ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #40677

Exploring Engineering Faculty Views on their Role in Broadening Participation in Engineering

Dr. Gerica Brown, University of Dayton

Dr. Gerica Brown serves as the inaugural Assistant Dean for Inclusive Excellence Strategic Initiatives in the School of Engineering at the University of Dayton. Previously, she led the Multi-Ethnic Engineers Program at UD since June of 2016. Prior to her time working in higher ed, Gerica had accumulated 9 years of service working in various Engineering and Supply Chain roles with GE Aviation, including working as a Process Engineer and Operations Manager at engine assembly and repair facilities, and as a Six Sigma Black Belt for Global Engine Overhaul Operations. Gerica is a 2008 graduate of UD's Mechanical Engineering program, received her Master's in Supply Chain Management from Penn State in 2014, and just recently earned her doctorate in Educational Leadership from the University of Dayton in December 2021. During her time with GE Aviation, Gerica also served as a University Relations lead-recruiter, and led a number of community engagement efforts with the GE Women's Network and African American Forum.

Gerica is passionate about equity and inclusion in STEM as a means to broadening the participation of underrepresented groups in STEM education and careers. Her experiences as the MEP Director have focused on developing and implementing high impact practices known to promote student success and persistence. In addition to her work as a practitioner in supply chain and engineering student success, Gerica is a qualitative researcher who centers the lived experiences of various engineering education stakeholders; including faculty, staff, students, and employers; in order to gain greater clarity on the current status of the engineering educational landscape. Gerica believes that each person's experiences and perspectives are important to understanding the current state of engineering education and thus critical for developing strategies toward a path forward.

Exploring Engineering Faculty Views on Their Role in Broadening Participation in Engineering

Abstract

Broadening participation in STEM is an initiative of critical importance within the United States. In order to maintain its global prominence in STEM fields, as well as maintain national security and other technological advances, the US must produce over one million more STEM professionals than what is currently projected. Broadening participation is a term used to describe increasing the participation of underrepresented groups in STEM fields. This includes providing STEM exposure, access, and opportunities for individuals from underrepresented groups. According to the National Science Foundation, those considered underrepresented in STEM include Alaskan Natives, Native Americans, Blacks or African Americans, Hispanics, Native Hawaiians, Pacific Islanders, Persons with Disabilities, and Women. The NSF considers broadening participation in STEM as a way to “contribute to the production of a diverse and well-qualified STEM field”. Furthermore, processes and procedures have been developed to provide financial support to individuals, institutions, and organizations who develop means to expand the population of STEM students and professionals. While some engineering education professionals, staff, and administrators may be aware of, and contribute to addressing, representation and retention challenges in engineering, little is known of engineering faculty members’ experiences, awareness, and perceptions of this landscape. Likewise, under-researched is the question of whether and how engineering faculty consider their roles in national broadening participation initiatives. This study explored, at a fundamental level, engineering faculty awareness of the engineering landscape, as well as how engineering faculty considered their roles broadening participation in engineering. Faculty participants in this interpretive phenomenological analysis research study demonstrated an awareness of the increasing demand for engineering talent in the US. Additionally, this study found that instead of discussing their role in k-12 outreach, most faculty focused on their interactions with current students as essential to broadening participation. Faculty identified; making meaningful connections with students, supporting and encouraging students, as well as helping students develop a connection to engineering, which supports their internal motivation to persist, as practices which they could implement to promote greater student persistence, thus broaden underrepresented student participation in engineering. While many faculty discussed the importance of engagement in outreach, creating inclusive classroom environments, and even exhibited a mindset which aligns with inclusive pedagogies, many expressed time constraints and varying priorities as being a barrier to this engagement and few expressed a high level of self-efficacy in achieving these goals even if time permitted.

Keywords

Broadening Participation; Faculty Views; Engineering Education; Success and Persistence

Introduction

Broadening participation in STEM is an initiative of national interest in the United States. In order for the US to maintain its global prominence in STEM fields, as well as maintain national security and other technological advances, the US must produce over one million more STEM professionals than what is currently projected [1]. Broadening participation is a term used to describe increasing the participation of underrepresented groups in STEM fields [2]. This includes providing exposure, access, and opportunities in STEM for individuals from underrepresented groups. According to the National Science Foundation (NSF), those considered underrepresented in STEM include Alaskan Natives, Native Americans, Blacks or African Americans, Hispanics, Native Hawaiians, Pacific Islanders, Persons with Disabilities, and Women. The NSF considers broadening participation in STEM as a way to "contribute to the production of a diverse and well-qualified STEM field" [2]. Furthermore, the NSF has developed processes and procedures to provide financial support to individuals, institutions, and organizations who develop means to expand the population of STEM students and professionals.

While broadening participation efforts are supported at the national level, there is evidence which suggests women and minorities remain underrepresented in STEM and leave STEM disciplines at higher rates. As of 2021, nationally, black students only made up 4.7% of engineering degrees awarded, Hispanic students made up 13.6%, and women earned just 24% of all undergraduate engineering degrees awarded [3]. These figures show severe inequities in representation when compared to the proportion of these groups in the US population more broadly, where women make up 50.4% of the population and Hispanics and those who identify as Black or African American comprise 19.1% and 13.6% of the US population, respectively [4].

60% of students who start in STEM disciplines ultimately transfer into another field of study during college, with women and minority students leaving STEM fields at disproportionately higher rates compared to their white male counterparts [1], [5]. Women and minority students are also less likely to transfer into STEM fields from non-STEM majors [6], reinforcing the lack of representation for these populations in STEM. Although there has been an increase in the number of women and minorities enrolling into STEM fields, discrepancies in retention and graduation rates remain**.** This indicates that students from traditionally excluded identities are expressing interest and being enrolled into STEM programs, however, are not being retained. The analogy of the leaky STEM pipeline "refers to the unintended loss of trainees from the disciplines" [7], and is a problem that needs to be addressed in order to fully realize the value of broadening the participation of traditionally excluded students in STEM disciplines, as well as to eliminate the inequities in institutional structures which impact the persistence and completion rates of students in STEM.

The current landscape of STEM in higher education, as discussed above, demonstrates examples which work against the goals of broadening participation efforts. These examples also serve as evidence for why continued efforts to understand components which support the success and persistence of underrepresented students in engineering are necessary. While some engineering education professionals, staff, and administrators may be aware of, and contribute to addressing, representation and retention challenges in engineering, little is known of engineering faculty members' experiences, awareness, and perceptions of this landscape. Likewise, under-researched is the question of whether and how engineering faculty consider their roles in national broadening participation initiatives. Thus, this study explored, at a fundamental level, engineering faculty awareness of the concept of broadening participation, as well as explored how engineering faculty perceived the roles they could play in broadening participation efforts. Additionally, this study provided insights as to how faculty view their role in promoting the success and persistence of underrepresented students in engineering.

A Review of Literature

Broadening Participation through Persistence of Underrepresented Groups

As discussed above, Women, Black, Native American, and Hispanic American students remain underrepresented in STEM fields, at a time when STEM job growth accounts for more than a third of all projected occupational growth, and STEM professionals have higher employment rates than those from non-STEM disciplines [8], [9]. With the demand for STEM professionals growing, the lack of women and minority student representation in STEM fields presents both a failing and a rich opportunity to broaden STEM participation. Broadening participation in STEM can serve as a strategy for addressing the growing need for STEM professionals in the US, as well as addressing the lack of equity and representation that exists in STEM education.

Existing research highlights the challenges associated with student retention in STEM fields. Between 2000 and 2009, up to forty-eight percent of students pursuing STEM bachelor's degrees did not complete their degrees [10], and this figure has not improved much in recent years [11]. Students describe STEM environments as chilly, where faculty and classroom experiences are considered "unapproachable, cold, unavailable, aloof, indifferent and intimidating" [12]. These experiences result in low sense of belonging for STEM students, negatively influencing student success and persistence [13]. This is a sign that there may be misalignments between student needs and their experiences in the classroom [11]. This further indicates the importance of engaging faculty in improving student persistence as a means to broaden participation in STEM fields.

Three common themes are present in existing literature which discusses the success and persistence of underrepresented students in STEM fields. These common themes suggest that building student (1) self-efficacy [14], [15], (2) sense of belonging [7], [15], [16], and (3) identity in STEM [15], [17], [18] are crucial to STEM student persistence and success. While inequities in academic preparation and socioeconomic status have also been found to correlate to student persistence in STEM, there is much evidence which details the chilly climate which has been identified as a major factor contributing to the departure of underrepresented students from STEM disciplines [19], [20]. Thus, the brief review of literature here focuses on the three named themes which promote student persistence in STEM education.

Self-efficacy represents a person's beliefs in their abilities to meet demands of and accomplish tasks associated within a given environment, and has been found to be among the most important predictors of student performance and persistence in STEM [15], [16], [21]. How students feel about their ability to be successful influences their effort and behaviors as well as their perception of whether they have the necessary tools to be successful [16]. Early STEM and K-12 educational experiences [14], interactions with faculty and other STEM environments [22], as well as being in a culturally affirming institutional culture [21], [23] have all been found to influence the self-efficacy of underrepresented students in STEM. Self-efficacy can be fostered in STEM environments and can assist with building student confidence in ways which promotes their persistence and success in STEM education [15]. Promoting student self-efficacy requires the utilization of a strengths-based approach which encourages students to develop a growth mindset and resilience [6], [24], while also encouraging faculty to integrate inclusive teaching pedagogies [25] and to maintain a healthy balance of challenge and support for students [23].

Sense of belonging is also important to student persistence in STEM, and has been defined as a basic human and psychological need to feel connected, valued and respected [26]. A lack of sense of belonging can contribute to mental health and academic performance challenges highlighted by feelings of self-doubt [26], [27]. Encouraging student sense of belonging in STEM and also focusing on student capabilities are particularly essential to student success and persistence in STEM fields [15]. Students thrive in an environment where the challenges they encounter within their STEM discipline are offset by a supportive community of peers, faculty and others who make them feel as though they belong [23], [28]. Having an authentically inclusive and welcoming campus climate [29], [30], [31] is also essential to the sense of belonging of underrepresented STEM students.

Faculty play an important role in the development of students' sense of belonging and self-efficacy, and faculty also contribute to the development of student's STEM identity which is particularly influential for underrepresented students in STEM [15], [17], [18], [32]. "The recognition of oneself as a scientist" [16] or an emerging STEM professional, promotes students' sense of belonging and builds their STEM identity [16]. STEM identity development can be promoted through student engagement in undergraduate research, as well as curricular and co-curricular learning experiences [15], [32]. Additionally, having opportunities to engage with and be acknowledged as a member of the STEM community by faculty, peers, and other STEM agents, in both professional and social spaces, is important [15], [17], [18]. Student's exposure and ability to engage with STEM role models, mentors, and culturally similar STEM peer groups was also found to be essential to building underrepresented student STEM identity [14], [22], [32], [33], in addition to in-class experiences. Academic settings including classrooms, labs, and office hours can significantly influence a student's perception of STEM [34], [35], and faculty have an opportunity to shape these environments. Creating more inclusive environments and helping students to connect the relevance of their STEM discipline to their values is particularly essential, and promotes underrepresented student STEM identity development [16], [33], [36].

Role of Faculty

Although underrepresented students are more likely to face barriers which influence their likelihood of getting into and persisting in STEM, STEM disciplines and higher educational institutions alike continue to enroll students from traditionally excluded populations without the proper infrastructure and support systems in place to ensure their success [37]. A critical, and oftentimes forgotten, component to ensuring student success and persistence is to engage faculty in strategies which promote student persistence, as well as encourages positive faculty-student interactions [38]. All students must interact with faculty, and faculty tend to be the most longstanding members of higher education institutions [7]. This makes them among the most important institutional agents within higher education as it relates to promoting student success and persistence. In STEM disciplines, which struggle to retain all students despite national efforts to broaden the participation and representation of STEM professionals, engaging faculty may in fact be even more critical.

There is research which suggests that STEM faculty serve as gatekeepers to STEM disciplines, where they have the ability to either encourage or discourage students' persistence in their field [39]. Faculty also play an essential roll in how students engage in STEM courses and access research and internship opportunities [40] in addition to faculty having the ability to affect student confidence in their pursuit of a STEM degree [39].

Faculty-student interactions are important to students' choice to continue in or depart from STEM [33], [40], [41]. Be this as it may, there is evidence which suggests that faculty may not recognize the critical role they can play in student's decision related to their field of study [34], [42]. There is evidence of a weed-out culture in STEM, where STEM faculty are said to have a perspective that not all are fit to succeed in the field and that it is solely the student's responsibility to demonstrate that they can withstand the rigors of STEM education [29], [43], [44]. Additionally, STEM faculty have reported a general lack of awareness, or concern, for the broader challenges related to student attrition in STEM. Faculty have reported being unaware of the national need to retain and produce a greater number of STEM professionals, in addition to their lack of knowledge and efficacy in influencing STEM student recruitment, retention, and success [34], [45]. Faculty have also been found to generally hold a more localized view of their discipline, being primarily focused on their own courses or departments, without expressing awareness of the national challenges within their discipline [34]. Another perspective that faculty have been found to possess is an assumption that there are not enough STEM jobs to support growth, as well as an expressed viewpoint that the US should rely more heavily on international talent [34]. These findings demonstrate the necessity to further explore faculty views on the status of STEM in the US and how their views connect to broadening participation of traditionally excluded populations in STEM.

Research Methods

In order to explore the perspectives of engineering faculty, an interpretivist phenomenological research method was used for this study. Interpretive phenomenological analysis (IPA) seeks to describe a phenomenon from the perspective of participants based on how they make meaning of their lived experiences, and to interpret these perspectives in order to gain understanding of said phenomenon [46]. This IPA study explored engineering faculty experiences and perceptions related to broadening participation in engineering. As discussed above, faculty have a vital role in promoting inclusive environments and interactions, within and outside of the classroom, which support student success and persistence. A climate that builds student engineering identity, fosters sense of belonging, and promotes student self-efficacy in engineering has positive effects on student persistence in engineering, thus supports national efforts to broaden participation in engineering.

After attaining IRB approval, a purposive sampling strategy was used to identify participants for this study. The study focused on gaining the perspective of white full-time faculty in engineering since white faculty make up approximately 63% of all engineering, computing, and science faculty members [47]. Based on a broader interest in using the data gained from this study to inform engineering student success and faculty development practices at a mid-sized, PhD granting, private, 4-year institution in the Midwest, this was the primary site for this study. Additionally, participants from a peer institution with an engineering program of similar size and demographics were invited to participate in this study in order to provide broader perspectives on how engineering faculty made meaning of their role in broadening participation and student persistence. This study was not intended to represent all engineering faculty and was rather meant to gain a richer understanding of the experiences and perspectives of individual faculty members, therefore the sample size for this study was 16 engineering faculty members, with 82% being from the mid-sized, private, 4-year institution in the Midwest in which this study is based, and the remaining participants being from a peer engineering program.

Semi-structured interviews via Zoom were conducted for this study, as they allowed the researcher to engage in dialogue with participants using an initial set of questions which were modified based on the direction of each discussion. Semi-structured interviews also helped with rapport building, as relationships and established trust are essential components of phenomenological research [48]. Memoing and reflexive journaling were used to support researcher reflexivity throughout the interviewing process to ensure the researcher's preconceived knowledge and beliefs did not influence how participant data were captured and analyzed. Recording interviews allowed the researcher to actively engage in listening during the interviews as is called for in phenomenological interviewing, as well as provided an interview transcript which was used as the starting point for further transcription and analysis.

Following each interview, the analysis process consisted of several rounds of reading through transcribed interviews, note-taking and the creation of codes and sub-codes, which were all used to identify emergent themes. The emergent themes identified were based on the researcher's interpretation of what the participant meant by what was shared, and finally, abstraction was used to group similar themes to identify patterns, or clustered themes [49], [50]. Clustered themes were identified for each individual participant's interview, and the researcher performed further analysis to identify recurrent themes between cases, which set the stage for the findings of this study [49]. The process of member-checking in the initial coding of individual participant findings [51] as well as the researcher's reflexivity throughout the interview, coding and analysis processes contributes to the credibility of the data analysis for this study [52].

Results and Discussion

The Interpretivist Phenomenological Analysis (IPA) research study conducted sought to capture the voices of engineering faculty in order to understand their experiences and perspectives related to broadening participation and persistence in engineering. This study captured the perspectives of 16 white engineering tenured and tenure-track faculty and lecturers from two mid-sized institutions in the Midwest. The following table (Table 1) provides an overview of each faculty participant, of which six were female and the remaining 10 were male. Engineering faculty participants represented each of the core engineering disciplines, with Chemical

Engineering, and Mechanical Engineering each having three faculty participants, two participants representing Civil Engineering and Electrical and Computer Engineering, and the remaining six being from Engineering Technology and Systems related disciplines. This information coupled with the information in Table 1 demonstrates the diverse faculty perspectives reflected in this study with regards to gender, discipline, and years of teaching. The lack of institutional diversity is identified as a limitation of this study.

Table 1: Participant Information

Pseudonyms	**Race**	**Gender**	**Professor type**	**Years of experience**	**Institution**
Adam	White	Male	Tenured	10-15	University C
Cameron	White	Male	Tenured	>20	Brownland University
Colin	White	Male	Lecturer	10-15	Brownland University
Douglas	White	Male	Tenured	15-20	Brownland University
George	White	Male	Tenured	15-20	Brownland University
Jacqueline	White	Female	Lecturer	5-10	Brownland University
Jane	White	Female	Tenure Track	1-5	Brownland University
John	White	Male	Tenure Track	1-5	Brownland University
Kermit	White	Male	Tenure Track	5-10	Brownland University
Michael	White	Male	Tenured	>20	University C
Rick	White	Male	Tenured	10-15	Brownland University
Sam	White	Female	Tenured	5-10	Brownland University
Sarah	White	Female	Lecturer	15-20	Brownland University
Sarah S	White	Female	Tenure Track	5-10	Brownland University
Scott	White	Male	Tenured	15-20	Brownland University
Suze	White	Female	Tenured	15-20	Brownland University

The research study performed using Smith, Flowers, and Larkin's [49] guide to conducting IPA qualitative research utilized a single researcher who recruited all participants, conducted all interviews, transcribed each set of interview data, and conducted all rounds of data analysis. The data analysis process included a deep immersion into transcribed data to capture initial notes and coding, which laid the groundwork for emerging and clustered themes to be identified. Member-checking was used as a way to validate the emerging themes for each participant. Once emerging themes were further analyzed using a combination of Dedoose (a cloud-based research analysis tool) and excel pivot tables, clustered themes arose which represent the three relevant themes which help us to understand how these engineering faculty perceive their role in student persistence and broadening participation in engineering. Those three themes include:

1. Support and encouragement as critical to student success and persistence in engineering
2. Internal motivation as critical for student persistence in engineering
3. Faculty-student relationships and guidance as critical to student success and persistence in engineering

Additionally, it was found that these engineering faculty demonstrated an awareness of the high demand for engineering talent in the US, which represents their view of the broader engineering landscape.

Engineering faculty interviewed for this study were able to express a number of ways in which they believed faculty could support broadening participation efforts. While some faculty discussed the importance of engineering outreach and recruitment as necessary to broadening participation in engineering, this did not emerge as a recurrent theme, and thus did not become a major finding of this study, which was an unexpected result. According to existing literature, STEM faculty have referenced k-12 outreach and recruitment initiatives as a way to broaden participation in STEM disciplines [34], with few seeing this as their responsibility. Additionally, few have been able to recognize their interactions with undergraduate students as a means to supporting or deterring broadening participation initiatives [34].

The findings from this study suggest, however, that the engineering faculty interviewed from two mid-sized institutions in the Midwest were able to connect their interactions with students to the concept of broadening participation, fully recognizing the increasing demand for STEM talent in the US. Participants articulated the role of faculty in 1) building relationships with students, 2) providing support and encouragement, as well as 3) helping students develop an interest and establish an internal goal within engineering. When prompted to discuss the means of promoting, particularly, underrepresented student participation and persistence in engineering, these same three themes emerged as strategies in which faculty should engage.

Awareness of High Demand for Engineering Talent in the US

Countering the sentiment found in existing literature which suggests that STEM faculty are generally unaware of the STEM landscape and challenges related to STEM attrition [34], [45], a vast majority of the faculty participants in this study expressed an awareness of there being a high demand for engineering talent in the US. This theme emerged from participant responses related to the state of the engineering job market, and led many to discuss their observations of student's ability to secure engineering employment. It also prompted expressions of concerns with increasing retirements and the lack of a sufficient talent pipeline, as well as discussions about increasing demands within particular engineering disciplines and sectors. As can be identified in the excerpt below, George expressed each of these sentiments:

> *The job market? I'd say its red hot. Very strong across a variety of sectors. Specifically, in manufacturing and automotive, there's a significant aging population in the workforce. A lot of demand for technical talent in those industries, and so, there is a need to replace those who are retiring and leaving the workforce. And they need to fill growth in just demand.*

George also went on to share his belief in the imbalance across engineering sectors:

> *Th…there is a disconnect … at times, though, between where students find… an interest and where the jobs are. For instance, I… I do know a lot of students go into the biomedical area it's an interest you feel maybe a deeper connection with impacting*

> *humans more closely. But the demand is not there for all the students are graduating with degrees in, or concentrations in biomedical.*

George described that while engineering demand may be high, it is not equally high in all engineering disciplines with some disciplines actually being more sought after than others.

While many faculty shared the sentiment that demand for engineering talent was high in the US, only a few then articulated a connection between the high engineering demand and the necessity to increase the engagement of potential diverse talent. Adam was among the few to verbally make this connection:

> *So… so this is something that I have seen actually. Um… there are some numbers for this and, you know, there's a demand for engineers and it… it seems like the trend, you know, the trend could be that the current rate of people graduating with engineering degrees in the United States won't be enough people to fill the demand for jobs. And so that's… that is a driver on for increasing diversity among like gender diversity or racial diversity for engineering graduates in the United States. But you know it's possible that if… if the current trend continues, that, you know, these jobs will have to be filled by students from… from other countries, perhaps.*

That engineering faculty consistently expressed an awareness of the demand for engineering talent in the US was an unexpected finding. In some cases, such as that mentioned by Adam, faculty even made the connection that broadening participation in engineering could be a way to address the increasing demand for engineering talent.

Faculty-Student Relationships and Guidance

More than half of the faculty participants in this study discussed the importance of establishing relationships with students and providing guidance as a means to promoting student persistence. Many faculty discussed the importance of being approachable, creating a comfortable environment – in and outside of class, and the necessity to have informal opportunities to connect with students. All of these practices and recommendations are situated in faculty participants' belief that their interactions with students can promote greater engagement and participation in engineering education, which can, in turn, make a difference in students' persistence as well as positively influence broadening participation efforts.

Engineering faculty who expressed the importance of building relationships and guiding students saw this something that went above and beyond teaching or academic advising. These faculty oftentimes expressed wanting students to see them, not only as faculty, but as whole people who were there to help students achieve their goals. Many faculty also highlighted their perception that students may feel intimidated by engineering faculty, and thus, may not reach out for help when needed. Michael's excerpt below demonstrates this viewpoint:

> *I think even unintentionally, students can feel intimidated in approaching a professor if the professor talks down to them, or says why don't you know this, or why… that sort of blames the student for having questions as opposed to encouraging questions, and so I*

think that having…having a relationship with students, where the students see the professor as approachable, goes a long way towards promoting student success. Because the students are going to ask questions, get help and not…not be as intimidated. And I think that's going to help make them successful.

Faculty saw breaking down the barriers between students and faculty, and building relationships as a way to create an environment where students would seek help when needed. This was not only in relation to academic support, but was discussed in relation to personal and professional guidance as well. Faculty who held the belief that building relationships was important seemed to acknowledge students as whole people who have lives which could impact their academics. Faculty saw their relationships with students as a catalyst to open communication and appropriately guiding and supporting students during their times of need and otherwise.

Much of the literature which discusses the positive impact that faculty can have on student persistence in STEM disciplines often discusses the importance of faculty-initiated positive relationships and student interactions. Hrabowski [24] talks about the importance of building a community of trust with students, which is necessary for students to open up and discuss their challenges. This connects directly to engineering faculty participants' view that relationships serve as a catalyst to greater communication. In their study, Leonard et al. [53] interviewed 138 underrepresented minority engineering students and found that students articulated their desire to form relationships with faculty. These students discussed a desire to have interactions with faculty beyond academic support, however also expressed feeling intimidated to initiate these interactions themselves. Not only have students expressed feeling intimidated to initiate faculty interactions, but engineering faculty participants in this study join other STEM faculty in reporting the same sentiment [54].

While more than half of the faculty participants explicitly discussed their practices and perspectives related to initiating relationships with students, all but three of the participants discussed their belief that students needed support in order to succeed in engineering. Those who discussed building relationships as important also tended to discuss these relationships as the bridge to providing students with the support and encouragement they needed. Below, Suze articulates this point by addressing the fact that relationships are the window to guidance and support, which are both necessary for engineering student persistence:

And a lot of persistence questions they wind up getting down to, you know.. there's not a persistence issue when things are going well. People don't just decide to stop. How do you have…There is research around you have to have good communication before you have hard communication. So, yeah you have to have a relationship... or it's easier to have a hard conversation, if you have relationship kinds of conversations. And students who are building relationships with…. and probably need a number of potential sources of support; whether it's... whether it's co-mentoring, you know, like peer to peer kinds of support, or teacher to student kinds of support…

Suze continued, in saying:

> *… It seems to me like the ones (students) that have been successful have that, you know, I see them talking to a faculty member in the hallway, not just around problems.*

In her excerpt, Suze discussed the importance of relationships to student comfort in discussing and eventually overcoming their challenges.

Support and Encouragement

One of the most consistent themes which emerged from this study was participant's recognition that students needed support and encouragement in order to succeed and persist in engineering. This view was discussed, generally, in two frames. First, faculty participants discussed the importance of peer support to individual students' persistence. The second view expanded this support to include the role of faculty in supporting and encouraging students to persist despite any challenges that students may experience, particularly within the discipline. This paper focuses on how faculty perceived their role in supporting student persistence in engineering rather than the peer support necessary for students.

While some faculty stopped at the notion that peer support was important to student success and persistence, others took this a step further and discussed their role in promoting student peer collaboration as well as providing direct support and encouragement to students. Several faculty participants discussed intentionally grouping students during class as a means of helping students connect with each other as well as to promote student collaboration on projects and in-class problem sessions. This intentional grouping, faculty often reflected, helped students engage more in class, and seemed to help students make connections with their peers which, at times, evolved into study groups outside of class.

Another important point that many participants either stated explicitly or implied, was that students needed a community of support within their discipline and classes. The assertion was that students may find that others outside of the discipline may not understand the academic norms of engineering regarding the direct correlation between time commitment and grade performance. Faculty participants expressed the need for students to have connections to one another, and also expressed that they themselves, as faculty, were an important part of engineering student support systems which could provide the encouragement that students needed to offset any internal or external doubts or challenges that they might encounter. Colin demonstrated this in the excerpt below as he discussed helping a student navigate a mental health crisis:

> *I had a student who was probably their sophomore year maybe… second semester of their sophomore year, in one of my classes, you know, had a huge kind of nervous breakdown. And struggled to finish the class. And so, we kind of worked on a plan to basically say if they will, you know, you're several assignments behind, I can delay your final grade for up to 30 days. Just get me some of these assignments, you know, it doesn't have to be all of them, just some of them. I'll grade them, and you know you'll probably end up with this …this lower grade, let's just get this…this past you and get you into the next semester and you'd start fresh. And so, she did that and a couple years later, she was in one of my design classes, and was one of my best engineers, she was a fantastic*

student… And so, you know that was someone basically saying okay you're in a rough spot, but you can do this. We'll work on a plan.

Faculty participants in this study saw an important role that they could play in supporting students' desire to pursue engineering, as well as providing the encouragement that students might need to engage in their classes as well as with their peers. Faculty seemed to understand the discouragement that students might feel when faced with academic, or personal, challenges, which most faculty agreed was common for engineering students. To combat the internal and external doubts that students may experience relating to their engineering education, faculty discussed themselves as being a part of the support system that students needed to stay the course. This viewpoint aligns with the concept of a community of support as being essential to STEM student persistence found throughout existing literature [15], [28]. Covington et al. [22] specifically discuss the important role that faculty play in a student's support system, noting that faculty encouragement and support can promote greater student engagement, success and persistence, and this, along with the community of support model, is supported in a number of additional studies [16], [23], [33].

Having an Internal Goal and Motivation

While many faculty in this study discussed the importance of building relationships with students and providing support and encouragement, many also ultimately shared that students needed their own internal motivation and drive to succeed. Without having an internal goal, faculty shared the view that students would be less likely to persist through the challenging moments of engineering. Additionally, faculty generally agreed that student motivation needed to be rooted in their own purpose for pursuing engineering, and go beyond just being good at math and science. While some faculty discussed having an internal goal as a student-centered trait that students either had or not, most faculty discussed it in more fluid terms suggesting that an internal goal was something which could be developed through engagement and exposure, and could drive students' motivation to persist.

The belief that students were either motivated or not was shared by faculty who pointed out the need for students to be willing to put forth the effort to succeed academically. That the effort required to complete an engineering degree was generally perceived to be high, faculty with this perspective discussed the need for students to be self-determined to put in the time and energy necessary; including developing study habits, staying organized, and utilizing existing resources. This was not something that these faculty saw as something that they should or could influence, although it was discussed as a necessary component of student persistence in engineering.

Faculty who viewed internal goal and motivation as fluid and something that could be developed did not necessarily discount the need for students to be intrinsically motivated to "do" school, nor the importance of students pursuing engineering as a personal choice. Faculty who discussed the fluidity of motivation suggested that students needed exposure and to be engaged in order to find their engineering niche, as Scott discusses in the excerpt below:

I think engineering professors could spark their interest. so if you're mechanical right you're taking… if you're in a mechanical degree….What does that mean. well, okay *you're taking these classes. but what does that mean once you leave here. Spark their interest, maybe I want to…maybe.. I always wanted to be a doctor; I decide not to be a doctor, well, maybe I can be a mechanical working in biomedical devices. You know, show them examples of that and spark their interest, in that maybe I always love working on cars, well where's the car industry going to go, is it going to go to you know self-driving vehicles, okay spark their interest in that..*

Several faculty participants in this study suggested that it was important for students to discover how engineering connected to their interests and values as well as how it could be applied in real world context. Thus, faculty discussed the importance of their role in providing students with exposure to real world application, making course content engaging and relevant, and encouraging students to pursue research, co-ops and internship opportunities. Many faculty who expressed this view discussed the impact of their own research and internship experiences in helping them to solidify why they had chosen engineering and what they could do with an engineering degree.

The role of faculty in engaging students in relevant course content and encouraging engineering-related experiences was not only discussed in relation to undergraduate engineering students. K-12 engineering outreach, although not a recurring theme amongst most participants, continued to surface as a means of attracting diverse talent into engineering. Providing early access and exposure to engineering, what engineers do, and the pathway and encouragement to become an engineer could spark the interest of underrepresented students, which many faculty perceived as a way to foster internal desire and motivation, thus broadening interest and participation.

Faculty in this study have discussed the importance of their role in making course curriculum relevant and engaging and connecting students to research and internship opportunities. Each of these has also been documented in existing literature as critical to assisting students in developing their engineering identity and establishing their own internal engineering goal [15], [39]. As an example, Micari & Pazos [42], in their study, discussed the importance of engaging students in relevant course work to students' perception of curriculum and their success. This was found again in Gasman et al's. study [55], which also discusses the importance of connecting students with STEM capital, including STEM related opportunities and resources.

Discovering that engineering faculty viewed their role in broadening participation as closely connected to how they support, encourage, and engage undergraduate students provides a potentially emerging engineering faculty perspective. Existing literature captures STEM faculty voice in discussing their role in attracting more students into STEM and the role of K-12 education. While K-12 outreach and recruitment was certainly discussed as an important component for increasing the representation of underrepresented students in their classes, this was not a recurrent theme among most faculty participants in this study. Most faculty participants in this study, instead, focused much of their discussions on specific practices, observations, and perspectives related to how they could engage the students in which they had access in efforts to broaden participation through encouraging persistence.

Conclusions and Implications to Practice

Within higher education institutions, engineering faculty are essential institutional agents who have the ability to broaden the participation of engineering students from underrepresented groups. Faculty participants in this study expressed an awareness of the high demands for talent in engineering and ultimately shared their perceived role in broadening participation to be through focusing on their interactions and engagement with current students. Making meaningful connections with students, supporting and encouraging students, as well as creating an inclusive classroom environment where students could connect their engineering discipline to their values were all practices that faculty discussed which can promote the success and persistence of students. While many faculty exhibited a mindset that aligns with inclusive practices and teaching pedagogies known to positively impact student persistence in STEM fields, few expressed a high level of self-efficacy toward achieving this goal. Many faculty attributed their lack of self-efficacy to an educational and/or industrial experience which centered on their technical expertise and not preparation for interacting with students, teaching or mentoring. Additionally, faculty pointed to limitations and conflicts on their time which they felt limited their ability to engage in faculty development focused on student-centered teaching and mentoring pedagogies.

Implications to Practice – Faculty Development

Participants from this study expressed the perspective that faculty have an important role in the success and persistence of engineering students. Building relationships was discussed as a catalyst to providing guidance, encouragement and support to engineering students, which faculty discussed as their role in student success and persistence. While faculty expressed their desire to engage and support students in meaningful ways, an underlying finding of this study was that faculty discussed a lack of self-efficacy stemming from a lack of formal training on how to teach. This, in addition to time constraints, they expressed, impacted their ability to effectively engage and connect with students. Thus, providing early and ongoing training opportunities of teaching and learning pedagogies to emerging engineering educators can provide faculty with what they need to develop greater self-efficacy with student engagement. However, limitations on time are real concerns that are only exacerbated by adding required training on top of busy faculty schedules. Thus, another recommendation includes being mindful of faculty time when planning faculty development initiatives. Providing faculty with immersive experiences where they have dedicated time to learn, collaborate with others to plan, and implement strategies is essential. Offering lighter course loads or additional course support such as teaching assistants or research assistants can also free up faculty time to engage in such initiatives. Providing incentives or structured planning which intentionally eases the time burden and invites faculty to engage in such immersive training experiences is also necessary.

Several faculty in this study offered up the recommendation for there to be more collaborative spaces within engineering buildings to encourage faculty-student interactions outside of class time. Others discussed the potential that academic advising could have on faculty relationships, guidance and encouragement of students. Faculty and student advising expectations were said to have shifted over the years becoming less personal and more transactional. Thus, being more intentional and strategic regarding the guidance of faculty who advise students is also recommended. If the goal is for faculty to be more relational than transactional, then this needs to be a clear expectation, with suggestions on how faculty can successfully achieve this goal within the context of their engineering school structures.

That faculty in this study expressed their role as engaging, supporting and encouraging students, demonstrates an emerging mindset among engineering faculty which is conducive to inclusive teaching and broadening participation in engineering. Thus, helping faculty connect their awareness, mindset, and desire to support and encourage students by providing practical training, as discussed above, as well as setting clear expectations on the role of faculty is recommended. If engineering education transformation calls for faculty to support efforts to broaden participation, faculty should be aware of this expectation. They should understand the context behind this need, as well as be provided with the education and time needed to develop in ways which support these expectations.

In providing training and education opportunities for faculty, it is essential to meet faculty where they are in the developmental journey. Understanding that there are faculty at varying points on the developmental spectrum is important. There are some engineering faculty who are committed to the ideals of diversity, equity, inclusion, and accessibility (DEIA), and have an inclusive mindset, however, may not have the knowledge or self-efficacy to implement practices which support these efforts. There are others who may be unaware of the needs of today's engineering students, as well as of the national focus to broaden participation in engineering, who would benefit from further education. Others may have personal philosophies or lived experiences which may negatively influence how they perceive DEIA related efforts in STEM. In either case, it is recommended that engineering education administrators assess engineering faculty to understand each person's baseline, and establish appropriate training plans in response to the needs of faculty. For those already committed to the ideals of DEIA and/or see broadening participation in engineering as necessary for the field, there may need to be an approach which acknowledges this perspective by offering practical opportunities to learn about and implement strategies. For those who may not see the relevance or value, it may be important for organizations to invest time understanding this perspective in order to determine how to best engage this group. Practicing inclusive and culturally relevant pedagogies in how faculty are engaged and how faculty development is offered is also important. A one size fits all training approach is evidenced to be ineffective [56], [57], and understanding that each person has had different lived experiences, has varying perspectives, and may have differing values and motivations for being a faculty member are important considerations when engaging engineering faculty in their development journey.

Faculty expressed the belief that students need internal motivation to be successful and persist in engineering. The same could be said for engineering faculty. Understanding what is important to faculty, as individuals, and their motivations for being in faculty positions can provide great insights for faculty developers. Additionally, understanding faculty motivation for engaging in professional development can provide important information which helps to better engage faculty. As an example, one faculty member discussed preferring to learn about diversity and inclusion in the context of their particular industry; another discussed wanting to be a better mentor for students doing research. While transparency of duties and responsibilities, as well as providing immersive training opportunities are important, the reality is that not all faculty will find broadening participation as important to their roles, nor will they engage in these efforts in the same ways. Thus, providing faculty with a multitude of ways to explore and contribute to the engineering educational enterprise, as well as connecting with faculty based on their interests, values and motivations is recommended.

The findings of this study provide valuable insights which can guide engineering education administrators and faculty developers in efforts to engage engineering faculty in broadening participation. The results of this study in many ways support existing literature as it relates to those elements which promote student success and persistence. However, the findings of this study do not necessarily align with the image of STEM faculty often depicted in existing literature, especially that which captures the voice of underrepresented students when sharing their lived experiences in engineering at predominately white institutions. This may indicate a disconnect between faculty intentions and student perceptions of engineering faculty, which warrants further investigation via future research. Regardless of the outcomes of future research, this study provides valuable insights for engineering administrators and faculty developers at mid-sized R2 institutions in the Mid-west. Assessing faculty motivations and values, providing individualized development plans which connects to faculty needs and values, and offering a multitude of ways in which faculty can develop and interact with students, are just a few recommendations institutions can enact to engage engineering faculty in broadening participation of underrepresented students through promoting student success and persistence in engineering.

References

[1] S. J. Gates and C. Mirkin. "Encouraging STEM Students Is in the National Interest," *The Chronicle of Higher Education*, p. 1–3, June 25, 2012. [Online]. Available: http://chronicle.com/article/Encouraging-STEM-Students-Is/132425/

[2] National Science Foundation, *Broadening Participation at the National Science Foundation: A Framework for Action*, Aug. 2008. [Online]. Available: https://nsf-gov-resources.nsf.gov/2022-03/nsf_frameworkforaction_0808.pdf

[3] American Society of Engineering Education, *Engineering and Engineering Technology by the Numbers*, 2021. [Online]. Available: https://ira.asee.org/wp-content/uploads/2023/08/Engineering-and-Engineering-Technology-by-the-Numbers-2021.pdf

[4] Census Bureau, *Quick Facts United States*. [Online]. Available: https://www.census.gov/quickfacts/fact/table/US/LFE046221. [Accessed Sept 2, 2023].

[5] A. L. Griffith, "Persistence of women and minorities in STEM field majors: Is it the school that matters?" *Economics of Education Review*, vol. 29, no. 6, pp. 911-922, Dec. 2010. [Online]. Available: https://doi.org/10.1016/j.econedurev.2010.06.010

[6] A. Lisberg and B. Woods, "Mentorship, Mindset and Learning Strategies: An Integrative Approach to Increasing Underrepresented Minority Student Retention in a Stem Undergraduate Program," *Journal of STEM Education*, vol. 19, no. 3, July-Aug. 2018.

[7] S. A. Allen-Ramdial and A. G. Campbell, "Reimagining the pipeline: Advancing STEM diversity, persistence, and success," *BioScience*, vol. 64, no. 7, pp. 612–618, July 2014. [Online]. Available: https://doi.org/10.1093/biosci/biu076

[8] U.S. Bureau of Labor Statistics, *Occupational Outlook Handbook*, [Online]. Available*:* http://www.bls.gov/ooh/. [Accessed Sept 2020].

[9] Y. Xue and R. C. Larson, "STEM crisis or STEM surplus? Yes and yes," *Monthly Labor Review*, U.S. Bureau of Labor Statistics, May 2015. [Online]. Available: https://doi.org/10.21916/mlr.2015.14

[10] X. Chen and M. Soldner, (2013). "STEM Attrition: College Students' Path Into and Out of STEM Fields: A Statistical Analysis Report," National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC., NCES 2014-001, Nov. 2013.

[11] M. S. Coleman, T. L. Smith, and E. R. Miller, "Catalysts for Achieving Sustained Improvement in the Quality of Undergraduate STEM Education," *Daedalus, the Journal of the American Academiy of Arts & Science*, vol. 148, no. 4, pp. 29–46, Fall 2019. [Online]. Available: https://doi.org/10.1162/daed_a_01759

[12] D. T. Flynn, "STEM Field Persistence: The Impact of Engagement on Postsecondary STEM Persistence for Underrepresented Minority Students," *Journal of Educational Issues*, vol. 2 no. 1, May 2, 2016. [Online]. Available: https://doi.org/10.5296/jei.v2i1.9245

[13] K. Gannon, "The Case for Inclusive Leadership," *Chronicle of Higher Education*, pp. 1–7, Feb 27, 2018. [Online]. Available: https://www.chronicle.com/article/The-Case-for-Inclusive/242636

[14] M. J. Chang, J. Sharkness, S. Hurtado, and C.B. Newman, "What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups," *Journal of Research in Science Teaching*, vol. 51, no. 5, pp. 555–580, Feb 18, 2014. [Online]. Available: https://doi.org/10.1002/tea.21146

[15] M. Syed, E. L. Zurbriggen, M. M. Chemers, B. K. Goza, S. Bearman, F. J. Crosby, J. M. Shaw, L. Hunter, and E. M. Morgan, “The Role of Self-Efficacy and Identity in Mediating the Effects of STEM Support Experiences,” *Analyses of Social Issues and Public Policy*, vol. 19, no. 1, pp. 7–49, Dec. 2019. [Online]. Available: https://doi.org/10.1111/asap.12170US
[16] J. Ahern-Dodson, C. R. Clark, T. Mourad, and J. A. Reynolds, “Beyond the numbers: understanding how a diversity mentoring program welcomes students into a scientific community,” *Ecosphere*, vol. 11, no. 2, Feb 2020. [Online]. Available: https://doi.org/10.1002/ecs2
[17] L. Oseguera, H. J. Park, M. J. De Los Rios, E. M. Aparicio, and R. Johnson, “Examining the Role o f Scientific Identity in Black Student Retention in a STEM Scholar Program”. *Jornal of Negro Education*, vol. 88, no. 3, pp. 229–248. Summer 2019.
[18] S. Rodriguez, K. Cunningham, and A. Jordan, “STEM Identity Development for Latinas: The Role of Self- and Outside Recognition”. *Journal of Hispanic Higher Education*, vol. 18, no. 3, pp. 254–272, Nov. 8, 2017. [Online]. Available: https://doi.org/10.1177/1538192717739958
[19] M. Bonous-Hammarth, “Pathways to success: Affirming opportunities for science, mathematics, and engineering majors,” *Journal of Negro Education*, vol. 69, no. 1/2, pp. 92–111, Winter-Spring 2020. [Online]. Available: http://www.jstor.org/stable/10.2307/2696267
[20] R. Winkle-Wagner and D. L. McCoy, “Feeling like an “Alien” or “Family”? Comparing students and faculty experiences of diversity in STEM disciplines at a PWI and an HBCU,” *Race Ethnicity and Education*, vol. 21, no. 5, pp. 593–606, Nov 2016. [Online]. Available: https://doi.org/10.1080/13613324.2016.1248835
[21] J. E. Fife, S. Bond, & A. Byars-Winston, “Correlates and Predictors af Academic Self Efficacy Among African American Students,” *Psychology*, vol. 132, no. 1, pp. 141–148, Jan 2011.
[22] M. Covington, T. Chavis, and A. Perry, “A scholar-practitioner perspective to promoting minority success in STEM,” *Journal for Multicultural Education*, vol. 11, no. 2, pp. 149–159, June 12, 2017. [Online]. Available: https://doi.org/10.1108/JME-01-2016-0001
[23] A. J. McKim, T. J. Sorensen, J. J. Velez, K. G. Field, W. K. Crannell, L.R. Curtis, P. L. Diebel, D. L. Stone, and K. Gaebel, “Underrepresented Minority Students Find Balance in STEM: Implications for Colleges and Teachers of Agriculture,” *NACTA Journal*, vol. 61, no. 4, pp. 317-323, Dec 2017.
[24] F. A. Hrabowski, “How to Get More Black Men into Science,” *Journal of Best Practices in Health Professions Diversity*, vol. 8, no. 1, pp. 1056-1059. Spring 2015.
[25] C. J. Ballen, C. Wieman, S. Salehi, J. B. Searle, and K. R. Zamudio, “Enhancing diversity in undergraduate science: self-efficacy drives performance gains with active learning,” *CBE Life Sciences Education*, vol. 16, no. 4, Winter 2017. [Online]. Available: https://doi.org/10.1187/cbe.16-12-0344
[26] T. L. Strayhorn, *College students’ sense of belonging: A key to educational success for all students*. NY: Routledge. 2012.
[27] S. Hurtado, and D. F. Carter, “Effects of college transition and Perceptions of the Campus Racial Climate on Latino College Students Sense of Belonging,” *Sociology of Education*, vol. 70, no. 4, pp . 324-345, Oct. 1997.
[28] E. Holcombe, and A. Kezar, “Ensuring Success Among First-Generation, Low-Income, and Underserved Minority Students: Developing a Unified Community of Support,” *American*

Behavioral Scientist, vol. 64, no. 3, pp. 349–369, March 2020. [Online]. Available: https://doi.org/10.1177/0002764219869413
[29] S. Farrell, and A. R. Minerick, "The Stealth of Implicit Bias in Chemical Engineering Education, its Threat to Diversity, and What Professors can do to Promote an Inclusive Future," *Chemical Engineering Education*, vol. 52, no. 2, Spring 2018.
[30] S. Hurtado, J. Milem, A. Clayton-Pedersen, and W. Allen, *Enacting Diverse Learning Environments: Improving the Climate for Racial/Ethnic Diversity in Higher Education*. ERIC Digest. ASHE-ERIC Higher Education Reports 26. 1999.
[31] J. F. Milem, "The Educational Benefits of Diversity : Evidence from Multiple Sectors," in *Compelling Interest: Examining The Evidence On Racial Dynamics In Higher Education*, M. J. Chang, D. Witt, J. Jones, K. Hakuta, Ed. Stanford: Stanford University Press, 2002, pp. 1-41.
[32] Z. S. Wilson, L. Holmes, K. deGravelles, M. R. Sylvain, L. Batiste, M. Johnson, S. Y. McGuire, S. S. Pang, and I. M. Warner, "Hierarchical Mentoring: A Transformative Strategy for Improving Diversity and Retention in Undergraduate STEM Disciplines," *Journal of Science Education and Technology*, vol. 21, no. 1, pp. 148–156. April 2011. [Online]. Available: https://doi.org/10.1007/s10956-011-9292-5
[33] S. Hurtado, C. B. Newman, M. C. Tran, and M. J. Chang, "Improving the Rate of Success for Underrepresented Racial Minorities in STEM Fields: Insights from a National Project," *New Directions for Institutional Research*, vol. 148, no. 7, pp. 1–11. Dec. 2010. [Online]. Available: https://doi.org/10.1002/ir
[34] E. Gandhi-Lee, H. Skaza, E. Marti, P. Schrader, and M. Orgill, "Faculty Perceptions of Student Recruitment and Retention in STEM Fields," *European Journal of STEM Education*, vol. 2, no. 1, pp. 1–11. April 2017. [Online]. Available: https://doi.org/10.20897/esteme.201702
[35] R. T. Palmer, D. C. Maramba, M. Gasman, K. A. Renn, and T. B. Lane, "Fostering Success of Ethnic and Racial Minorities in STEM: The Role of Minority Serving Institutions," *Journal of College Student Development*, vol. 56, no.1, pp. 103-105, Jan. 2015.
[36] T. Perez, S. V. Wormington, M. M. Barger, R. D. Schwartz-Bloom, Y. Lee, and L. Linnenbrink-Garcia, (2019). "Science expectancy, value, and cost profiles and their proximal and distal relations to undergraduate science, technology, engineering, and math persistence," *Science Education*, vol. 103, no. 2, pp. 264–286. Jan. 2019. [Online]. Available: https://doi.org/10.1002/sce.21490
[37] C. Engstrom, and V. Tinto, "Access Without Support is not Opportunity," *Change*, vol. 40, no. 1, pp. 46-50, Jan/Feb. 2008. [Online]. Available: https://www.jstor.org/stable/pdf/40178285.pdf
[38] V. Tinto, "Research and Practice of Student Retention: What Next?" *J. College Student Retention*, vol. 8, no. 1, pp. 1–19. May 2006.
[39] D. L. McCoy, C. L. Luedke, and R. Winkle-Wagner, "Encouraged or weeded out: Perspectives of students of color in the STEM disciplines on faculty interactions," *Journal of College Student Development*, vol. 58, no. 5, pp. 657–673. July 2017. [Online]. Available: https://doi.org/10.1353/csd.2017.0052
[40] J. J. Park, Y. K. Kim, C. Salazar, and M. K. Eagan, "Racial Discrimination and Student – Faculty Interaction in STEM : Probing the Mechanisms Influencing Inequality," *Journal of Diversity in Higher Education*, vol. 15, no. 2, pp. 218-229. April 2020.
[41] B. Hong, and P. Shull, "A Retrospective Study of the Impact Faculty Dispositions Have on

Undergraduate Engineering Students," *College Student Journal*, vol. 44, no. 2, pp. 266–278. June 2010.
[42] M. Micari, and P. Pazos, "Connecting to the Professor: Impact of the Student–Faculty Relationship in a Highly Challenging Course," *College Teaching*, vol. 60, no. 2, pp. 41–47, April 2012. [Online]. Available: https://doi.org/10.1080/87567555.2011.627576
[43] National Academies of Sciences, Engineering, and Medicine. (2016). "Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Diverse Student Pathways," S. Malcom and M. Feder, Eds. Washington, DC: The National Academies Press. 2016. [Online]. Available: doi: 10.17226/21739.
[44] E. Seymour, and N. M. Hewitt, *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview, 1997.
[45] B. Christe. "Implementation of an Asynchronous Workshop for STEM Educators Designed to Enhance Professor-Student Rapport," *Journal on Excellence in College Teaching*, vol. 26, no. 4, pp. 9–28. 2015.
[46] M. Larkin, S. Watts, and E. Clifton, "Giving voice and making sense in interpretative phenomenological analysis," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 102–120, Jan. 2006. [Online]. Available: https://doi.org/10.1191/1478088706qp062oa
[47] National Center for Education Statistics. (2018). Table 314.40. Employees in degree-granting postsecondary institutions, by race/ethnicity, sex, employment status, control and level of institution, and primary occupation: Fall 2017. National Center for Education Statistics. https://nces.ed.gov/programs/digest/d18/tables/dt18_314.40.asp
[48] J. A. Smith, and M. Osborn, "Interpretative Phenomenological Analysis," in *Qualitative Psychology: A practical guide to research methods*, J. A. Smith, Ed. Sage Publications, 2013, pp.
[49] J. A. Smith, P. Flowers, and M. Larkin, *Interpretive Phenomenological Analysis*. United Kingdom: SAGE Publications Inc., 2009.
[50] I. Pietkiewicz and J. A. Smith, "A practical guide to using Interpretative Phenomenological Analysis in qualitative research psychology," *Czasopismo Psychologiczne Psychological Journal*, vol. 20, no. 1, pp. 361–369, Jan. 2014. [Online]. Available: https://doi.org/10.14691/cppj.20.1.7
[51] L. Birt, S. Scott, D. Cavers, C. Campbell, and F. Walter, "Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation?" *Qualitative Health Research*, vol. 26, no. 13, pp. 1802–1811, July 2016. [Online]. Available: https://doi.org/10.1177/1049732316654870
[52] M. T. Bevan, "A method of phenomenological interviewing," *Qualitative Health Research*, vol. 24, no. 1, pp. 136–144, Jan. 2014. [Online]. Available: https://doi.org/10.1177/1049732313519710
[53] S. E. Leonard, B. M. Pearcy, R. L. Shehab, and S. E. Walden, "Minority student informed retention strategies," *Proceedings of the IEEE Frontiers in Education Conference (FIE)*, Oklahoma City, OK, USA, 2013, pp. 567-573.
[54] R. Ceglie, "Science Faculty's Support for Underrepresented Students: Building Science Capital," *International Journal of Science and Mathematics Education*. vol. 19, no. 4, pp. 661-679. April 2021.
[55] M. Gasman, T. H. Nguyen, T. Lundberg, C. F. Conrad, and F. Commodore, "Blackmale success in STEM: A case study of morehouse college," *Journal of Diversity in Higher Education*, vol. 10, no. 2, pp. 181–200. June 2017. [Online]. Available:

https://doi.org/10.1037/dhe0000013
[56] O. R. Aragón, J. F. Dovidio, and M. J. Graham, “Colorblind and multicultural ideologies are associated with faculty adoption of inclusive teaching practices,” *Journal of Diversity in Higher Education*, vol. 10, no. 3, pp. 201–215, Sept. 2017. [Online]. Available: https://doi.org/10.1037/dhe0000026
[57] M. Vosen Callens, P. Kelter, J. Motschenbacher, J. Nyachwaya, A. Semanko, and J. Ladbury, (2019). “Research and Teaching: Developing and Implementing a Campus-Wide Professional Development Program: Successes and Challenges,” *Journal of College Science Teaching*, vol. 49, no. 2, Nov. 2019. [Online]. Available: https://doi.org/10.2505/4/jcst19_049_02_68