advising Relationships: The Advisor Perspective," *The Counseling Psychologist*, vol. 34, no. 4, pp. 489–518, 2006, doi: Available: https://epublications.marquette.edu/edu_fac/53.

[9] V. M. Lechuga, "Faculty-graduate student mentoring relationships: mentors' perceived roles and responsibilities," *Higher Education*, vol. 62, no. 6, pp. 757–771, Dec. 2011, doi: 10.1007/s10734-011-9416-0.

[10] Y. He and B. Hutson, "Assessment for Faculty Advising: Beyond the Service Component," *NACADA Journal*, vol. 37, no. 2, pp. 66–75, Jan. 2017, doi: 10.12930/NACADA-16-028.

[11] E. Hart-Baldridge, "Faculty Advisor Perspectives of Academic Advising," *NACADA Journal*, vol. 40, no. 1, pp. 10–22, Jun. 2020, doi: 10.12930/NACADA-18-25.

[12] S. E. Brownell and K. D. Tanner, “Barriers to Faculty Pedagogical Change: Lack of Training, Time, Incentives, and…Tensions with Professional Identity?,” *LSE*, vol. 11, no. 4, pp. 339–346, Dec. 2012, doi: 10.1187/cbe.12-09-0163.

[13] M. Artiles and H. Matusovich, “Doctoral Advisor Selection in Chemical Engineering: Evaluating Two Programs through Principal-Agent Theory,” vol. 2, no. 2, Art. no. 2, Feb. 2022, doi: 10.21061/see.57.

[14] S. K. Gardner, “Conceptualizing success in doctoral education: Perspectives of faculty in seven disciplines,” *Review of Higher Education: Journal of the Association for the Study of Higher Education*, vol. 32, no. 3, pp. 383–406, 2009, doi: 10.1353/rhe.0.0075.

[15] B. J. Barnes, E. A. Williams, and S. A. Archer, “Characteristics That Matter Most: Doctoral Students’ Perceptions of Positive and Negative Advisor Attributes,” *NACADA Journal*, vol. 30, no. 1, pp. 34–46, Mar. 2010, doi: 10.12930/0271-9517-30.1.34.

[16] B. A. Burt, A. S. McKen, J. A. Burkhart, J. Hormell, and A. J. Knight, “Racial Microaggressions within the Advisor-advisee Relationship: Implications for Engineering Research, Policy, and Practice,” presented at the 2016 ASEE Annual Conference & Exposition, Jun. 2016. doi: 10.18260/p.26029.

[17] N. Curtin, A. J. Stewart, and J. M. Ostrove, “Fostering Academic Self-Concept: Advisor Support and Sense of Belonging Among International and Domestic Graduate Students,” *American Educational Research Journal*, vol. 50, no. 1, pp. 108–137, Feb. 2013, doi: 10.3102/0002831212446662.

[18] S. Joy, X. F. Liang, D. Bilimoria, and S. Perry, “Doctoral Advisor-Advisee Pairing in STEM Fields: Selection Criteria and Impact of Faculty, Student and Departmental Factors,” *International Journal of Doctoral Studies*, vol. 10, pp. 343–363, Sep. 2015.

[19] H. L. Perkins *et al.*, “An Intersectional Approach to Exploring Engineering Graduate Students’ Identities and Academic Relationships,” *International Journal of Gender, Science and Technology*, vol. 11, no. 3, Art. no. 3, 2019.

[20] B. Bozeman and M. Gaughan, “Job Satisfaction among University Faculty: Individual, Work, and Institutional Determinants,” *The Journal of Higher Education*, vol. 82, no. 2, pp. 154–186, 2016.

[21] K. O’Meara and E. Niehaus, “With a little help from my friends: The role of on and off-campus relationships in faculty careers,” presented at the The Annual Meeting of the American Educational Research Association., San Francisco, CA, San Francisco, CA, 2013.

[22] P. Waychal, “Full article: Examining the effect of goal clarity on faculty performance,” *European Journal of Engineering Education*, vol. 43, no. 4, pp. 597–605, 2018, doi: https://doi.org/10.1080/03043797.2017.1352565.

[23] The Kern Family Foundation, “Engineering Unleashed – Entrprenurial Mindset,” https://engineeringunleashed.com/, 2023.

[24] Arizona State University, “Mentorship 360 – Entrepreneurship + Innovation,” https://engineeringunleashed.com/, 2023.

[25] B. J. Barnes and A. E. Austin, “The Role of Doctoral Advisors: A Look at Advising from the Advisor’s Perspective,” *Innov High Educ*, vol. 33, no. 5, pp. 297–315, Mar. 2009, doi: 10.1007/s10755-008-9084-x.

[26] C. Denis, N. Colet, and C. Lison, “Doctoral Supervision in North America: Perception and Challenges of Supervisor and Supervisee,” *Higher Education Studies*, vol. 9, no. 1, p. 30, 2018, doi: https://doi.org/10.5539/hes.v9n1p30.

[27] L. Mcalpine, “Doctoral supervision: Not an individual but a collective institutional responsibility,” *Journal for the Study of Education and Development*, vol. 36, no. 3, pp. 259–280, Jan. 2013, doi: 10.1174/021037013807533061.

[28] M. J. Robertson, “Trust: the power that binds in team supervision of doctoral students,” *Higher Education Research & Development*, vol. 36, no. 7, pp. 1463–1475, Nov. 2017, doi: 10.1080/07294360.2017.1325853.

[29] R. A. Barnard and G. V. Shultz, “‘Most important is that they figure out how to solve the problem’: how do advisors conceptualize and develop research autonomy in chemistry doctoral students?,” *High Educ*, vol. 79, no. 6, pp. 981–999, Jun. 2020, doi: 10.1007/s10734-019-00451-y.

[30] C. Devos, G. Boudrenghein, N. Van der Linden, M. Frenay, A. Azzi, B. Galand, and O. Klein, “Misfits Between Doctoral Students and Their Supervisors: (How) Are They Regulated?,” *International Journal of Doctoral Studies*, vol. 11, pp. 467–486, Dec. 2016.

[31] M. Grimwood and R. Hetherington, “A neglected area: supervision development opportunities for doctoral researchers involved in undergraduate and masters project mentoring,” *International Journal for Academic Development*, vol. 0, no. 0, pp. 1–13, Sep. 2021, doi: 10.1080/1360144X.2021.1959336.

[32] C. E. Hilmer and M. J. Hilmer, “On the Relationship between the Student-Advisor Match and Early Career Research Productivity for Agricultural and Resource Economics Ph.D.s,” *American Journal of Agricultural Economics*, vol. 89, no. 1, pp. 162–175, 2007.

[33] B. Kamler and P. Thomson, *Helping Doctoral Students Write: Pedagogies for supervision*. Routledge, 2014. Accessed: Apr. 09, 2023. [Online]. Available: https://www.routledge.com/Helping-Doctoral-Students-Write-Pedagogies-for-supervision/Kamler-Thomson/p/book/9780415823494

[34] S. Jeong, D. Feldon, M. Maher, and J. Peugh, “Doctoral Satisfaction With Faculty Advisers: Advisement Characteristics and Relationship to Socialization Outcomes,” in *AERA Annual Meeting*, New York, NY: American Educational Research Association, 2018. Accessed: Apr. 09, 2023. [Online]. Available: http://tinyurl.com/y9rlaaxa

[35] M. A. Maher, A. M. Wofford, J. Roksa, and D. F. Feldon, “Finding a Fit: Biological Science Doctoral Students’ Selection of a Principal Investigator and Research Laboratory,” *LSE*, vol. 19, no. 3, p. ar31, Sep. 2020, doi: 10.1187/cbe.19-05-0105.

[36] B. A. Burt, “Toward a Theory of Engineering Professorial Intentions: The Role of Research Group Experiences,” *American Educational Research Journal*, vol. 56, no. 2, pp. 289–332, Apr. 2019, doi: 10.3102/0002831218791467.

[37] E. Crede and M. Borrego, “Learning in Graduate Engineering Research Groups of Various Sizes,” *Journal of Engineering Education*, vol. 101, no. 3, pp. 565–589, 2012, doi: 10.1002/j.2168-9830.2012.tb00062.x.

[38] D. R. Simmons, J. Van Mullekom, and M. W. Ohland, “The Popularity and Intensity of Engineering Undergraduate Out-of-Class Activities,” *Journal of Engineering Education*, vol. 107, no. 4, pp. 611–635, 2018, doi: 10.1002/jee.20235.

[39] K. O’Meara, M. Rivera, A. Kuvaeva, and K. Corrigan, “Faculty Learning Matters: Organizational Conditions and Contexts that Shape Faculty Learning,” *Innov High Educ*, vol. 42, no. 4, pp. 355–376, Aug. 2017, doi: 10.1007/s10755-017-9389-8.

[40] M. Artiles, “Advisor Selection Processes in Doctoral STEM Programs in the US,” Ph.D. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA, 2019.

[41] A. E. Austin, “Cognitive apprenticeship theory and its implications for doctoral education: a case example from a doctoral program in higher and adult education,” *International Journal for Academic Development*, vol. 14, no. 3, pp. 173–183, Sep. 2009, doi: 10.1080/13601440903106494.

[42] J. C. Weidman, D. J. Twale, and E. L. Stein, *Socialization of Graduate and Professional Students in Higher Education: A Perilous Passage? ASHE-ERIC Higher Education Report, Volume 28, Number 3. Jossey-Bass Higher and Adult Education Series*. Jossey-Bass,

Publishers, Inc, 2001. Accessed: Apr. 04, 2023. [Online]. Available: https://eric.ed.gov/?id=ED457710

[43] M. J. Barker, "Racial context, currency and connections: Black doctoral student and white advisor perspectives on cross-race advising," *Innovations in Education and Teaching International*, vol. 48, no. 4, pp. 387–400, Nov. 2011, doi: 10.1080/14703297.2011.617092.

[44] L. Utzinger, "Advising, Gender, and Career Decision-Making of STEM Doctoral Students at an Elite Research University," presented at the American Educational Research Association, Toronto, Canada, 2019.

[45] S. Bloom and P. Jordan, "Setting realistic expectations for graduate students: A faculty perspective," *Journal of Higher Education Theory and Practice*, vol. 12, no. 1, pp. 1–6, 2012.

[46] S. M. Mazerolle, T. G. Bowman, and J. C. Klossner, "An Analysis of Doctoral Students' Perceptions of Mentorship During Their Doctoral Studies," *Athletic Training Education Journal*, vol. 10, no. 3, pp. 227–235, Jul. 2015, doi: 10.4085/1003227.

[47] A. Holbrook, K. Shaw, J. Scevak, S. Bourke, R. Cantwell, and J. Budd, "PhD Candidate Expectations: Exploring Mismatch with Experience," *International Journal of Doctoral Studies*, vol. 9, pp. 329–346, doi: https://doi.org/10.28945/2078.

[48] C. G. P. Berdanier, A. Tally, S. E. Branch, B. Ahn, and M. F. Cox, "A strategic blueprint for the alignment of doctoral competencies with disciplinary expectations," *International Journal of Engineering Education*, vol. 32, no. 4, pp. 1759–1773, 2016.

[49] L. Z. Schlosser, S. Knox, A. R. Moskovitz, and C. E. Hill, "A qualitative examination of graduate advising relationships: The advisee perspective.," *Journal of Counseling Psychology*, vol. 50, no. 2, pp. 178–188, Apr. 2003, doi: 10.1037/0022-0167.50.2.178.

[50] M. S. Artiles and H. M. Matusovich, "Examining doctoral degree attrition rates: Using expectancy-value theory to compare student values and faculty supports," *International Journal of Engineering Education*, vol. 36, no. 3, pp. 1071–1081, 2020.

[51] R. Eleftheriades, C. Fiala, and M. D. Pasic, "The challenges and mental health issues of academic trainees," *F1000Res*, vol. 9, p. 104, Feb. 2020, doi: 10.12688/f1000research.21066.1.

[52] T. Evans, L. Bira, J. Gastelum, T. Weiss, and N. Vanderford, "Evidence for a mental health crisis in graduate education," *Nature Biotechnology*, vol. 36, pp. 282–284, 2018, doi: https://doi.org/10.1038/nbt.4089.

[53] K. Levecque, F. Anseel, A. De Beuckelaer, J. Van der Heyden, and L. Gisle, "Work organization and mental health problems in PhD students," *Research Policy*, vol. 46, no. 4, pp. 868–879, May 2017, doi: 10.1016/j.respol.2017.02.008.

[54] S. J. Bork and J.-L. Mondisa, "Engineering graduate students' mental health: A scoping literature review," *Journal of Engineering Education*, vol. 111, no. 3, pp. 665–702, 2022, doi: 10.1002/jee.20465.

[55] E. Hocker, E. Zerbe, and C. G. P. Berdanier, "Characterizing Doctoral Engineering Student Socialization: Narratives of Mental Health, Decisions to Persist, and Consideration of Career Trajectories," in *2019 IEEE Frontiers in Education Conference (FIE)*, Oct. 2019, pp. 1–7. doi: 10.1109/FIE43999.2019.9028438.