Self-Awareness and Mentoring in STEMM Research: Faculty Perspective

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Background

Self-awareness is a psychological construct described within the confines of philosophical underpinnings of psychology, and its definition is generally accepted by many disciplines. Self-awareness is our ability to see ourselves by becoming the object of our attention [1], [2], [3]. In mentoring relationships, particularly those in STEMM, it is required that those engaged in the mentoring relationships engage in some level of self-reflection if the mentorship is going to be effective [4]. However, self-awareness as a concept is often vaguely presented by using verbiage such as "practice self-reflection", "engage in introspection", and "understand your goals, motivations, and shortcomings", all of which describe aspects of the self-awareness process [2]. Because self-reflection is just one aspect of "becoming self-aware", mentors and mentees can still have limited self-awareness if there is no insight or new knowledge gained from their reflection practices. For engineering graduate students experiencing a decline in their mental health, a lack of self-awareness or dysfunctional self-awareness can exacerbate issues within the mentoring relationship. This may occur if they are misinterpreting or ignoring how others perceive them [2], [5]. If self-awareness is our ability to see ourselves by becoming the object of our attention [3], a lack of self-awareness may suggest that one cannot "see" or understand themselves internally. They cannot perceive how others may be perceiving them because they are unaware of the influence of their thoughts, emotions, and behaviors on their environment.

STEMM (science, technology, engineering, mathematics, and medicine) graduate students who engage in research mentoring relationships need to exercise a healthy degree of self-awareness while maintaining these relationships. In addition to their research mentoring relationships, they also have to balance their personal and professional life, while carrying out their research. Because of their many responsibilities, it is not surprising that graduate students often have a poor work-life balance, which has been linked to their poor mental health status [6]. This decline in mental health can negatively impact their ability to carry out their work and persist within their program [7], while simultaneously impacting their overall self-awareness. The increase in studies within the last five years shows that graduate students' mental and physical wellness is a growing problem [6], [8], [9], [10]. Even though graduate students are in mentoring relationships, often with their faculty research advisor, they do not feel comfortable turning to them for support [11], [12]. Prior research indicates many faculty feel their students' well-being is simply not their problem, while others do not feel properly trained to have such conversations with students regarding their personal problems, especially their mental health [12], [13]. Unlike a traditional research advisor, a research mentor is invested in their mentee's professional and personal development and may be more likely to engage in these crucial conversations [14], [15]. A graduate student's mental health can impact their personal development, which can be influenced by the quality of psychosocial support they receive from their mentor. According to the National Academies of Science, Engineering, and Medicine (NASEM) mentorship in STEMM focuses on research development (career support) and psychosocial support (psychological and social development) [4]. Despite this description of what STEMM mentoring relationships should entail, some mentors do not consider the psychosocial support of graduate students their responsibility [16]. This lack of engagement in psychosocial support can influence the self-awareness of the mentor and the mentee, which tends

to show up in the form of (mis)communication between the mentor and mentee. Studies have found that faculty tend to react negatively to students who attempt to address their mental health, and faculty are less likely to initiate conversations about the students' mental health [9], [17]. This negative reaction is thought to be related to the belief that graduate student productivity is under threat if mental health conversations arise, resulting in faculty being more likely to disengage in those conversations [13]. These actions are contrary to the psychosocial support necessary for effective mentoring relationships, which graduate students identify as a valued support [18]. Furthermore, these actions demonstrate a lack of self-awareness since the mentors appear not to understand how their disengagement or negative reaction is impacting the student mentees' mental and emotional well-being.

Beyond the psychological and emotional support of the mentee, psychosocial support functions include role modeling and socializing [4]. These functions work at the interpersonal level in a mentoring relationship [19]. Interpersonal relationships require each person to be open, align their expectations, and use effective communication strategies to achieve a goal [11]. Self-awareness is a construct that focuses on mental states and perceptions, whether those perceptions are internally or externally directed [3], [20], [21]. Lack of self-awareness can result in dysfunctional mentoring relationships, especially in the context of engineering, where faculty and graduate students expect the other to have self-awareness [11], [22], [23]. This often results from a lack of mutual understanding, caused by poor verbal and nonverbal communication. To better understand the self-awareness of graduate students, we previously surveyed STEMM graduate student mentors. To assess the state of their self-awareness, we used the Self-Reflection and Insight scale [24]. This scale focuses on private consciousness, which focuses on one's internal state, unlike public consciousness, which considers external awareness [1], [25]. The findings suggested that engineering graduate student mentors were less insightful than their non-engineering STEMM counterparts. These findings raised new questions about engineering graduate students' ability to understand self-awareness and how it impacts their mentoring relationships.

According to the literature, self-awareness occurs once insight is gained [1], [26]. The Objective Self-Awareness Theory, originally developed by Duval & Wicklund (1972), states that directing one's attention inward could lead to conscious self-awareness and ultimately ignite the process of self-evaluation. The process of self-evaluation involves engaging in self-reflection followed by the gaining of insight. They considered this to be an automatic process, however, later research would suggest that this is an intentional process that first begins with the recognition of a past or current event that gives rise to the need to direct attention to oneself [2], [3], [27], [28]. The conceptual framework driving this work states that the simple process to improve self-awareness in the context of engineering research mentoring relationships involves the following components in the following order: 1) Recognition of a past or present situation, experience, or moment; 2) Self-reflection on the identified moment, especially concerning one's thoughts, behaviors, and emotions during and after the experience; and 3) Gaining insight (clarity) or new knowledge from the self-reflection. Previous studies highlight the need for both the faculty mentor and the students to be self-aware and be able to communicate this awareness to each other to mitigate unintentional harm in the mentoring research relationships [11]. This unintentional harm can stem from a lack of awareness on the part of the mentor, since they have more research and mentoring experiences compared to the student and may assume their communication strategies translate across mentees. Furthermore, the unintentional harm caused

by a lack of awareness can give rise to dysfunctional mentoring experiences that negatively impact the mental and emotional health of students [29], [30]. This may lead current and future STEMM graduate students to struggle to persist in their programs, especially those in engineering programs [7], [9]. The opposite is also true, that the presence of self-awareness can help to foster more positive mentoring experiences, when the mentor and mentee understand their own being, especially any assumptions, biases, and motives they may have as they engage in mentoring relationships [31]. Studies addressing the presence or the lack of self-awareness and what the process of improving one's self-awareness might look like, particularly in engineering research mentoring relationships, are limited. Awareness in general is still a developing field within the context of engineering-related research that needs further exploration [11], [22], [24], [32].

Methods

To understand how self-awareness is described within the context of engineering research mentoring relationships, this work was initiated with a focus on the faculty perspective. Faculty often serve as research mentors to graduate students, in addition to providing academic advising and career guidance. Doctoral students may ultimately choose to pursue faculty positions where they will serve as mentors to new graduate and undergraduate students [33], [34]. Their engagement in these relationships is the training ground for the next generation of faculty. The training of engineers differs from that of psychologists. The value proposition of what's considered "important to know" within the respective fields is focused on different domains. Therefore, we anticipated that the described process of becoming self-aware would vary from what has been established through decades of research in the field of psychology. The research questions that guided this study are as follows:

1. **RQ 1 (Primary):** How do STEMM faculty research mentors describe the process to improve one's self-awareness?
    a. **RQ 1.1 (Secondary):** What concept from the conceptual framework of self-awareness appears most frequently based on the way STEMM faculty research mentors describe their mentoring experiences?
2. **RQ 2 (Primary)**: What are the qualitatively different ways STEMM faculty research mentors describe their mentoring relationships?

Positionality

For this study, the researchers were positioned as both an insider and outsider. The primary researcher is an insider to the study, as she is a graduate student researcher within the University of Florida. However, she is not a faculty member, which makes them an outsider to the perspectives presented. The secondary researcher is an insider, as she is a faculty member at the same university within the same department as the graduate student researcher.

Recruitment

All research was completed in accordance with the University of Florida's Institutional Review Board (IRB). Study participants were recruited from a single institution. Solicitations for participation were sent via email to STEMM faculty mentors affiliated with 1) Clinical and Translational Science Institute (CTSI) Mentoring Academy, 2) Biomedical Engineering Department, and 3) Maximizing Access to Research Careers (MARC) Mentoring Program. Of the 15 respondents, seven participated in a 45 minute – 1-hour long one-on-one interview.

Participants

Demographic information for each of the participants is shown below in Table 1. A total of seven STEMM faculty from six STEMM (science, technology, engineering, mathematics, and medicine) related departments at the University of Florida participated in this study. Participants were compensated $50 for their participation in the study after completing the interview. The study participants' races consisted of White (n=4), African American/Black (n=2), and Asian (n=1). Regarding the type of mentoring relationships they were actively involved in, all seven participants identified themselves as having formal (contractual) mentoring relationships, while only four of the participants identified themselves as also having informal (mutual agreement) mentoring relationships.

Table 1. Self-Identified Participant Demographics

Participant ID	Pseudonym	Gender	Discipline	Professorship	Lab Type
1	Amy	Woman	Material Science and Engineering	Assistant	Hybrid
2	Charlie	Man	Medicine – Quantitative Health	Associate	Dry
3	Jess	Woman	Chemical Engineering	Assistant	Wet
4	Carla	Woman	Biomedical Engineering	Assistant	Wet
5	Rachel	Woman	Neuroscience	Professor	Hybrid
6	Thomas	Man	Biology	Associate	Hybrid
7	Lesley	Woman	Biomedical Engineering	Professor	Wet

Design

This study used a phenomenological method of inquiry. This is a method of inquiry where the researcher must set aside their biases in an attempt to understand the essence of a phenomenon in a specific context [35], [36], [37]. This concept of bracketing is done so that the researchers' biases do not affect the study [35]. An interview protocol was developed using the predefined codes to outline the order in which interview questions would be asked. Some of the interview questions are shown below in Table 2.

Table 2. Interview Protocol Goals and Sample Open-Ended Interview Questions

Goal	Purpose of Goal	Example Interview Question
General	To elicit general concepts related to self-awareness	What experiences have you had with your graduate (and/or undergraduate) student mentees that made you are feel you are self-aware?
Recognition	To elicit descriptions of how the participant recognizes shifts in their mentoring relationships.	Can you tell me of a time when something occurred within your mentoring relationship that left an impression on you?
Self-Reflection	To elicit descriptions of how the participant reflects on their mentoring experiences throughout their mentoring relationship.	Can you tell me about a time when you did engage in the act of self-reflecting after a mentoring related experience?
Insight	To elicit descriptions of how the participant gained insight in response to their moments of self-reflection in the context of their mentoring relationship.	Based on your previously described experience *[described in Question X*], can you describe to me in detail what you learned from that experience?
Self-Awareness	To elicit descriptions of how participants define, describe, and respond to self-awareness or the lack thereof within their mentoring relationship.	Can you describe to me what a basic step-by-step process to improve one's self-awareness would look like?

The questions were specific to the goal they addressed. Definitions for the predefined codes were provided to the study participants to ensure their understanding of the questions was framed in the appropriate context in which the question was asked.

Concept Coding – Thematic Analysis Process

To analyze the qualitative data, addressing **RQ2,** a concept coding thematic analysis was performed on the data. A concept coding analysis involves assigning meaning to the data that suggests an idea rather than an object or observable behavior [38]. Concepts that aligned with the big picture of what was suggested by the data were applied. Predefined codes were initially used for this process. The a priori codes used in the analysis include 1) recognition, 2) self-reflection, 3) insight, and 4) self-awareness. These codes represent the concepts that make up the conceptual framework guiding this study. New and emergent codes that did not represent any of the predefined codes were listed in a separate category. This process was done simultaneously.

The coding process was performed individually by two coders for the first round of coding. For the second round of coding, a third coder was brought in to ensure agreement on the code assigned to the coded data. This is known as an intercoder agreement [39]. Round one of coding was done individually. The coders used colored highlights to identify sections of the interview responses they believed represented the a priori codes and any emergent codes. Coded data that fit into a sub-category of an existing code was identified as such. Round two of coding focused on the intercoder agreement process to ensure consistency in how the codes were applied to the data. When their codes did not align, they justified why they selected their codes based on what was stated in the data. Agreement on the code applied during these instances was reached once all justifications were provided and all coders agreed to a code that best represented the data. Similar steps were taken when reassessing the data for the interview question that focused on addressing **RQ1** in order to develop a step-by-step guide based the participant's description of the process to improve one's self-awareness.

Conceptual Content Analysis – Rank Order Comparison

To address **RQ1.1**, a directed approach to content analysis was completed to give validity to the conceptual framework. It should be noted that this is foundational work that continues to inform future studies that involve larger sample populations to explore this same concept. Existing literature was used to predict the relationships between the predefined codes and their relationship to self-awareness core concept. Because this was a small qualitative study, the qualitatively coded data was not presented using a statistical test of difference. Instead, rank order comparisons of frequency were employed to determine the incidence of codes that represented the predefined codes [40].

Results and Discussion

Thematic Analysis

After completing the coding of the data, all of the codes identified were quantified. A total of 65 new/emergent codes were identified out of 392 lines of coded responses, not including the four predefined codes. Collectively, the new/emergent codes were identified a total 244 times, with each code appearing at least once. After reviewing the codes, it was determined that there were six themes consistently present throughout the data. These themes are shown below in Table 3, and address the second research question which asked: *What are the qualitatively different ways STEMM faculty research mentors describe their mentoring relationships?* The

themes are ordered in the order of most frequently occurring to least occurring in the interview responses.

Table 3. Themes Related to STEMM Faculty Mentors Mentoring Relationships

Category	STEMM Mentoring Features	Frequency of Theme in the Codes
1	Self-awareness	133
2	Tailored Mentoring	27
3	Communication	22
4	Self-regulation	14
5	External Factors	13
6	Psychosocial Support	9

Because recognition, self-reflection, and insight are viewed as steps to be taken to improve one's self-awareness, according to the conceptual framework, these codes were treated as sub-themes for self-awareness. Table 4 provides the predefined codes, their definition according to the available literature, and example descriptive terms and/or phrases that were indicative of them being reflected in the participant's responses. For the remaining themes, there were a total of 18 sub-themes identified which are also representative of the remaining five themes that frequently appeared throughout the data. These sub-themes are mapped to their main theme in Figure 1.

Table 4. Framework used to Code the Working Concepts for Self-Awareness

Concept Focus	Literature Characteristic	Example Descriptive (indicator) Terms/Phrases
Recognition	To take into account one's impact on others (Carden et al., 2022)	I notice(d); I see; recognizing something
Self-Reflection	The inspection and evaluation of one's thoughts, feelings, and behaviors (Carver & Scheir, 1998)	Think about; Consider; "aha moments"
Insight	The clarity of understanding of one's thoughts, feelings, and behavior (Carver & Scheier, 1998)	I realized; I/m understand(ing); suddenly see; clearly
Self-Awareness	Self-awareness is the ability to see ourselves by becoming the object of our own attention (Eurich, 2017)	"Based on the experiences that I have had and realizing that I need to ask more questions to understand…"

Process to Improve Self-Awareness

The first research question asked: *How do engineering faculty research mentors describe the process to improve one's self-awareness?* To answer this question, we examined the participants' responses for the interview question that asked: *Can you describe to me what a step-by-step process to improve one's self-awareness would look like?* Below in Table 5, example responses to the research question are provided. From these responses, key phrases were pulled out and coded for the essence they represented in order to describe a concise, basic step-by-step process to improve one's self-awareness based on the perspective of the STEMM faculty research mentors. The findings suggests that the process to improve self-awareness in STEMM research mentoring relationships involves some combination of 1) Recognition, 2) Self-reflection, 3) Feedback 4) Insight, and 5) Self-regulation.

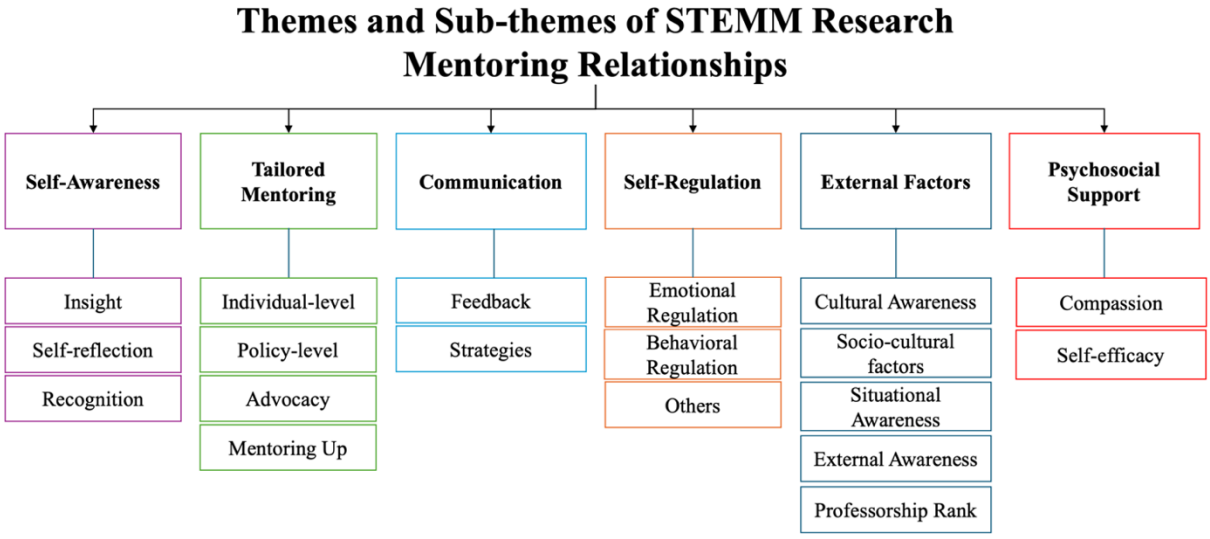

Figure 1. Visual representation of the main category themes and the associated sub-themes.

Table 5. Example Responses on Describing the Steps to Improving One's Self-Awareness

Pseudonym	Can you describe to what a basic step-by-step process to improve one's self-awareness would look like?
Jess	I would say, to find someone who for some reason is completely different from you, and, like, have coffee once a month like and just talk about the things that you know are important to them, or that cause challenges for them, or that, you know, like that, are you know, different from the challenges that you face… It could be, you know, somebody who is from a different part of the country, a different religion or a different cultural background. [Because] you'll come back with a new perspective like you'll just have different thoughts about things, and you'll see situations differently than you see them now…
Carla	I think do some more self-reflection. So being really understanding [of] who you are, what drives you, what triggers you like, just be able to understand how you move and think in certain environments… That, then you can further understand what are your thoughts and feelings in these different settings… then endorse some self-reflection to really understand, maybe, why you had those thoughts and feelings and emotions and those responses in that setting… give yourself a couple of things that you would work on next time.
Thomas	I think the most important thing is to recognize your own inherent biases, and how your own goals are your own goals and motivations and aspirations and prejudices you know, subconsciously affect your decisions and your interactions. And I think you have to recognize that being aware of that recognizing that is important. And recognizing that these same things are happening to the people you're mentoring. Right? So, basically, we're, we're all human. And we all are biased. And we all are easily seduced by things that appear to get us closer to our unconscious or conscious goals.

Content Analysis of Conceptual Framework Dimensions of Self-Awareness

The second research question asked: *What concept from the conceptual framework of self-awareness appears most frequently based on the way engineering faculty research mentors describe their mentoring experiences?* To answer this question, we analyzed the relative frequency of the faculty mentors' responses that represented *recognition, self-reflection, insight, and self-awareness* in their descriptions of their mentoring experiences (Table 4). We used the descriptive indicator terms and phrases to identify instances of the dimensions of self-awareness

present within their responses. Our analysis shows that most of the STEMM faculty described their research mentoring experiences using verbiage indicating they exhibit self-awareness or have self-awareness as mentors (see Fig. 2). Self-awareness was the most coded predefined concept (44%). The faculty members' responses aligned with the concept of insight at a moderate level of incidence (24%). The least aligned predefined concepts found in the responses were self-reflection (18%) and recognition (14%).

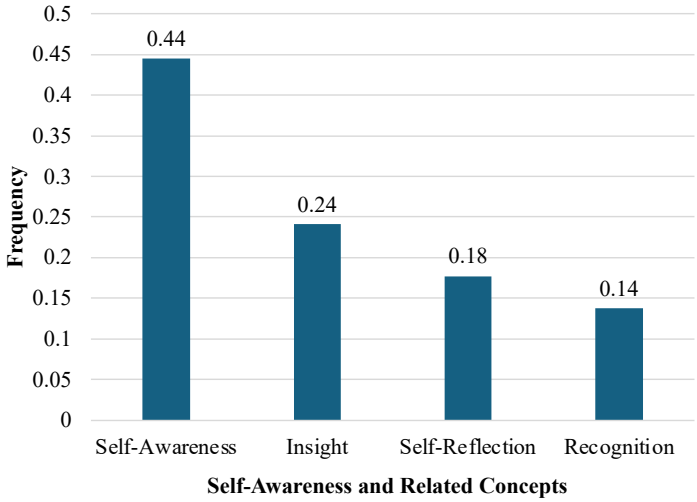

Figure 2. Frequency of instances of self-awareness and its dimensions reflected in participant responses.

Engineers have historically been considered "problem-solvers" due to the nature of their work. Thus, the work of engineers is external to oneself and, instead, often centers on solving problems directed at other's needs, wants, and desires when it comes to completing a task. When it comes to consideration for constructs like self-awareness and its related practices in STEMM, little thought has been given to understanding, defining, and operationalizing these terms since they do not align with the traditional focus of teaching, training, and mentoring engineering student researchers. Rather than learning these concepts in courses, students tend to rely on their peers to navigate unclear situations or suspicious interactions, especially with their mentors [11].

Nevertheless, this study aimed to establish foundational knowledge concerning the concept of self-awareness by starting with STEMM faculty mentors that engage in these relationships. Focusing on the key components in the faculty's responses that describe what someone can do to be more self-aware resulted in a process that begins with a conscious act occurring within the mind, and this act eventually becomes a thought that takes place in the physical by way of self-regulation. At the core of "How to be Self-Aware" in the context of STEMM research mentoring relationships, recognition, self-reflection, and insight represent the clear and consistent pattern for self-awareness practices that should be observed. The conceptual framework states that recognition would be the first step to improving one's self-awareness. In previous literature, it was stated that recognition in the context of awareness focuses on recognizing the feelings of others and considering one's impact on others [20], [41]. As the first step in the process, being able to recognize moments, situations or experiences within yourself and external to yourself can create the need for engagement in self-reflection. Faculty participant Rachel described her perspective on the self-awareness process as follows:

> "Okay. So yes, I think one would be like wanting to do it. So, the want has to be there. After that, then I [think] what I would call after action review, like, you see yourself in a situation and then you sit back and you're like, okay. And I think it's actually more effective when… it probably is effective at the extremes, like when something went really well or like something went really bad. So not neutral, but like, you know, after a very positive or very negative experience, sitting back and

being like, ‘Okay, why did it go down that way and like what can I do more of to have it positive outcome? Or what should I avoid in the future to not have the negative outcome.’”

After recognition comes self-reflection. Among the responses from the different perspectives, self-reflection was frequently mentioned or demonstrated in their responses by all of the faculty as being a necessity in these relationships. This finding was interesting since all of the faculty agreed that some form of self-reflection was needed but the frequency in which it was coded was relatively low compared to insight and self-awareness (see Fig. 2). Statements that were initially coded as has having at least two of the three predefined codes that demonstrate “self-awareness’ were ultimately coded as self-awareness, rather than the two predefined codes. For example, a statement may have been coded as recognition and insight, but not as demonstrating self-reflection. This statement would be re-coded as self-awareness, since the insight the participant demonstrated would have come after self-reflection that led to their conclusions.

The simplest understanding of how one can become more self-aware is the act of engaging in some form of self-reflection and introspection. Faculty member Lesley describes this process by providing questions she would ask herself after her mentoring experiences:

> “A simple start is again reflection on when you leave a conversation. So when you're leaving a room. Or even if I answer a question, or if I ask a question, what I think sometimes is, why did I ask that question? I'm not talking about technical things I'm talking about in just casual conversation outside of mentoring relationships or in, whatever. But ‘why did I make that assumption’ is important.”

Other faculty responses suggested that some of the self-reflection process should be done with someone you can trust, be honest with, and have open communication about your experiences, emphasizing the importance of healthy communication exchange when attempting to become more self-aware. Faculty member Amy describes her perspective on what a step-by-step process to improve one’s self-awareness as the following:

> “Okay, I think a first step is have a relationship with another person based in a lot of trust in which you can be radically honest with them about your experiences and open about your experiences… slowly integrating via that self-reflection some kind of formal practice of self-reflection, and … sharing about some of the insights and things that you've noticed in your self-reflection… And then, I think, translating it to action, either in the form of an apology addressing the more negative parts, and addressing the more the positive parts…”

The descriptions for how to become self-aware from the faculty interviewed for this study either involve a multi-step process by stating that one or more things need to occur to be self-aware. Some faculty stated that there is an initial step in the process that serves as a catalyst, and assuming that if the initial step is done, the remaining steps will innately proceed. These descriptions of this process differ slightly from the work done by Carden et al. (2022), which describes the steps to becoming self-aware as including 1) self-evaluation - introspection/self-reflection and understanding/awareness, 2) process - the ongoing act of engaging in self-awareness practices continuously and, 3) attention - directing one’s attention to their awareness [3], [20], [42]. Their guide to becoming self-aware slightly differs from London et al. (2023) who developed a model of positive and continuous self-awareness through self-reflection, feedback, and coaching. Perspectives from faculty members Amy and Jess (Table 5) highlight

the importance of having a support person you can turn to and converse about the growth and challenges one may face as a mentor/mentee. Communication is the other half of psychosocial support since it is necessary in the social aspects of these research mentoring relationships. Poor communication practices are often the primary issue in STEMM research mentoring relationships [43], [44], [45], [46]. Feedback and coaching rely on communication with another person to receive external insight, which London et al. (2023) suggests is likely to lead to individuals who partake in constructive feedback, growing self- and interpersonal awareness [2]. This perspective is aligned with some of the responses given by some faculty members. While "process" explicitly states feedback and coaching as being part of the self-awareness process, their descriptions are essentially pointing to the need to gain insight, which can occur at the individual level or in partnership with someone else.

Limitations

One of the limitations of this study was the small sample size and localized perspectives. This work was conducted at one university. The faculty were representatives of different STEMM departments, but more perspectives would strengthen the results. Of particular interest to the authors are the perspectives from engineering faculty who are also mentors to engineering graduate students are needed to better understand the attitudes and perspectives towards the relevance of self-awareness in engineering research mentoring relationships. Due to the small, disaggregated sample size, we cannot make claims for engineering, specifically.

Conclusions

As it stands, current STEMM faculty research mentors, especially those in engineering research mentoring relationships, should ensure that they are taking the time to consider the different mentoring experiences they have had, whether positive or negative, and reflect on them. This reflection can be done independently or with others, with the goal of ultimately gaining insight into their experiences so they can learn from them, and (if need be) make improvements to how they mentor students. The findings from this study acknowledge that at the core of being self-aware in STEMM research mentoring relationships, one must recognize, self-reflect, and gain insight from their past and present mentoring experiences. Mentors and mentees should demonstrate this newfound awareness with changed actions through self-regulation. Through further exploration of this space, we may be able to address and mitigate the decline of graduate student mental health and improve the retention of STEMM researchers.

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