Developing a Research and Mentoring Training Tool for Minority Graduate Students in Engineering

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Cara London, Texas A&M University

Cara is a Ph.D. student in the Biological and Agricultural Engineering Department at Texas A&M University. Her research focuses on understanding shared patterns of cultural influence on engineering decisions. She is particularly interested in the integration of behavioral modeling into engineering design decisions and adoptability predictions of health preserving technologies, specifically, regarding rural and smallholder stakes.

Eldridge Raymond Jr., Texas A&M University

My name is Eldridge Raymond Jr., and I am an Interdisciplinary Engineering Department (ITDE) graduate student at Texas A&M University. I work for the Naval Undersea Warfare Center (NUWC) Division Keyport in Keyport, WA and I work as an Information Systems Security Officer (ISSO). I also recruit for NUWC Keyport and NAVSEA (Naval Sea System Command).

I believe that the next major conflict between countries will be conducted within the realm of cyberspace and the United States needs to be at the forefront of technology and have the ability to protect this nation from any attacks within cyberspace. In addition to currently working on my PhD focused on Autonomous Shipping and the Impacts on Agricultural Terrorism, I have a Master's Degree in Systems Engineering from the Naval Postgraduate School and my Bachelor's Degree in Computer Science. I am also CompTIA Security + Certified.

I am a military dependent and I was raised in numerous places (California, England, and Texas) but the majority of my upbringing was in Wichita Falls, TX. I am a graduate of S.H. Rider High School in Wichita Falls, TX. I have had internships and worked for companies such as Siemens Automation and Engineering, National Aeronautics Space Administration (NASA) - Johnson Space Center (JSC), The Raytheon Company, The Boeing Company (Space Division), Alcatel, USA (Alcatel-Lucent) and the Naval Sea Systems Command (NAVSEA).

My professional goals consist of achieving the position of Senior Executive Service (SES) member within the Department of Defense (DoD). Afterwards, I would like to pursue either a research position at a national laboratory, think-tank, or board of directors and/or academia as a second career.

I am a certified scuba diver, I enjoyed skydiving, trying different foods/eating, traveling the world, live sporting events/comedy shows, attending events such as Homecoming at Prairie View A&M University, spending time with my family, friends, fraternity brothers, and love ones!

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Abstract

Effective mentoring is critical to the success of graduate students; however, many mentors lack the skills and resources necessary to provide comprehensive support. To address this issue, the STAND model offers a framework for faculty mentors to guide and support their students through five main actions: setting expectations, providing training and education, activating and motivating, facilitating network development, and documenting and analyzing progress. In this paper, we synthesize the current literature on mentoring in graduate education, highlight the main actions of the STAND model, and discuss limitations and next steps. Our methodology includes a systematic review of graduate-level mentorship literature with a focus on identifying areas for improvement, particularly as it pertains to minority graduate students. To implement the STAND model effectively, faculty mentors must be educated and trained on its principles, and clear guidelines and expectations should be established. Ongoing evaluation and feedback are also essential. Our findings suggest that academic mentorship has traditionally focused on learning rather than career development or psychosocial needs, highlighting a gap that the STAND model aims to address. By implementing the STAND model, institutions have the potential to foster positive mentoring relationships and support the success of graduate students. We recommend that institutions prioritize effective mentoring strategies and incentivize the retention of diverse students to build a stronger and more inclusive community of scholars.

Introduction

The United States is facing a surge in the demand for science, technology, engineering, and mathematics (STEM) professionals due to global economic shifts, but the undergraduate turnover rate for students majoring in STEM disciplines remains one of the highest among all undergraduate students (Science and engineering indicators, 2006 ; Tinto, 1993). This leads to low ranking in terms of the supply of STEM professionals and threatens the nation's economic dominance in the global marketplace. As a result, a considerable amount of research has been generated to develop intervention and preventative initiatives, including mentorship programs that address the primary causes of student attrition from STEM fields.

Less than half of students who enroll in STEM undergraduate programs as first-year students graduate with a STEM degree at the national level (Hayes et al., 2009). In part as a result of these high attrition rates, the United States has a consistently low ranking in terms of the supply of STEM professionals, which, as some political leaders and others have noted, threatens the nation's economic dominance in the global marketplace (Committee on Prospering in the Global Economy of the 21st Century (US) and Committee on Science Engineering and Public Policy (US) 2007; Galama et al., 2007; Lapointe et al., 1989).

There is also evidence that shows a considerable number of graduate students in STEM fields switch out of their field during graduate school, with rates ranging from 30-50% (Huang, 2017). This can be attributed to a variety of factors, such as a lack of interest or passion, difficulty with coursework or research, insufficient mentoring or support, and challenges with work-life balance (Schultz, 201; Chen, 2009 and 2013). The high rates of switching out of STEM

fields have implications for the pipeline of STEM professionals and can lead to a shortage of qualified professionals in certain areas(National Science Foundation, 2018 and 2019; National Academy of Sciences, 2019). To address this issue, strategies such as improving mentoring and support systems, providing professional development opportunities, increasing diversity and inclusivity in STEM fields, and better aligning graduate programs with the needs and interests of students may be effective. By implementing these strategies, it may be possible to improve retention rates and ensure a steady supply of qualified STEM professionals.

A considerable amount of research has been generated as a result of the high dropout rate among students majoring in STEM fields, and this has led to the development of a great deal of intervention and preventative initiatives. Some of these programs have targeted the preparation that STEM majors receive before enrolling in post-secondary programs (Harper, 2010; Roemer et al., 2020), others have focused on the experiences of STEM students on university or college campuses (Kelley et al., 2016; Moore et al., 2020), or on implementing a new and refined mentorship strategy for faculty and administrators that mentor undergraduate and graduate students.

Theoretical Framework

The mentorship strategy is built on the concept that mentoring is one of the main components that will result in college and post-college perseverance in STEM areas. This approach involves providing graduate students with a mentor who can provide guidance and support throughout their academic journey. The mentor should be knowledgeable in the field of study, possess effective communication skills, and be available to provide feedback and advice as needed.

To further improve graduate student retention in STEM fields, it is essential to create a supportive and inclusive environment that values diversity and provides opportunities for students to engage in research and other activities that align with their interests and career goals. One potential solution to this problem is to develop effective mentoring approaches that can provide support and guidance to minority students as they navigate the complexities of STEM education and careers. Through this literature review, we aim to identify gaps in current mentoring approaches for minority graduate and undergraduate students in STEM fields and develop a new mentoring strategy that addresses their specific needs and challenges.

Historically, academic mentorship has concentrated on learning rather than career development or psychosocial needs (Ensher, 1997; Stromei, 1998). According to research, undergraduate students who are mentored had higher GPAs, greater retention rates, and more units finished each semester than their unmentored peers (Campbell and Campbell 1997). Mentoring addresses key aspects of student identification and social integration into scholarship and academic community (Freeman 1999; Good et al. 2000; DuBois et al. 2002) and serves as a support base system for students who are historically underrepresented in STEM fields (Good et al. 2000; Summers and Hrabowski 2006). There is limited research on graduate student retention, however, several studies suggest that factors such as financial support, mentoring, sense of community, and engagement in research and professional development opportunities can positively impact graduate student retention rates (e.g., Golde & Dore, 2001; Lovitts, 2001; Tinto, 1993).A condensed, thorough mentor model can be an effective way to improve graduate

student retention in STEM fields. This approach involves providing graduate students with a mentor who can provide guidance and support throughout their academic journey. The mentor should be knowledgeable in the field of study, possess effective communication skills, and be available to provide feedback and advice as needed.

Through this approach, graduate students can develop a stronger sense of community and belonging, which can help them stay motivated and engaged in their studies. Additionally, a mentor can provide guidance on career opportunities and help students develop the skills they need to succeed in their chosen field.

To further improve graduate student retention in STEM fields, it is essential to create a supportive and inclusive environment that values diversity and provides opportunities for students to engage in research and other activities that align with their interests and career goals. This can include providing access to resources such as workshops, seminars, and networking events.

In recent years, there has been growing concern about the underrepresentation of minority students in science, technology, engineering, and mathematics (STEM) fields. Despite efforts to increase diversity and inclusion in these fields, minority students continue to face significant challenges that can lead to lower retention rates and reduced success in their academic and professional careers. One potential solution to this problem is to develop effective mentoring approaches that can provide support and guidance to minority students as they navigate the complexities of STEM education and careers.

Through this literature review, we aim to identify gaps in current mentoring approaches for minority graduate and undergraduate students in STEM fields. By examining the existing literature on mentoring and retention in STEM fields, we hope to gain a deeper understanding of the challenges that minority students face, as well as the factors that contribute to successful mentoring relationships. With this knowledge, we can develop a new mentoring strategy that addresses the specific needs, challenges of minority students, and provides them with the support and resources they need to succeed in STEM fields and therefore reduce attrition rates.

Methods

A systematic review's goal is to summarize all primary research that has been conducted in order to address a specific research issue. Our review question was, how can we increase graduate student retention in STEM subjects through graduation? The ability to narrow down database results in such a way that one could conduct a repeatable process for each term was made possible by using the search criteria to identify themes that connected to the authors shared experiences.

The inclusion criteria for the search were the search terms mentor*, engineer*, STEM*, and graduate* alongside publication years 2018 to 2023. A systematic review entails a thorough search of all relevant literature on the subject, including peer-reviewed journal articles, conference proceedings, and other publications. This guarantees that the review includes all relevant research. This process reduces bias by incorporating a rigorous procedure of research selection, data extraction, and quality evaluation, which aids in the reduction of bias in the review process. It is a transparent and reproducible method that allows others to replicate the study and assess the quality of the evidence. Through the search a more thorough and nuanced

understanding of the effectiveness of mentoring techniques in promoting graduate student retention in STEM areas was gained than relying on anecdotal evidence alone. Because it allows for a comprehensive search, minimizes bias, is transparent and replicable, synthesizes evidence from multiple studies, and identifies gaps in the literature, a systematic review is the best way to answer the question of how to improve graduate student retention in STEM fields through mentoring approaches.

Results

Mentoring has been recognized as a promising approach to improve graduate student retention in STEM fields. While the literature on mentoring is extensive, several gaps in the research have been identified. Firstly, most of the research has focused on the short-term effects of mentoring treatments, and there is a need for long-term studies to evaluate the impact of mentorship on graduate students' employment and success after graduation. Secondly, while the qualities of the mentor have received significant attention in mentoring models, the impact of mentee qualities, such as motivation and cultural background, on the mentoring relationship has been understudied. Thirdly, the intersectionality of graduate students' identities, including race, ethnicity, gender, and sexual orientation, and how it may affect mentoring relationships and retention rates, has not been thoroughly explored. Fourthly, there is a lack of clarity on the most effective formats and structures of mentoring for various graduate student groups. Finally, while most of the existing work on STEM mentoring has been conducted in academic settings, the role of mentoring in professional contexts, where graduate students may face unique challenges, requires further investigation. Addressing these gaps in the literature will contribute to a more comprehensive understanding of the role of mentoring in enhancing graduate student retention in STEM fields, which could inform the development of effective mentoring interventions.

Systematic review results

From the abstracts reviewed, 38 related directly to our search criteria. The ones that were excluded, mainly related to undergraduate mentoring. Some works showed strong connections between undergraduate mentoring and students propensity to enter graduate school.

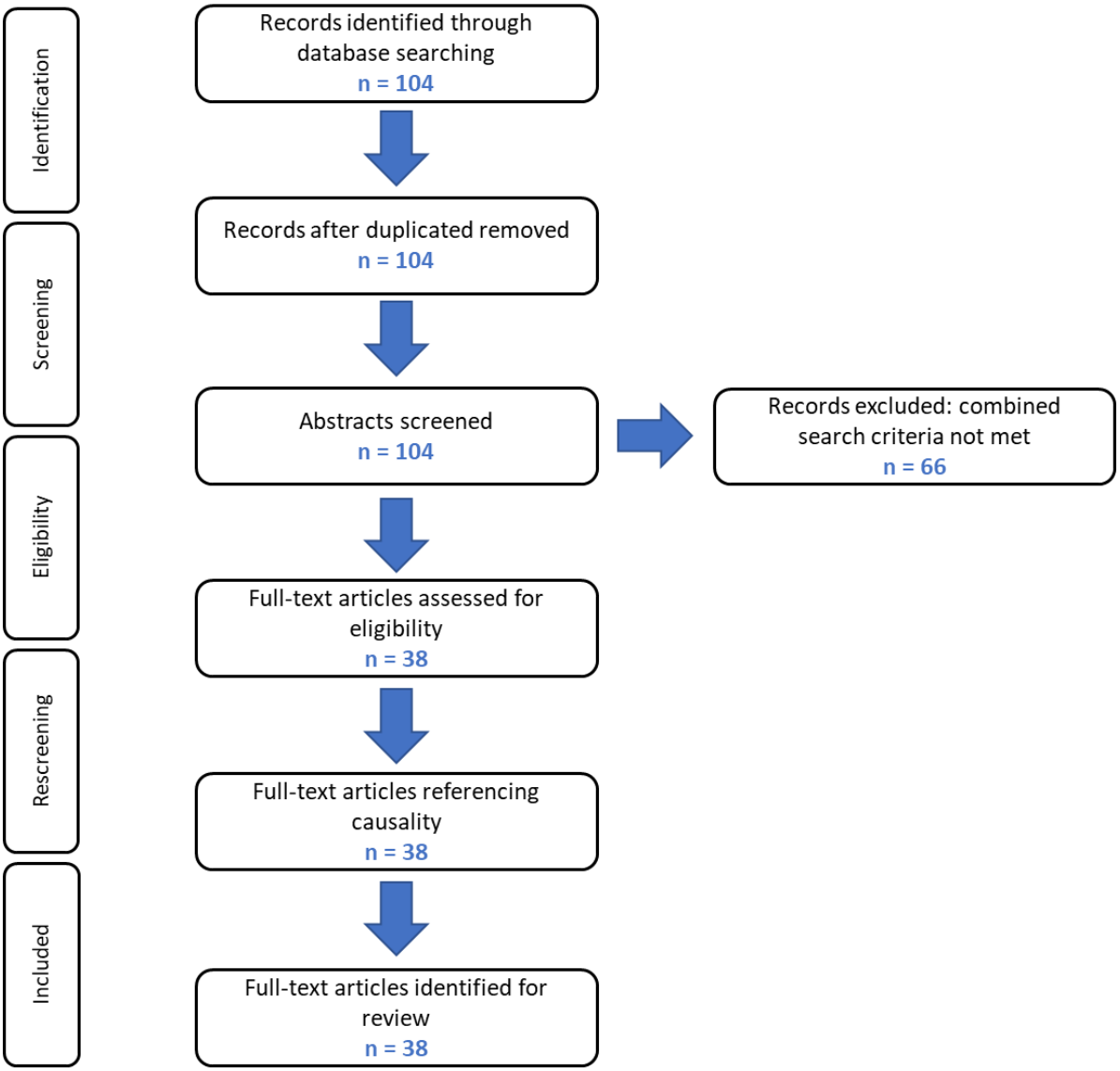

Figure 1. Systematic Review Flow Chart

Previous STEM mentoring models

There have been several mentoring models developed for minority graduate students in STEM fields, including:

1. The Meyerhoff Scholars Program: This program at the University of Maryland, Baltimore County (UMBC) provides mentoring, academic support, and research opportunities for underrepresented minority students in STEM fields. The program has been successful in increasing the number of minority students who complete STEM degrees and go on to graduate school or professional careers in STEM fields.
2. The Alliances for Graduate Education and the Professoriate (AGEP) Program: This program, funded by the National Science Foundation, supports the development of

mentoring programs for underrepresented minority graduate students in STEM fields. The program aims to increase the number of underrepresented minority students who earn STEM doctorates and pursue academic careers.

3. The Center for the Integration of Research, Teaching, and Learning (CIRTL): This program, based at several universities across the United States, provides mentoring and professional development opportunities for graduate students and postdoctoral researchers in STEM fields. CIRTL aims to increase the diversity and effectiveness of STEM faculty by providing mentoring and training in evidence-based teaching practices.
4. The Louis Stokes Alliance for Minority Participation (LSAMP) Program: This program, funded by the National Science Foundation, provides mentoring, academic support, and research opportunities for underrepresented minority undergraduate and graduate students in STEM fields. The program aims to increase the number of underrepresented minority students who earn STEM degrees and go on to graduate school or professional careers in STEM fields.
5. The National GEM Consortium: This program provides mentoring and financial support for underrepresented minority graduate students in STEM fields who are pursuing doctoral degrees. The program aims to increase the diversity of the STEM workforce by providing support for underrepresented minority students to earn advanced degrees in STEM fields.

There are several mentoring models that have been developed for minority graduate students in STEM fields, including programs like the Meyerhoff Scholars Program, AGEP, CIRTL, LSAMP, and the National GEM Consortium. These programs provide mentoring, academic support, research opportunities, and financial support for underrepresented minority students, with the goal of increasing diversity in STEM fields and promoting the success of minority graduate students in STEM.

Addressing minorities specifically

Minority graduate students in STEM fields often face unique challenges, including a lack of representation and mentorship in their fields. Addressing these challenges requires specific attention to mentoring approaches that can support and empower minority graduate students to persist through graduation. Some ways in which the literature on mentoring approaches to improve graduate student retention in STEM fields can be applied specifically to minorities are:

1. Culturally Responsive Mentoring: Culturally responsive mentoring can be particularly beneficial for minority graduate students, as it recognizes and respects their cultural backgrounds and experiences. This approach can help to build trust and rapport between mentors and mentees, provide a safe space for discussion of sensitive topics, and increase the effectiveness of mentoring relationships.
2. Peer Mentoring: Peer mentoring can be particularly effective for minority graduate students, as it provides a supportive environment where they can connect with peers who have faced similar challenges. Peer mentoring can also help to address feelings of isolation and provide a sense of community among minority graduate students.
3. Faculty Mentoring: Faculty mentoring can be particularly beneficial for minority graduate students, as it can provide access to role models who can help to guide their academic

and professional development. Faculty mentors can also provide support and advocacy for minority graduate students, helping them to navigate the academic and professional challenges they may face.

4. Intersectional Mentoring: Intersectional mentoring recognizes the multiple identities and experiences that minority graduate students may have and provides tailored support that addresses their unique needs. This approach can help to address the complexity of the challenges faced by minority graduate students and provide more effective support.
5. Professional Development Mentoring: Professional development mentoring can be particularly beneficial for minority graduate students, as it can provide guidance and support in navigating the job market and building professional networks. This approach can help to prepare minority graduate students for successful careers in their fields.

The literature on mentoring approaches to improve graduate student retention in STEM fields can be applied specifically to minorities by using culturally responsive mentoring, peer mentoring, faculty mentoring, intersectional mentoring, and professional development mentoring. These approaches can help to address the unique challenges faced by minority graduate students and support them to persist through graduation and succeed in their careers.

Types of mentoring relationships

There are several types of mentoring relationships that can be used to support graduate students in STEM fields. These include:

1. Traditional Mentoring: This is the most generic form of mentoring and involves a one-on-one relationship between a mentor and a mentee. The mentor provides guidance, advice, and support to the mentee as they navigate their academic and professional development.
2. Peer Mentoring: This type of mentoring involves a relationship between peers who have similar levels of experience and can provide support, feedback, and guidance to each other. Peer mentoring can be especially beneficial for graduate students who may feel isolated or disconnected from their academic community.
3. Group Mentoring: This involves a mentoring relationship between a mentor and a group of mentees. Group mentoring can provide a sense of community and support for mentees and can also allow for the sharing of experiences and ideas among the group.
4. Informal Mentoring: This type of mentoring relationship is less structured and may occur spontaneously between a mentor and mentee. It can take the form of occasional conversations or interactions that provide support and guidance to the mentee.
5. E-Mentoring: E-mentoring involves mentoring that takes place online, through email, video conferencing, or other digital communication channels. E-mentoring can be beneficial for graduate students who may not have easy access to mentors in person.
6. Reverse Mentoring: In this type of mentoring relationship, the mentee takes on a mentoring role for the mentor. This can be useful when the mentor is seeking to learn more about the experiences and perspectives of the mentee, such as when a senior faculty member mentors a graduate student from a diverse cultural background.

There are several types of mentoring relationships that can be used to support graduate students in STEM fields. Each type has its own advantages and can be used in different situations depending on the needs of the mentee and the goals of the mentoring relationship.

Components for success

There are several components that are important for the success of a mentoring relationship:

1. Clear Goals and Expectations: A mentoring relationship should begin with a discussion of the goals and expectations of the mentor and the mentee. This can help to establish a shared understanding of what the mentoring relationship is intended to achieve and what each party hopes to gain from it.
2. Regular Communication: Regular communication between the mentor and mentee is critical for the success of the mentoring relationship. This can take the form of regular meetings, check-ins, or other forms of communication that allow the mentor and mentee to stay connected and provide support as needed.
3. Trust and Rapport: A successful mentoring relationship requires trust and rapport between the mentor and mentee. This can take time to develop, but can be facilitated by open and honest communication, active listening, and mutual respect.
4. Flexibility: A mentoring relationship may need to evolve over time to meet the changing needs of the mentee. This may require flexibility on the part of the mentor to adapt to new goals, challenges, or circumstances.
5. Feedback and Evaluation: A successful mentoring relationship should include opportunities for feedback and evaluation. This can help the mentor and mentee to assess progress towards goals, identify areas for improvement, and adjust as needed.
6. Accountability: Both the mentor and mentee should be accountable to each other for the success of the mentoring relationship. This may involve setting specific benchmarks or milestones, and following through on commitments made.

A successful mentoring relationship requires clear goals and expectations, regular communication, trust and rapport, flexibility, feedback and evaluation, and accountability. These components can help to establish a strong mentoring relationship that supports the academic and professional development of the mentee.

Discussion

The components for success from the literature examined in the systematic review were used to identify five pillars of graduate mentoring, which we call STAND. The components for success in retention of minority graduate students in STEM fields through mentoring include:

1. Culturally responsive mentoring: Mentors who are aware of and responsive to the cultural backgrounds, experiences, and needs of minority students can help to create a supportive and inclusive mentoring environment. (Campbell et al., 1997) noted that imposter phenomena needed to be addressed in order to affect change in diverse students matriculation through their education and into the workforce.

2. Mentoring networks: Building a mentoring network that includes multiple mentors from diverse backgrounds can provide minority graduate students with a range of perspectives and support.
3. Research opportunities: Providing minority graduate students with research opportunities that align with their interests and goals can help to increase their engagement and sense of belonging in the field.
4. Professional development: Providing opportunities for professional development, such as workshops and conferences, can help minority graduate students develop the skills and knowledge needed to succeed in their field.
5. Peer support: Building a supportive community of peers can help minority graduate students to feel connected and supported in their academic and professional development.
6. Leadership development: Providing opportunities for leadership development can help minority graduate students to develop the skills and confidence needed to take on leadership roles in their field.
7. Funding and financial support: Providing funding and financial support, such as scholarships, fellowships, and research assistantships, can help to alleviate financial barriers that may prevent minority graduate students from completing their degree.

Success in retaining minority graduate students in STEM fields through mentoring requires a culturally responsive mentoring approach, mentoring networks, research opportunities, professional development, peer support, leadership development, and funding and financial support. By implementing these components, mentors can create a supportive and inclusive mentoring environment that supports the academic and professional development of minority graduate students in STEM fields.

The themes supported in the literature have been synthesized into 5 main actions by the current authors illustrated in figure 2. Faculty mentors should work with their students to set mutual expectations, train and teach their students throughout the main and auxiliary functions of a graduate program, support students' self actualization and actively motivate them, contribute to the student's professional and academic network development, and make use of formal documentation to keep track of not only progress towards students' goals, but also of the faculty member’s own involvement.

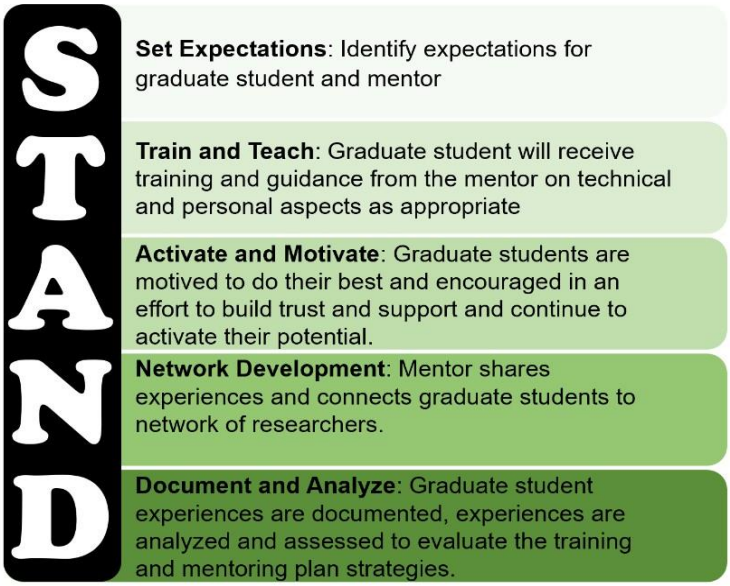

Figure 2. The STAND Model (Authors)

Set Expectations

Setting expectations at the beginning of the faculty (mentor)-student (mentee) relationship is a critical first step. Not only will dialogue about boundaries and expectations open both parties up to each other - deepening the bond - but will also help piece together each party's background. There can be no culturally responsive mentoring without acknowledgment of individual and current workplace cultures. Universities and faculty always set expectations for students: credit hours, teaching responsibilities, theses, etc. Good mentoring (good relationships in general) require space for both parties to set expectations for the other and that those expectations are respected and observed. Faculty/student power dynamics may intimidate students into staying quiet about breached boundaries or unmet needs. About the culture of graduate school in general it can be said that students are expected to endure any amount of strife under their principal investigators. In STEM fields, this manifests in long lab hours, overburdened TAs, extreme publishing pressure, or limited development experiences outside of research. Discussion of any and all expectations must take place at the beginning of mentor/mentee relationship and should be reviewed throughout. Explained more later in the paper, these expectations would be well documented. In the STAND model, expectations are not something given, they are established through mutual understanding and compromise and can change over time. Of course, certain expectations are uncompromisable; PhD students must defend a dissertation, teaching assistantships require teaching. We maintain that those are more akin to job requirements than to expectations for the relationship between faculty and student. An example of an expectation may be that the pair meet at least once a month. Another example in the form of a boundary expectation is that the student will not answer work

related emails after business hours. Mentors are recommended to ask as many questions as possible about the mentee's expectations using examples. This is because the student may not even know of something to be brought up. Each of us holds assumptions that the other does not know. That is why the STAND model emphasizes this important first step.

Train and teach

After assessing skills and expectations for the degree program, mentors should train students to improve their performance and close skill gaps. Students do not enter a program with the same knowledge or skill level in all areas. Rather than leaving the student to fend for themselves and struggle, mentors should address and skill concerns quickly. This applies not only to discipline or research specific skills but also to navigating academia and the degree program. Faculty should teach students about university resources and research procedures. Although independent work is a major component of graduate level studies, passing off all training responsibility to the student is irresponsible and can have long term effects not only on the quality of work produced but also student mental health as they deal with the burden of insecurity and the lack of motivation that accompanies perceived incompetence (Clark et al., 2014; Liebendörfer & Hochmuth, 2017). Feeling competent in one's work is a necessary part of the ability to self motivate (Ryan & Deci, 2002). Establishing that feeling early on via training could turn out to be the difference between success and failure.

As a mentor, teaching may be needed to manage various personal situations that come up. A faculty member may need to help lead a Black student through discrimination in her field or teach an international student about potential visa roadblocks. It may not be possible to prepare for each and every case, but the STAND model encourages faculty to be proactive. Take classes or read about emotional intelligence and educate yourself about managing new situations. There may be a feeling of "I wouldn't want to overstep" or "this is outside of my professional responsibilities." This stance, however, contributes to attrition and is antithetical to student development. Create an environment where students feel comfortable learning and seeking advice, even if the advice ultimately comes from a third party university service recommended by the mentor.

Activate and motivate

As self motivation is an important skill to have for success in rigorous programs like graduate degrees, the STAND model requires faculty to address each of those needs. According to Ryan and Deci's (2002) theory of self-determination, feelings of competence, relatedness or connection to others, and autonomy all play important roles in the ability to self motivate. Mentors can activate graduate student potential by supporting and feeding into these three psychological needs. External motivation (either via reward or punishment) provides the initial push towards actions, but cannot sustain them (Ryan & Deci, 2002). Providing a positive learning environment, setting achievable goals, and recognizing and rewarding students for their hard work contribute to increasing perceived competence while

establishing mutual trust. The other items of the STAND model feed into this activation as well. Network development contributes to fostering a sense of community and collaboration for students. Setting expectations reinforces a student's autonomy as a valued member of the research team. Training improves competence. For a student to reach self motivation is to help that student act and persist in the face of obstacles and challenges, which is necessary if we hope to improve retention rates until graduation. For minority students, faculty should consistently strive to create a safe and inclusive learning environment and to combat imposter syndrome. Feelings of inadequacy and self-doubt can lead to a lack of confidence and a fear of failure. Minorities already often feel like they do not belong or that they do not measure up to their peers. This can lead to a lack of motivation and a fear of taking risks, which can prevent minorities from achieving their full potential. Higher rates of imposter syndrome in minorities are acknowledged as a threat to the science career pipeline and retention rates (Chrouosos & Mentis, 2020). The STAND model addresses this threat by encouraging mentors to motivate and encourage mentees to remind them of their intrinsic worth and important contributions throughout their studies.

Network development

Mentors should play an active role in expanding mentees' academic and professional networks. Casual observation by the authors suggests that many minority graduate students are unsure both of how to network and of where to network. Faculty members are connected within their fields, departments, and often across their universities. After understanding their mentee's needs and goals within their career or research paths, it is the faculty member's responsibility to leverage connections to support said goals. Developing a mentee's network can be as simple as providing introductions or passing along opportunities. Faculty should also promote meaningful research collaborations. Collaborative research contributes to the researcher's ability to work effectively in a team, discipline specific knowledge, and degree completion, all while establishing concrete ties to other academic professionals. As previously stated, these ties can help minority students, who already have a lessened sense of belonging, engage with an increased feeling of acceptance. Worth noting is that while faculty may find providing academic contacts easy, many students also desire industry contacts. At the doctoral level especially, much weight is placed on pure academic research and the transition to postdoctoral or faculty positions. Some students may leave programs early for industry jobs for a myriad of reasons. Networking with industry professionals can show students the value of completing their STEM degree prior to entering the workforce by broadening their perspectives on various jobs and their own value. As a student progresses throughout their program, the network needs may change. Mentors must work with their students to gauge how best to increase the size and quality of the student's network.

Document and analyze

In research, the necessity of proper documentation is well established, however, this is rarely the case for interpersonal relationships. There are documented benchmarks for graduate students such as degree plans, proposals, and theses. Although important for the documentation of work completed towards the degree, they are very rarely qualitative or quantitative of the experience had by the student. Just as a degree plan or a proposal sets expectations and outlines a plan of action for work, an Individual Development Plan (IDP) additionally documents the expectations and action items for the working relationship between a faculty mentor and their student. The IDP was developed by the American Association for the Advancement of Science and experts from multiple universities as a tool for students to assess their skills and career goals. Individual universities or departments may have their own version building from the AAAS IDP or similar plan. The mentoring and development sections of an IDP from a large, public university is included as an appendix. One of the features of an IDP is that it is a living document and should be updated regularly throughout the degree program. Mentors can have students complete the forms ahead of their first official meeting, then discuss during the meeting. This allows for students to come with meaningful questions and gives them prompts even when they may not be sure what to ask. This is an excellent feature for all students, but especially for minority students who may feel intimidated or have limited prior experience in similar situations than their peers. It also helps train faculty on baseline mentoring and gives structure to the relationship. Documenting also gives mentors data on how their students are doing compared to their goals and how they themselves are doing in supporting the student. Overtime, as many students complete these IDPs, the mentor can analyze patterns and adjust. Without any documentation, it can be difficult for students to make grievances or for faculty to ensure they are living up to their set expectations for the other aspects of the STAND model.

Conclusion

The research synthesized by the authors highlights the critical role that faculty mentors play in supporting the success of their graduate students. The five main actions identified by the authors represent key areas where faculty mentors can make a meaningful impact on the academic and professional development of their students.

The first action, setting mutual expectations, is important because it establishes clear guidelines and goals for both the mentor and student. This helps to ensure that both parties are on the same page and working towards the same objectives.

The second action, providing training and teaching on both the main and auxiliary functions of a graduate program, is critical because it helps students develop the skills and knowledge necessary to succeed in their program and in their future careers. This could include providing instruction on research methods, academic writing, or other key skills relevant to the program.

The third action, supporting students' self-actualization and actively motivating them, is important because it helps students to develop a sense of agency and self-efficacy. This can be

achieved through encouragement, positive feedback, and support for their personal and professional growth.

The fourth action, contributing to the development of the student's professional and academic network, is critical because it can help students build valuable connections and opportunities for their future careers. This could include introducing students to relevant professionals in their field, helping them network at conferences or other events, or providing guidance on how to build a strong professional brand.

Finally, the fifth action, keeping formal documentation to track progress towards students' goals as well as the faculty members' own involvement, is important because it helps to ensure accountability and progress. By keeping track of goals and progress, both the mentor and student can stay on track and make necessary adjustments along the way.

Limitations and Recommendations

Incorporating the STAND model into mentoring comes with several limitations and challenges, with mentor accountability being one of the biggest hurdles. This refers to the challenge of mentors devoting sufficient time to each student in order to get the best results from the mentoring relationship. This can be particularly difficult for faculty mentors who may have multiple mentees or other responsibilities that compete for their time and attention. In order to address this limitation, the recommendation is for mentors to find ways to connect their students with other mentors or peers within the department who can provide support. This can help to alleviate the burden on any one mentor and distribute the workload more evenly. Additionally, incentivizing effective mentoring strategies and retention of diverse students within the department can help to encourage faculty to prioritize mentorship and devote more time and resources to their students.

The second limitation pertains to the "T" in the STAND model, which stands for "Train and teach". This refers to the challenge of mentors needing to handle personal situations that come up for their mentees, such as discrimination or visa issues. Mentors may not always have the expertise or experience to manage these topics, which can make them uncomfortable or unsure of how to proceed. In these cases, it is recommended that mentors seek out appropriate resources or connect their students with potential support networks to help them address these issues. It is also important for faculty to take classes or seminars to educate themselves on how to manage these types of situations proactively, so that they are better equipped to support their students.

Next steps

To effectively implement the STAND mentoring strategy, several steps should be taken. Firstly, faculty mentors should be educated on the principles and techniques of the model, and trained on how to apply these concepts in their mentoring relationships. Clear guidelines and expectations should also be established for both mentors and mentees to facilitate mutual understanding and effective communication. Mentors should work with their students to set mutual expectations and establish goals and objectives for the mentoring relationship. They should also actively support their mentees' self-actualization and motivation, and contribute to their professional and academic network development. Formal documentation should be used

to keep track of progress towards students' goals, and of the faculty members' own involvement. The department should incentivize effective mentoring strategies and retention of diverse students, and provide support and resources to faculty mentors. Finally, ongoing evaluation and feedback should be conducted to assess the effectiveness of the STAND model, identify areas for improvement, and make necessary adjustments. By following these steps, institutions can effectively implement the STAND mentoring strategy and foster positive mentoring relationships between faculty and students.

Overall, effective mentoring is a critical component of graduate education and retention in STEM fields. The STAND model offers a comprehensive framework for faculty mentors to support and guide their students. By incorporating the five main actions of the STAND model, faculty mentors can provide their students with the necessary guidance, support, and resources needed to succeed in their academic and professional pursuits. However, implementing the STAND model requires careful planning, training, and ongoing evaluation to ensure its effectiveness. Institutions should prioritize effective mentoring strategies and incentivize retention of diverse students, as these efforts can contribute to the overall success of graduate programs. Through these efforts, institutions can build a stronger and more inclusive community of scholars, and support the next generation of leaders in their respective fields.

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