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The Advisor-Advisee Relationship in Engineering and Computer Science Ph.D. Programs: Understanding Who Benefits and How

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Catherine E. Brawner is President of Research Triangle Educational Consultants. She received her Ph.D.in Educational Research and Policy Analysis from NC State University in 1996. She also has an MBA from Indiana University (Bloomington) and a bachelor's degree from Duke University. She specializes in evaluation and research in engineering education, computer science education, and technology education. Dr. Brawner is a founding member and former treasurer of Research Triangle Park Evaluators, an American Evaluation Association affiliate organization and is a member of the American Educational Research Association and American Evaluation Association, in addition to ASEE. Dr. Brawner is the principal formative evaluator for the AGEP-NC project. She has also served as an Extension Services Consultant for the National Center for Women in Information Technology (NCWIT) and, in that role, advised computer science and engineering departments on diversifying their undergraduate student population. She remains an active researcher, including studying academic policies, gender and ethnicity issues, transfers, and matriculation models with MIDFIELD as well as student veterans in engineering. Her evaluation work includes evaluating teamwork models, broadening participation initiatives, and AGEP, S-STEM and LSAMP programs.

Ms. Andrea Stancescu, NC State University

Hello, My name is Andrea Stancescu and I am a junior in the undergraduate applied mathematics and statistics program at NC State. I have been working with Dr. Brawner since August of 2021 on collecting and analyzing the survey results from the AGEP-NC project. I am looking forwards to working with everyone!

Dr. Maureen Grasso, NC State University

Maureen Grasso former Dean of the Graduate School at North Carolina State University and the University of Georgia has over 16 years as a dean in graduate education. She worked with faculty and students to improve and enhance mentoring. Grasso was an active participant in the Council of Graduate School's "PhD completion project", The Commission on "Pathways Through Graduate School and into Careers" and the Advancement Advisory Committee. She was a founding member of the CGS Advisory Committee on Advocacy and Public Policy. Grasso served as President and Past President of CSGS and in 2009, She received the CSGS Award for Outstanding Contribution to Graduate Education in the Southern Region. She served on the National Academy of Sciences committee on "Revitalizing Gradute Stem Education for the 21st Century." Grasso currently serves as a Co-PI on the NC AGEP grant An Institutional Transformative Model to Increase Minority STEM Doctoral Student and Faculty Sucess.

Dr. Yvette Maria Huet,

Yvette Huet is Director of the ADVANCE Faculty Affairs and Diversity Office and a Professor of Kinesiology at UNC Charlotte. She has worked with and created a variety of workshops for faculty, graduate students and post-doctoral fellows, and current and future leaders and provided professional development consultation to faculty. She has provided training at UNC Charlotte and other programs and institutions across the country, many with current or previous ADVANCE grants, that addresses best practices in recruitment, inherent bias, communication, mentoring and reappointment, promotion and tenure in the academia.

She graduated with bachelor's degrees in Microbiology and Human Biology from the University of Kansas and a Ph.D. with Honors in Physiology from the University of Kansas, Medical Center. She went on to a postdoctoral fellowship at Monsanto Company in Chesterfield, MO and then to UNC Charlotte. She was tenured and went on to be a Full Professor in the Biology Department at UNC Charlotte, she has been Director of the Interdisciplinary PhD program in Biology as well as the Health Services Research Doctoral program. She was the Faculty Development Coordinator in the College of Liberal Arts

and Sciences and the Interim Chair of Kinesiology. She continues as a Professor of Applied Physiology, Health and Clinical Sciences (previously Kinesiology) and has been Director of the ADVANCE Faculty Affairs and Diversity Office for over 10 years. Her research is in the areas of Endocrinology, Reproductive Biology and Sexually Dimorphic Disease as well as on Mid-Career Mentoring.

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Lisa R. Merriweather is a professor at the University of North Carolina at Charlotte. She received her PhD in Adult Education with a graduate certificate in Qualitative Inquiry from the University of Georgia in 2004. Her research focuses on issues of equity and social justice within adult education, informal education, and doctoral education. She explores the critical philosophy and sociology of race and antiblack racism and employs Africana Philosophy, Critical Race Theory, and qualitative and historical methodology to investigate topics found at the nexus of race and adult education.

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Rebecca Brent is President of Education Designs, Inc., a consulting firm located in Chapel Hill, N.C. She is a certified program evaluator and a faculty development consultant and researcher specializing in STEM fields. Brent received her B.A. from Millsaps College in Jackson, Miss., her M.Ed. from MS State University, and her Ed.D from Auburn University. In 2014 she was named a Fellow of the American Society for Engineering Education.

The Advisor-Advisee Relationship in Engineering and Computer Science Ph.D. Programs: Understanding Who Benefits and How

Abstract

Doctoral advisors are key to ensuring positive outcomes, especially for underrepresented students in STEM fields. In this study, graduate faculty and doctoral students with three or more years in their programs in the AGEP-NC Alliance were surveyed about the advising practices they engaged in (faculty) or received (students). Faculty were also asked about their confidence advising graduate students generally as well as students who are different from themselves demographically and culturally. Students were also asked about their relationship with their advisors. Findings show that faculty are significantly more confident advising students generally than they are advising students who are different from themselves. On all common measures of advising practices, faculty report that they engage in those practices significantly more often than students report experiencing the advising practice from their advisor. Black, Hispanic, and Native American U.S. citizen students report receiving research guidance from their advisors significantly less than White and Asian U.S. citizens or international students. International students are offered teaching opportunities significantly more often than White and Asian students. There was a significant difference in whether students understood their advisor's expectations and Black, Hispanic, and Native American students were significantly less likely than international students to report that their advisor respects their contributions. We find that there is a clear lack of alignment between faculty confidence and student perceptions of faculty advising. This gap is especially clear in key advising behaviors like research and presentation guidance. Given that the goal of the AGEP program is to prepare underrepresented U.S. citizen students for the professoriate, both the lack of research guidance and lack of opportunity to build teaching experience for these students is troubling. Change is thus required at both the departmental level to improve the climate for all students as well as at the individual faculty advisor level to ensure that all students are treated equitably with high quality advising.

Keywords: AGEP; doctoral students; underrepresented students; international students; faculty; advising practices; advising relationships

Introduction

Doctoral advisors play a pivotal role in ensuring positive outcomes for students especially in Science, Technology, Engineering, and Math (STEM) fields. Students who identify as Black, Hispanic, and American Indian, Native Hawaiian, Alaska Native, and Native Pacific Islander face challenges in graduate study in engineering and computer science not only due to the rigor of the academic work, but also because they may face a hostile climate, racial microaggressions, and racial trauma [1, 2]. This means that the advisor-advisee relationship can be a particularly powerful determinant of students' success and degree completion [3-5]. The North Carolina Alliance for Graduate Education and the Professoriate (AGEP-NC) was created to improve 1) the departmental climate and 2) advising and mentoring practices that can impede students' success, particularly the success of US citizen students who are underrepresented in STEM. In this paper, we examine the advising practices that are known to positively impact student outcomes and the perception of faculty and students of the degree to which students experience these advising practices as well as the relationships between advisors and doctoral students.

Literature Review

Burt et al. [3] suggest that strong advising includes an ethic of care where not only are the student's academic needs addressed and supported, but also where the advisor genuinely supports the whole student and their life away from school. By contrast, Burt et al. consider basic advising to be helpful to the student (particularly administratively) and to include providing research guidance, but it is less concerned with the wellbeing of the whole student. Weak advising is harmful to students' wellbeing and progress, by creating a hostile working environment and creating barriers to academic and research progress [3, p. 41]. Poor relationships with advisors, including overtly racist encounters, can negatively impact students' physical and emotional health [2]. Felder [4] found that successful African American doctoral completers had faculty advisors who were willing to help them form professional networks and collaboration opportunities. On the other hand, racial microaggressions from advisors led Black men to question their engineering identities and belongingness, which forced them to engage in strategies, such as discounting the offensive comments or rationalizing the different treatment received compared with White and Asian students, in order to cope [1]. As Burt et al. note "…interactions within the College of Engineering mediates students' learning, influencing their decisions about whether or not to persist in the graduate program, and perhaps whether or not to remain in the field of engineering" [1, p. 502]. Some students make the politically difficult decision to cope by switching advisors or institutions to find a more welcoming and supportive advising relationship [2].

De Welde and Laursen [6] suggest the *ideal type* advisor performs a variety of functions, both transactional and transformational, from academic guidance, supervision, and socialization to career advice, support, and advisorship. Most in their role of advisor do not perform all of these functions, nor are they seen as being equally effective across demographic groups. The quality of the advisor-advisee relationship is subject to multiple factors, such as race, gender, and advisor experience and knowledge.

Often, advisors serve to transfer disciplinary and departmental norms to their mentees as a means to create a cognitive map to demystify the doctoral process and to make the implicit explicit resulting in their student's success [7]. While this does contribute to success, it is most impactful on short-term career outcomes. For longer-term success, personal, individual-centered advising is more beneficial. This type of advising can contribute to success, advancement of goals, the overcoming of barriers and retention in STEM, especially for students from marginalized backgrounds [8, 9]. This requires the identification of a mentee's individual short and long-term career goals, personal aspirations relative to career advancement, and the assessment of what the specific mentee needs to reach these career goals. This needs assessment includes identifying areas that benefit from advising. It is important to recognize that this individual-centered advising framework can empower and give agency to the individual in defining their career [10]. An advising map and a clear determination of who is and could be in one's advising network is key to success [11, 12]. This is one framework for developing a scholarly network that supports not only a successful career but also one in which the mentee can thrive [12].

High quality advising is particularly important in STEM disciplines where Black, Hispanic, and American Indian, Alaska Native, Native Hawaiian, and Native Pacific Islander people are woefully underrepresented among doctoral degree completers and academic faculty [13]. To address this lack of diversity in the STEM academic workforce, the National Science Foundation has created the Alliance for Graduate Education and the Professoriate (AGEP) program which supports alliances of doctoral granting institutions as they work to address the systemic factors that support equity and inclusion and achieve the AGEP program goal to increase the number of historically underrepresented STEM faculty [14].

The AGEP-NC Alliance

AGEP-NC is a partnership among North Carolina A&T State University (NCA&T), North Carolina State University (NC State) and the University of North Carolina Charlotte (UNCC) to develop and implement a model to promote the success of students underrepresented in STEM disciplines in completing their PhD degrees and advancing to faculty positions. This is critically important in engineering and computer science where only 569 doctoral degrees or 4.4% were conferred on students from underrepresented groups in the USA in 2019 [13]. The participating institutions differ in institutional mission. NC State is a large, predominantly White research-extensive land grant university; NCA&T is a STEM-focused historically Black land grant university and a national leader in graduating Black STEM PhD students; and UNC Charlotte is an urban research university where many STEM PhD programs are young and developing. In 2019, NC State was among the top 25 producers nationally of engineering and computer science PhDs and the number of degrees awarded to foreign nationals; NC A&T was in the top five in the percentage of doctoral degrees awarded to students from underrepresented groups; and UNCC was the top 25 in percentage of doctoral degrees awarded to foreign nationals [13]. As a consequence, the culture, expectations of faculty and their experiences and attitudes toward diversity differ.

Each participating STEM graduate program in the alliance nominates a faculty fellow who then becomes a member of a campus cohort. Through readings, monthly campus cohort meetings, and semi-annual alliance-wide workshops, fellows develop knowledge about cross-cultural mentoring, promoting diversity in doctoral programs, and facilitating departmental dialog. Faculty fellows work within their departments to develop and implement sensemaking initiatives with the goal to share information with faculty and to provide opportunities to learn and build inclusive doctoral programs. This requires that the faculty fellows and the faculty in the departments/programs critically examine policies, procedures, practices, and department climate that may serve to promote or impede the success of Ph.D. students from underrepresented groups and develop an action plan to remedy existing barriers and enhance graduate program climate. Detailed information about the inception and organization of the AGEP-NC Alliance can be found in [15-18].

One of the areas for critical reflection within the departments is the advisor-advisee relationship. In this paper, we examine faculty perceptions of the frequency with which they provide key advising benefits with students' perceptions of receiving those same benefits and compare how students' perceptions differ based on underrepresentation status. We present updated findings

from [19], focusing on baseline surveys from engineering and computer science departments at the three AGEP-NC universities and answer the following questions:

1. What advising practices do faculty report using with doctoral students? What advising practices do dissertation-stage doctoral students report receiving? Are there differences in those perceptions?
2. Among dissertation stage doctoral students, are there differences in the reported advising experiences of US Citizen Black, Hispanic and Native (including American Indian, Alaska Native, Native Hawaiian, and Native Pacific Islander) students compared with US citizen White and Asian students and International (any race) students?

Like others, (e.g., [20]), this work distinguishes between advisors and mentors, and will focus on phenomena most often understood as being within the realm of advising: programmatic and discipline-based guidance.

Methods

Doctoral students with at least one year in their program and faculty who were members of a department or program with a participating AGEP fellow were surveyed about advising practices and department climate at the beginning of the fellows' term in one of the three AGEP-NC cohorts. Surveys were developed as part of the project's formative evaluation and were thus exempt from Institutional Review Board review. The survey questions used in this study, audience, and Likert-type scale endpoints are shown in Table 1. Numeric values were assigned to each point on the Likert scale, with 1 being the lowest/least (e.g., "strongly disagree" or "never") and 4 or 5, as appropriate, representing the highest/most (e.g., "strongly agree" or "frequently"). Surveys were administered online via Qualtrics. Following an email from their department chair, director of graduate programs, or fellow encouraging them to reply, students and faculty were sent an email link to the surveys from the evaluator using the Qualtrics mailer. Non-respondents were sent two to four follow-up emails.

Response rates for all students in Cohort 1 departments ranged from 25% to 53%; in Cohort 2 departments from 23% to 51%; and in Cohort 3 departments from 44% to 82%. There was no separate tracking of the response rates for students who had been in their program for three or more years. Response rates for faculty in Cohorts 1 and 2 are difficult to ascertain due to inaccuracies in the initial mailing lists, but are most likely in the mid- to high-30% range. Response rates for faculty in Cohort 3 departments ranged from 32% to 63%.

Table 1. Survey Questions used in this study

Student (Faculty) Survey Questions	Students	Faculty	Scale (range)
How confident are you advising doctoral students?		☑	Not confident (1) – Very confident (4)
How confident are you advising doctoral students from cultural groups different from your own?		☑	Not confident (1) – Very confident (4)
Frequency receiving (giving) guidance in conducting research.	☑	☑	Never (1) – Frequently (4)
Frequency presenting (facilitating presentation of) student's research at seminars at my university.	☑	☑	Never (1) – Frequently (4)
Frequency presenting (facilitating presentation of) student's research at regional or national conferences.	☑	☑	Never (1) – Frequently (4)
(Helping) Author/co-author a paper on student's research.	☑	☑	Never (1) – Frequently (4)
Being introduced by my advisor (introducing advisee) to faculty in student's research area from other institutions.	☑	☑	Never (1) – Frequently (4)
(Inviting advisees to) fill in for an instructor in a session of a class or recitation.	☑	☑	Never (1) – Frequently (4)
(Encouraging advisees to) Being encouraged to teach a semester-long course or recitation.	☑	☑	Never (1) – Frequently (4)
(Encouraging advisees to) Being encouraged to attend a workshop or course on teaching.	☑	☑	Never (1) – Frequently (4)
Receiving (Giving) career advice from my advisor.	☑	☑	Never (1) – Frequently (4)
Receiving (Giving) personal advice from my advisor.	☑	☑	Never (1) – Frequently (4)
I understand what my faculty advisor expects of me.	☑		Strongly disagree (1) – Strongly agree (5)
I am satisfied with the quality and quantity of the feedback I receive from my advisor.	☑		Strongly disagree (1) – Strongly agree (5)
My advisor respects my opinions and contributions.	☑		Strongly disagree (1) – Strongly agree (5)
I feel safe voicing my feelings to my advisor.	☑		Strongly disagree (1) – Strongly agree (5)
Rate your relationship with your advisor.	☑		Poor (1) – Excellent (4)

Study Population

For the departments listed in Table 2, the study population consists of 419 doctoral students who had completed three or more years in their doctoral program at the time of the survey and 288 graduate faculty in the same departments. Institutional responses ranged from 18-357 students and 10-236 faculty.

Table 2. Participating Departments

School/Department	Cohort	Surveys administered
NCA&T		
Applied Engineering and Technology	2	Fall 2020
Computational Data Science and Engineering	2	Fall 2020
Mechanical Engineering	1	Fall 2019
Nanoengineering	1	Fall 2019
NC State		
Biological and Agricultural Engineering	2	Fall 2020
Biomedical Engineering	3	Fall 2021
Chemical and Biomolecular Engineering	3	Fall 2021
Civil, Construction, and Environmental Engineering	3	Fall 2021
Computer Science	3	Fall 2021
Electrical and Computer Engineering	3	Fall 2021
Industrial and Systems Engineering	3	Fall 2021
Materials Science and Engineering	3	Fall 2021
Mechanical and Aerospace Engineering	3	Fall 2021
Nuclear Engineering	3	Fall 2021
Textile Engineering, Chemistry and Science	3	Fall 2021
UNC Charlotte		
Computing and Information Systems	2	Fall 2020
Civil and Environmental Engineering	1	Fall 2019
Electrical and Computer Engineering	2	Fall 2020
Mechanical Engineering and Engineering Science	2	Fall 2020

Student and faculty demographics are summarized in Table 3. Students were categorized as "B+H+N" which includes U.S. Citizen and permanent resident students who identified as Black, Hispanic, and Native American (includes American Indian, Native Hawaiian, Alaska Native or Native Pacific Islander) or multi-racial including one of these identities; "W+A," which includes U.S. citizen/permanent resident students who identify as White or Asian; and International, without regard to ethnicity. Students from one department that was surveyed as part of Cohort 1 were not asked for their citizenship status. Based on university data, those who provided an ethnic identification were assigned to the most likely group. In this case, one person who identified as Hispanic female, one who identified as a Black male and one who identified as Asian male were recoded to "International" because there were no or few US citizens enrolled at the time of the survey who matched those demographics. One woman who identified as Caucasian was recoded as W+A. All faculty were assumed to be US citizens or permanent

residents given their employment status, although many may have been born abroad. Representation of B+H+N faculty (6.3%) aligns with national data on tenured/tenure-track faculty demographics in engineering and computer science disciplines [13].

Table 3. Student and Faculty Demographics

Ethnic Group	Students				Faculty			
	Female	Male	Other/ N/A	Total	Female	Male	Other/ N/A	Total
B+H+N	4	12		16	4	14		18
W+A	37	73	9	119	42	189	22	253
International	78	184	11	273				
Other/No answer		1	10	11		3	14	17
Total	119	270	30	419	46	206	36	288

Note: B+H+N = Black or Hispanic or Native American US Citizen/permanent resident; W+A = White or Asian US Citizen/permanent resident

Data Analysis

Data were analyzed using standard parametric statistical techniques in RStudio. T-tests were performed using the t.test() function in the r-base package. To compare B+H+N, W+A and International groups, analysis of variance was used with the Bonferroni adjustment. In RStudio, ANOVA was performed using the aov() function in the r-base package with pairwise comparisons using pairwise.t.test() and the p.adjust.method="bonferroni" option. Statistical tests were performed using parametric statistics, which is appropriate for Likert-type responses when there is a large sample size [21]. The figures below show the distribution of responses across the response options to help the reader better visualize the results.

Author Positionality

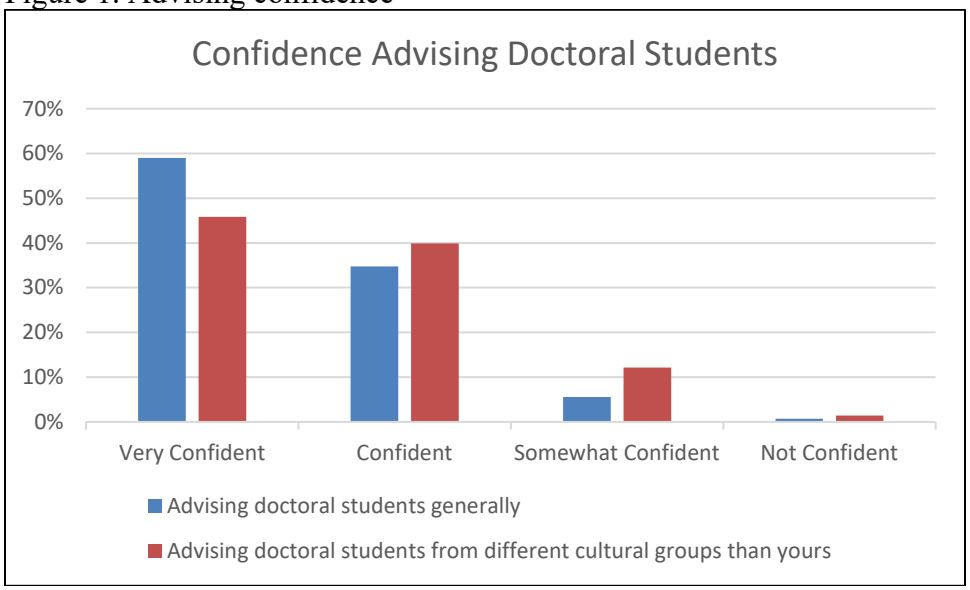
The authors represent the AGEP-NC formative evaluation consultants, members of the leadership team and an undergraduate research assistant. The evaluation consultants are both White women with significant research and evaluation experience with minoritized populations in STEM. The members of the leadership team include a White female professor of Textiles, an African American female professor of Educational Research, and a Hispanic female professor of Applied Physiology, Health and Clinical Science and ADVANCE program director. The undergraduate research assistant is a White female junior statistics major whose parents immigrated into the US for graduate education.

Results

Advising confidence

As shown in Figure 1, faculty report that they are more confident advising doctoral students generally than they are advising doctoral students from different cultural groups from their own ($t(574) = 3.64$, $p<.001$).

Figure 1. Advising confidence



Advising practices

Both students and faculty were asked how often they engaged in advising practices (faculty) or received guidance (students) known to help doctoral students advance in their profession, including advancing to faculty positions. In every case, faculty reported that they more frequently engaged in these practices than students reported receiving such counsel from their advisors ($p<.001$) as shown in Table 4. Particularly large gaps were noted in authoring papers and presenting research at the home universities or at conferences. This gap in presentation opportunities may have been impacted by the COVID-19 pandemic which prevented many in-person gatherings during most students' time in their programs but is in the same direction as found previously with non-engineering departments prior to the pandemic [19]. Activities that would tend to help prepare students for the professoriate, such as teaching classes and attending workshops on teaching are seldom engaged in or recommended to students.

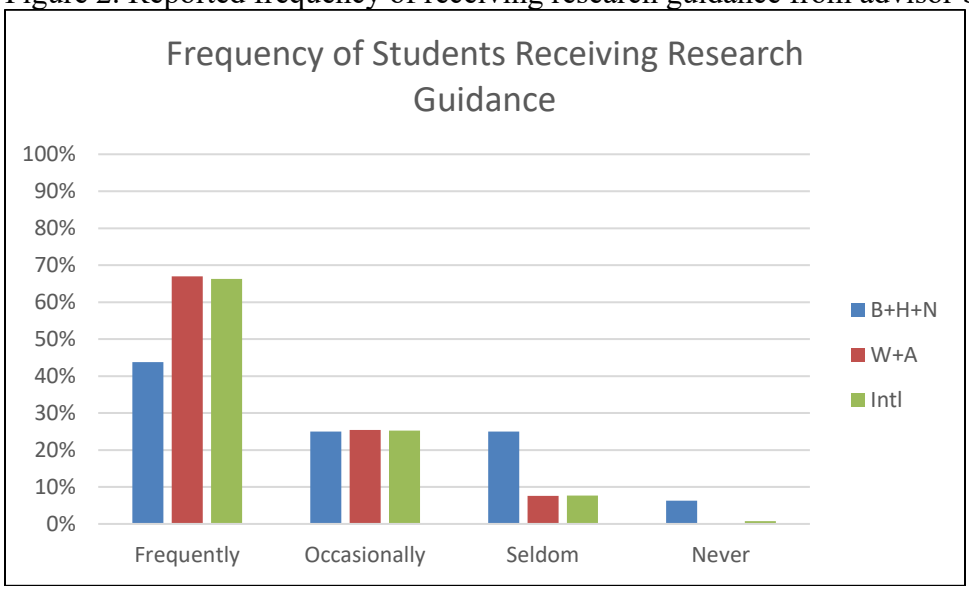
Table 4. Comparison of Faculty and Doctoral Student Responses to Common Questions

	Faculty (n=288)		Students (n = 419)		2 Sample T-Test
Activity	Mean	SD	Mean	SD	T-Value (d.f.)
Student getting guidance in conducting research	3.92	0.34	3.55	0.69	t(640) = 9.6 ***
Student presenting research at home university	3.54	0.64	2.65	0.87	t(689) = 15.44 ***
Student presenting research at national or regional conference	3.6	0.64	2.94	0.87	t(688) = 11.39 ***
Student authoring or co-authoring a paper on research	3.85	0.47	3.19	0.81	t(673) = 13.49 ***
Student being introduced to faculty in their research area at other universities	3.05	0.77	2.68	0.96	t(672) = 5.58 ***
Student substitute-teaching a session of a class or recitation	2.42	0.93	2.1	0.99	t(621) = 4.27 ***
Student being encouraged to teach a semester-long course or recitation	2.11	1.01	1.82	1.05	t(615) = 3.65 ***
Student being encouraged to attend a workshop or course on teaching	2.58	0.99	2.02	0.99	t(598) = 7.28 ***
Student being assigned to mentor an undergraduate student	3.01	0.91	2.55	1.08	t(660) = 6.00 ***
Student getting career advice	3.72	0.53	2.94	0.89	t(682) = 14.36 ***
Student getting personal advice	2.99	0.86	2.73	1.01	t(657) = 3.70 ***

Note: 1 = Never, 2 = Seldom, 3 = Occasionally, 4 = Frequently; *** p<.001; unequal variances assumed when calculating t-statistic.

Arguably, the most important advising function is providing research guidance to students. In this study, pairwise comparisons show that Black, Hispanic, and Native students report that they receive this guidance significantly less than both White + Asian, and international students ($F(2, 404) = 4.57$, $p=.011$) as shown in Figure 2. For other areas regarding authorship, professional presentation opportunities, and professional networking, there are no significant differences in how often students receive such professional guidance from their advisors when considering citizenship and ethnicity.

Figure 2. Reported frequency of receiving research guidance from advisor by ethnicity.



There were significant differences among groups in how often students were asked to fill in for instructors for a class period or recitation ($F(2, 397) = 6.02$, $p=.003$) (Figure 3), being asked to teach a semester long course ($F(2, 399) = 5.18$, $p=.006$) (Figure 4), and attending a teaching workshop ($F(2, 401) = 9.24$, $p<.001$) (Figure 5). Using pairwise comparisons, it is evident that International students are offered these opportunities significantly more than White+Asian students, but not significantly more than Black+Hispanic+Native students.

Figure 3. How often student invited to fill in for instructor for a class period

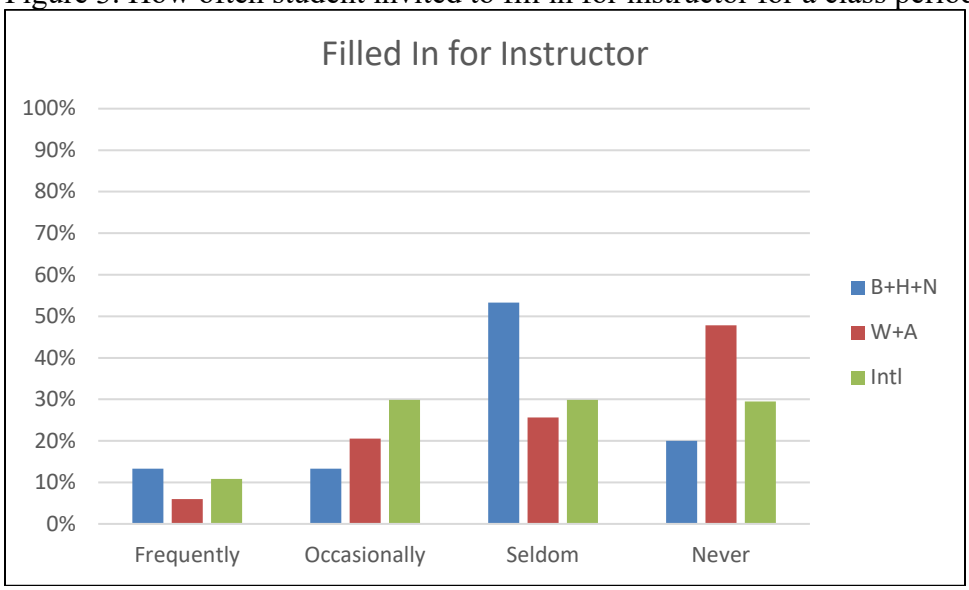


Figure 4. How often students are encouraged to teach a semester-long course

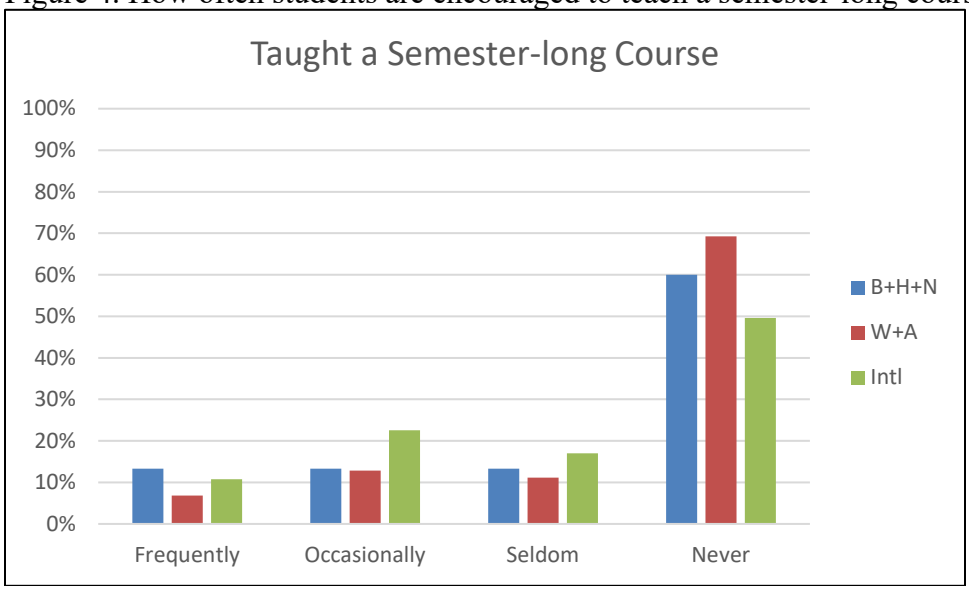
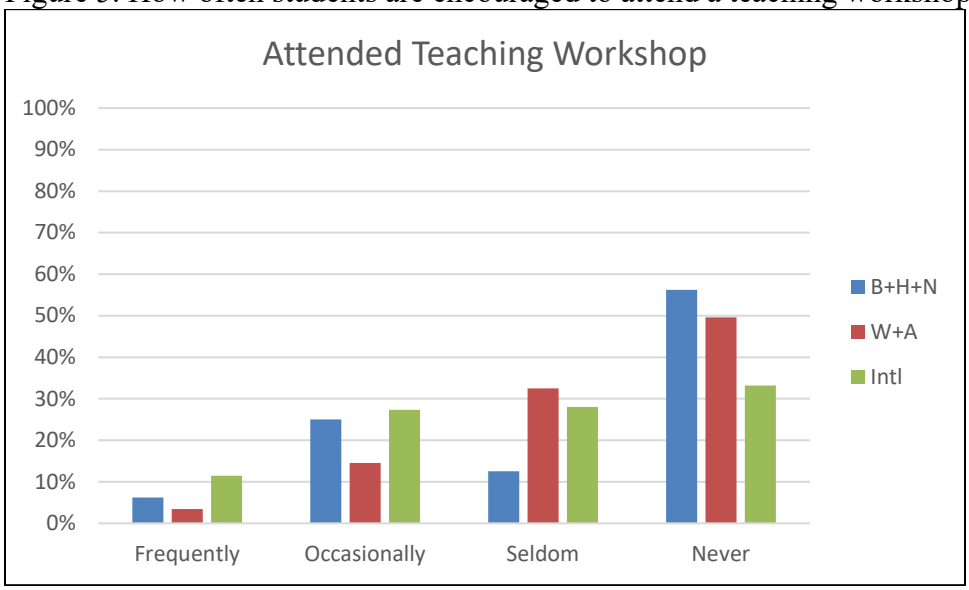


Figure 5. How often students are encouraged to attend a teaching workshop



Advising relationships

In addition to examining specific advising behaviors, we also considered relationships between the students and their advisors and how the students perceive their interactions with their advisors. As shown in Figure 6, there were significant differences among groups in terms of whether the students understood their advisors' expectations ($F(2, 403) = 3.22$, $p=.041$). It appears that Black, Hispanic and Native students were less likely to feel that they understood their advisors' expectations than other students, but pairwise comparisons did not reveal a significant difference between groups. When it came to having their opinions and contributions valued by their advisor, Black, Hispanic, and Native students were significantly less likely than

International students to believe that this was the case and much more likely to strongly disagree ($F(2, 404) = 4.64$, $p = .01$) as shown in Figure 7.

Figure 6. Students understand advisor expectations

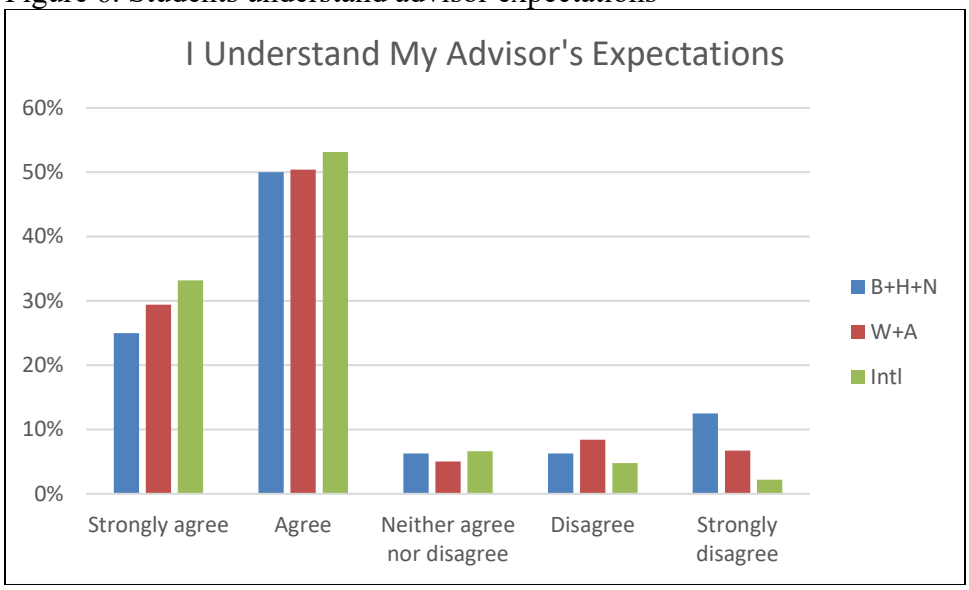
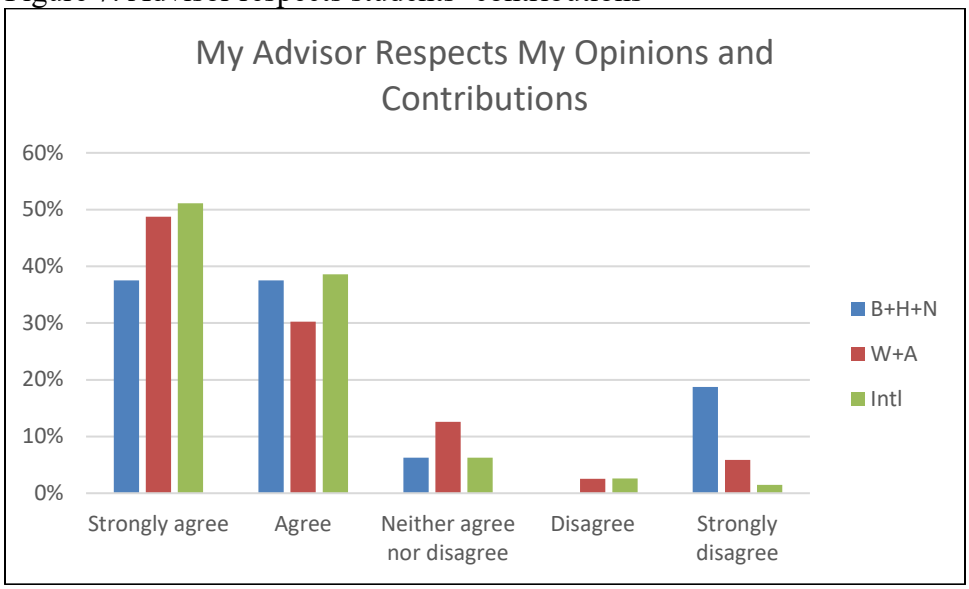


Figure 7. Advisor respects students' contributions



Overall, International students more often reported an excellent relationship with their advisor than any other group and Black, Hispanic, and Native students more often reported that it was poor, however, these differences were not significant. Other interactions where there were no significant differences among groups included receiving professional and personal advice,

quality and quantity of feedback from the advisors, and whether the students feel safe voicing their opinions to the advisors.

Discussion

Research has demonstrated that advising is key to persistence and successful completion of graduate programs. In this paper, we have examined faculty confidence in advising doctoral students; compared faculty and student perceptions of advising practices and relationships; and compared Black+Hispanic+Native U.S. citizens, White+Asian U.S. citizens, and international students' perceptions of advising practices and relationships. Other studies (e.g., [3]) have focused on understanding what skills and behaviors are critical for being a successful advisor and many of these studies survey students about their perceptions of positive and negative attributes of advisors or examine behaviors of highly successful advisors. However, the literature is limited on the assessment of advising competency as perceived by faculty and the students in their programs. We found that there is a clear lack of alignment between faculty confidence and student perceptions of faculty advising. This gap is especially clear in key advising behaviors like research and presentation guidance. Thus, while faculty advisors may understand what they can do to support their students they are overconfident in their abilities relative to their students' perceptions of their competence. We found this to be true across programs and institutions in this study. Clearly these gaps are impacted to some extent by the fact that most faculty members have advised numerous students over the years while each student has a much narrower frame of reference with one or a few advisors in their three to six or so years in their programs. The COVID-19 pandemic certainly may have impacted the ability to present research, but most disciplines offered virtual conferences and other engagement opportunities.

Among the eight questions related to advising practices, there were significant differences among students by their ethnicity or international status in four of them. Arguably, one of the most important functions an advisor can provide is to give students guidance in conducting research as this is critical for degree completion [22]. Therefore, it is particularly disconcerting that Black+Hispanic+Native students report that they receive such guidance significantly less often than their White+Asian and international peers. This may be related to the dearth of faculty who identify as Black+Hispanic+Native as well as faculty discomfort in advising students who are different from them. Roughly half of all faculty and students in the computer science and engineering departments at the three schools replied to the survey, so the results can be considered fairly representative. Among the 16 Black+Hispanic+Native students, eight were in departments where no faculty member who identified as Black+Hispanic+Native responded, indicating that half of the students were likely the "only ones" in their department, which can lead to feelings of isolation and loneliness, [2, 22]. They may also experience racial microaggressions [4], even if they are unintentional [22], from faculty who are uncomfortable advising them, which can make them less likely to seek the guidance that they need [22].

Of the seven questions related to advising relationships, two had significant differences among the ethnic groups. Black+Hispanic+Native students appear to understand advisor expectations less well than their peers. More troubling is that the Black+Hispanic+Native students are significantly less likely than international students to feel that their contributions are respected by their advisors. This may be related to the substantial number of foreign-born faculty at our three

institutions. We have anecdotal evidence that some foreign-born faculty seek to admit students from their native countries, which may explain why international students feel respected and understood. Feeling disrespected becomes another hurdle for the students to overcome, in addition to not receiving adequate guidance in conducting research.

The overarching goal of the NSF AGEP program is to "increase the number of historically underrepresented minority faculty in STEM" [14] and thus among the outcomes for the AGEP-NC Alliance is to prepare underrepresented citizen students for faculty positions following the completion of their degrees. Although proper preparation for faculty positions is to some extent discipline specific, being provided with opportunities to teach and mentor undergraduate students is one way to help students prepare. There were significant differences among ethnic groups related to opportunities to teach and attend workshops on teaching. Here, international students had significantly more opportunities than White+Asian students. Black+Hispanic+Native students did not differ significantly from either international students or White+Asian students, which may be a result of the small sample size. These differences may be related to career plans since 45% of international students expressed a desire for an academic career, either immediately post-graduation or following work in industry or a post-doc, which may be related to a desire to remain in the U.S. following graduation. Fewer White+Asian students and Black+Hispanic+ Native students (32% and 19% respectively) expressed a desire for an academic position. Another possibility is that international students may be more likely to consider teaching positions during their graduate programs in order to fund their education where U.S. students may have other sources of funding. The importance of teaching experience relative to research productivity for people applying for academic positions may differ by discipline and impact how students and faculty responded to these questions.

Implications

It is clear through the work of the AGEP-NC Alliance that we recognize that change requires a collective approach that involves investment by faculty, department heads, and campus leaders. Removing barriers to success on campuses requires working across the silos that usually exist in higher education institutions. Faculty are like independent entrepreneurs. They have additional responsibilities and goals such as their own research productivity that may take precedence over their willingness to change their advising behavior. If faculty have the opportunity to fully understand how that how well they advise their doctoral students will in fact enhance their own research productivity and make a difference and not impede their goals we may see some significant changes. We hope to find that after two years of departments' participation in the AGEP-NC Alliance that students will report more consistently positive advising experiences and that the gap between Black+Hispanic+Native U.S. citizens and other students is reduced.

Limitations

The COVID-19 pandemic may have impacted the results of the 2020 and 2021 surveys in unknown ways, but all students with three or more years in their doctoral programs will have had at least some pre-pandemic experience in their program. Students were not asked how comfortable they felt with advisors who were different from them on sociodemographic characteristics so direct comparisons to faculty responses to these questions is not possible. Persons with race and gender identifications who might be considered the only one or one of a few in their departments may have declined to answer demographic questions or the survey

itself, in spite of assurances of confidentiality from the evaluators. Therefore, the results may understate the experiences of people in underrepresented groups. In fact, the responses of the people who did not provide demographic information are generally more negative than the responses of those who did but we do not present them here.

Future Work

Future work will include comparing post-survey results to the pre-survey results to assess changes that may have been made as a result of the departments' participation in the AGEP-NC Fellows program. In addition, open-ended questions, which would give insight into the nuances of the student and faculty responses will be analyzed.

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References

[1] B. A. Burt, A. McKen, J. Burkhart, J. Hormell and A. Knight, "Black men in engineering graduate education: Experiencing racial microaggressions within the advisor-advisee relationship," *Journal of Negro Education,* vol. 88, no. 4, pp. 493-508, 2019.

[2] K. A. Truong and S. D. Museus, "Responding to racism and racial trauma in doctoral study: An inventory for coping and mediating relationships," *Harvard Educational Review,* vol. 82, no. 2, pp. 226-254, 2012.

[3] B. A. Burt, C. M. Mccallum, J. D. Wallace, J. J. Roberson, A. Bonanno and E. Boerman, "Moving toward stronger advising practices: How Black males' experiences at HPWIs advance a more caring and wholeness-promoting framework for graduate advising," *Teachers College Record,* vol. 123, no. 10, pp. 31-58, 2021.

[4] P. Felder, "On doctoral student development: Exploring faculty mentoring in the shaping of African American doctoral student success," *The Qualitative Report,* vol. 15, no. 2, pp. 455-474, 2010.

[5] C. M. Millett and M. T. Nettles, "Expanding and cultivating the Hispanic STEM doctoral workforce," *Journal of Hispanic Higher Education,* vol. 5, no. 3, pp. 258-287, 2006.

[6] K. De Welde and S. L. Laursen, "The 'Ideal Type' advisor: How advisors help STEM graduate students find their 'Scientific Feet'," *The Open Education Journal,* vol. 1, pp. 49-61, 2008.

[7] B. E. Lovitts, Making the Implicit Explicit: Creating Performance Expectations for the Dissertation, Sterling, VA: Stylus Publishing, 2007.

[8] E. A. Ensher, C. Thomas and S. E. Murphy, "Comparison of traditional, step-ahead, and peer mentoring on protégés' support, satisfaction, and perceptions of career succeess: A social exchange perspective," *Journal of Business and Psychology,* vol. 15, pp. 419-438, 2001.

[9] C. Pfund, A. Byars-Winston, J. Branchaw, S. Hurtado and K. Eagan, "Defining attributes and metrics of effective resarch mentoring relationships," *AIDS and Behavior,* vol. 20, no. S2, pp. 238-248, 2016.

[10] K. A. Rockquemore, "A new model of mentoring," 22 July 2013. [Online]. Available: https://www.insidehighered.com/advice/2013/07/22/essay-calling-senior-faculty-embrace-new-style-mentoring.

[11] B. L. Montgomery, "Mapping a mentoring roadmap and developing a supportive network for strategic career advancement," *Sage Open,* vol. 7, pp. 1-13, 2017.

[12] R. N. Chapman, "The thrive mosaic developmental framework: A systems activist approach to marginalized STEM scholar success," *American Behavioral Scientist,* vol. 62, no. 5, pp. 600-611, 2018.

[13] American Society for Engineering Education, "Engineering and Engineering Technology by the numbers," American Society for Engineering Education, 2020.

[14] National Science Foundation, "Alliances for Graduate Education and the Professoriate (AGEP)," 2021. [Online]. Available: https://beta.nsf.gov/funding/opportunities/alliances-graduate-education-and-professoriate-agep. [Accessed 2 September 2022].

[15] M. Gumpertz, R. Brent, C. D. Campbell, M. Grasso, Y. M. Huet and K. A. Schimmel, "An institutional transformation model to increase minority STEM doctoral student success," in *2019 CoNECD - The Collaborative Network for Engineering and Computing Diversity*, Crystal City, VA, 2019, April.

[16] K. A. Schimmel, C. D. Campbell, M. Gumpertz, Y. M. Huet, A. D. Kelkar and J. P. Kizito, "Minority STEM doctoral student success (Experience)," in *Proceedings of the 2020 ASEE Virtual Annual Conference*, 2020.

[17] M. Grasso and C. D. Campbell, "A change model that helps faculty mentor underrepresented minorities (URM) doctoral students for the STEM professoriate," *The Chronicle of Mentoring and Coaching,* vol. Special Issue 13, no. 1, pp. 407-412, 2020.

[18] M. Gumpertz, D. Foster, M. Grasso and Y. M. Huet, "Creating continuous change: Adapting and NSF ADVANCE approach to the development of the AGEP-NC model of institutional transformation," *The ADVANCE Journal,* vol. 3, no. 1, 2022.

[19] R. Brent, K. Schimmel and M. Gumpertz, "How do departments support their underrepresented minority doctoral students? Are they doing enough?," in *2021 CoNECD Virtual Conference*, 2021.

[20] B. J. Barnes and A. E. Austin, "The role of doctoral advisors: A look at advising from the advisor's perspective," *Innovative Higher Education,* vol. 33, pp. 297-315, 2009.

[21] C. Mircioiu and J. Atkinson, "A comparison of parametric and non-parametric methods applied to a Likert scale," *Pharmacy,* vol. 5, no. 2:26, May 2017.

[22] B. A. Burt, K. L. Williams and W. A. Smith, "Into the storm: Ecological and sociological impediments to black males' persistence in engineering graduate programs," *American Educational Research Journal,* vol. 55, no. 5, pp. 965-1006, 2018.