A Systematized Literature Review of The Factors that Predict the Retention of Racially Minoritized Students in STEM Graduate Degree Programs

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Abstract

According to ASEE's 2018 "Engineering by the Numbers" Report, racially minoritized students constituted 19.1% of engineering baccalaureate degrees awarded, 17.4% of engineering master's degrees awarded, and 12.1% of engineering doctoral degrees awarded across the United States. There is a significant and troubling decrease in the representation of Hispanic or Latinx, Black and/or African American, American Indian or Native American, and Hawaiian/Pacific Islanders as we move up the graduate seniority levels. This is a concern that is mirrored in a lack of continuance to graduate study across all Science, Technology, Engineering, and Mathematics (STEM) fields. While there is currently an extensive body of research on the factors that predict the retention of racially minoritized groups in undergraduate education, it fails to provide scholarly insights or recommendations for practice on factors that impact graduate education. To combat the issue of underrepresentation, it is important for researchers to understand these factors, how they may differ from K-12 and undergraduate levels, and what types of interventions can be put in place to address them. To respond to this need, we present a systematized literature review of articles relevant to understanding the factors that predict the retention of underrepresented and/or racially minoritized students in STEM graduate degree programs.

This systematized literature review found three emergent themes that contribute to the internal attitude to persist and external environment conducive to retention. These themes are grouped by personal factors, social factors, and institutional factors. Findings suggest that there are personal factors that influence minoritized graduate students' retention such as internal motivation, identity development, perception of support, and resilience towards stereotypes, bias, and past experiences. Social/relational aspects also heavily influence students' retention through factors such as sense of belonging, discrimination, advisor and faculty support, mentoring, and work-life balance. Furthermore, the results also identify institutional factors as key players in the retention of minoritized graduate students. These factors are department and campus culture, access to URM (underrepresented minority) role models, and vast networks of societies, alumni, and government programs. The amount of information that was available on these minoritized groups in STEM graduate degree programs was a limitation for this study, but it also pointed to an important gap in the literature, which must be addressed in order to create effective interventions that broaden participation in STEM graduate studies and furthermore in the STEM ecosystem.

Introduction and Literature Review

Although there has been a slow increase of research aimed at understanding URM graduate retention, researchers have made great strides in understanding the factors that influence educational attainment for URM STEM undergraduates. Early exposure to STEM is one of the primary predictors of interest in STEM for undergraduate minorities [1]. The transition from

high school to college and students' adjustment to the college educational system are also important to their persistence [2]. The development of mentoring relationships with others that are peers, graduate students, or faculty and staff members within the university or within professional networks are just as important [3]. Financial barriers, advocacy needs, and negative attitudes are also common factors that affect retention [4]. Peer support and involvement with STEM-related activities are predictors of retention [5].

Many of these concepts could be believed to have some effect on students at the graduate level, but there are differing characteristics between undergraduate and graduate school that may result in other factors. Researchers, interested in making the engineering ecosystem more diverse and inclusive, desire to understand what has an influence on the retention of these URM groups and what strategic actions can they execute that positively influence these factors. At the graduate level, a few recent articles were found in a preliminary search that pointed to factors like culture, connection [6], community, sense of belonging [6], academic sense of self [7], advising and mentoring relationships [7], and internal motivation [8] as all influential.

Although the few articles cited above point towards some influential factors, there is still a great amount of systematic investigation and implementation that needs to be done in order to help mitigate the risks of departing URM students. That is why it is vital for us to add to the literature organizing and describing the sets of factors that influence retention for these students so that the proper interventions can be developed. This systematized literature review addresses the consistent factors that can negatively or positively impact racial minorities' pursuit of STEM graduate degrees. It more clearly delineates the dimensions that are impactful for URM graduate students in STEM by addressing the following research question:

What factors influence the retention of racially minoritized students in STEM graduate degree programs?

This systematized literature review clearly identifies three broad areas of factors that related to the retention of racial minorities in STEM graduate programs: personal, social/relational, and institutional factors. Our review describes what the factors are and the ways in which they operate to effect retention for marginalized groups. By understanding these factors, engineering education researchers can build a foundation of knowledge that can be utilized to develop effective interventions that will broaden URM participation in STEM graduate studies.

Methods

Search Procedure

This systematized literature review investigates the factors that influence the retention of racially minoritized students in STEM graduate degree programs in the United States. The review is limited to full-text peer-reviewed journal articles that include any racially minoritized students at the graduate level in a science, technology, engineering, or mathematics major that is recognized as a STEM discipline by federal agencies such as the National Science Foundation (NSF) [9]. These disciplines include fields such as chemistry, geosciences, life sciences, mathematical sciences, social sciences, information technology, engineering, mathematics, and education (e.g., engineering education) [9]. The term "racially minoritized" is used to describe students that are

not only the minority by number but have also been treated as less-than by the majority group. In this paper, we use the terms "racially minoritized" and "underrepresented minorities (URM)" interchangeably to describe our focus for ease of wording, though they refer to different categorizations. In this article we limit our study of racially minoritized student experiences to Hispanic/Latinx, Black/African American, Native American/American Indian, and Hawaiian/Pacific Islander students. We acknowledge that Asian Americans are racially minoritized, even though they are referenced by the model minority myth, which suggests that they succeed more academically and do not face the same academic challenges as other racial groups [10]. We understand that subgroups within this category also suffer from microaggressions related to race and linguistics, and deal with other forms of systemic oppressions as well. But, because they are not numerically underrepresented in STEM graduate programs based on institutional enrollment data, we did not include them in our definition of underrepresented minorities for this review. Graduate degree programs include programs that result in the earning of a masters, doctoral, or professional degree.

We did not include URM students in undergraduate STEM education because of the differences in classroom settings, academic expectations, funding opportunities, faculty interactions, and extent of existing scholarly literature on their experiences. Although there is still a scarcity in the number of minorities represented in undergraduate degree programs, there are several interventions and programs designed to assist in their persistence that are not visible at the graduate level. The terms "persistence" and "retention" are used synonymously in this review to showcase the overall success of a graduate student completing a masters, doctoral, or professional degree. This systematized literature review focuses on personal, social, and institutional factors that influence the retention of URMs in STEM graduate degree programs. While experiences in undergraduate education may have influenced, or hindered, their persistence to degree completion, it was not examined in this review.

We evaluated literature retrieved from selected databases using search strings to query articles that have a direct correlation to the factors outlined in our research question. We used the Education Source, Scopus, and ERIC databases to search for relevant findings. Education Source, hosted by EBSCOhost, was the primary database used because it contains full-text educational peer-reviewed articles that focus on education and the educational experience. Scopus was used as a secondary database because it is the largest database for peer-reviewed literature that encompasses research interests of engineering education researchers. ERIC, also hosted by EBSCOhost, was used in initial searches since its database indexed journal articles in education as well.

Although the search strings were diversified per database, we used variations of the words "retention", "minorities", "engineering", and/or "graduate school" to identify relevant articles. For the primary database search (the Education Source query) four major components were used. "Retention" was used interchangeably with "persistence" and "success" to show articles that discussed keeping students within programs. In order to reduce the amount of undergraduate research listed in the results, the term "Higher education" was used synonymously with "PhD", "Masters", "Doctoral", and "Post Grad*" to identify articles with a focus on graduate students. To find articles that were specifically about URMs, we listed the term minority as "minorit*" and was used interchangeably with "Black*", "African American", and "Underrepresented

Minorit*". To scope this first systematized literature review, we chose to focus our search on one particular minoritized group "Black/African American". Although we focused on including this particular group in our search string, we still included research that pointed out factors that influenced retention for Hispanics, Native Americans, and Pacific Islanders when these articles were identified by the overall URM search term. In future work, we will thoroughly explore each specific racial/ethnic category of interest to ensure that we can capture a more robust picture that speaks to the differences and similarities amongst URMs. The asterisk was used to search for any variation of the words "Black" and "minority". To identify articles that pertained to research relevant to engineering, we used "engineering". However, due to the limited number of articles found, we had to extend our search string to include "STEM". For the ERIC query, only "retention" AND "minorities" AND "engineering" were used to identify articles. This selection of terms was used because it yielded the best initial results of the ERIC search. Similar search string components were used in the Scopus query, as in the Education Source query, but were restricted by location of the component within the article. To ensure that relevant articles were found, these specific terms were used due to their prominent use in scholarly engineering and STEM education research. Review Table 1 below to see the detailed search strings, queried databases, and initial results.

When searching the databases, a variety of methods were applied to identify the most relevant possible articles based on the search string components, location of those terms, and the coverage of initial results. For the Education Source and ERIC queries, the database searched the entire article for the presence of the search string components to maximize on the number of articles that reference our key terms and can be used in the review.   For the Scopus search, we found that the title, abstract, and keyword combinations shown in Table 1 provided the best output of initial results. Our database search yielded 184 articles in ERIC, 170 in Education Source, and 96 in Scopus.

Table 1. Search Strings and Database Results		
Search String	**Database**	**Initial Results**
(Retention OR Persistence OR Success) AND (Higher Education OR PhD OR Masters OR Doctoral OR Post Grad*) AND (Minorit* OR Black* OR African American OR Underrepresented Minorit*) AND (Engineering OR Stem)	Education Source	170
(Retention) AND (Minorities) AND (Engineering)	ERIC	184
(TITLE-ABS-KEY (retention OR persistence OR success) AND ABS (engineering OR stem) AND ABS (PhD OR doctorate OR graduate AND school OR grad*) AND TITLE (minorit* OR Black OR African-American))	Scopus	96

Inclusion and Exclusion Criteria

We developed the inclusion criteria during the initial phase of the process of this systematized literature review. To ensure that we reviewed articles that captured the essence of our interest, we include papers if they:

1.) Are scholarly peer-reviewed journal articles
2.) Focus on any URM group in a masters, professional, or PhD program
3.) Discuss graduate school experiences of URMs holding masters or PhD
4.) Explicitly focus on retention and/or persistence
5.) Mention any strategies or interventions for retention in STEM.

We developed the exclusion criteria during the screening and appraisal phases of this process. To ensure that only unrelated articles were excluded, we do not include articles if they:

1.) Are dissertations or books
2.) Are published outside of the United States
3.) Are written in a language other than English
4.) Focus on any program other than a science, technology, engineering, or math field.

5.) Focus on all graduate students, not just URMs
6.) Did not emphasize retention or persistence within the article
7.) Focus on K-12 students or undergraduate URMs.

Based on the inclusion and exclusion criteria, which are also outlined in Table 2 below, empirical papers emerged as the primary source of information for articles relevant to the research question. Many of the articles reviewed used the experiences, as told by URM graduate students, as a data source to then identify common themes that influenced retention as well as created barriers in their program.

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
- Scholarly Peer-Reviewed Journal Article - URMs in Graduate Education (Masters, Professional, or Ph.D. Programs) - URMs Holding Graduate Degrees (Ph.D., Masters) - Focus on Retention/Persistence - Mention of Retention Strategies	- Dissertation or Book - Non-US Publication - Non-English Language - Non-STEM Related - No Focus on URMs - No Emphasis on Retention/Persistence - Focus on K-12 or Undergraduate URMs

After completing the process of using the databases to conduct the search string query and then more narrowly identify articles that met the inclusion/exclusion criteria, a total of 20 articles were selected to be included in this analysis. The selection process involved 3 main steps to identify the articles that were included in the review: 1) identify relevant articles by searching databases, 2) screen the title and abstracts based on the inclusion and exclusion criteria, and 3) assess the entire text of the remaining articles to identify the final literature collection. This selection process and steps are associated with the PRISMA selection process (Moher et al., 2009) that was recommended by Borrego et al. (2014). Figure 1 shows an adaptation of the PRISMA flowchart below, which describes the search process and the number of articles we reviewed in our work.
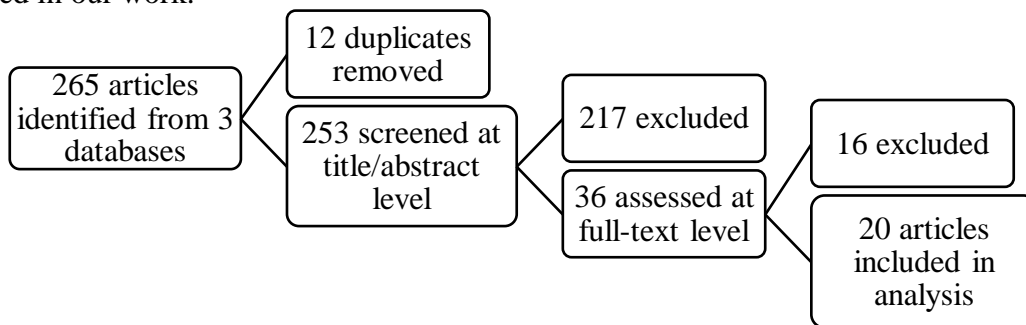

Figure 1: Adaptation of the PRISMA flowchart (Moher et al., 2009) for search process described in our paper

This selection process narrowed down the articles to specific papers that were relevant to the research aim that we address.

Analysis

The use of thematic analysis allowed us to appraise the collected literature that is relevant to this review. This analysis consisted of the reading of 20 selected articles, identification of relevant content, coding of each paper, and the emergence of themes for discussion. We read 20 articles in their entirety to identify emerging themes related to factors that influence the retention of URM graduate students.

We performed the initial analysis by reading each article and taking specific notes on the details within the article such as the focus of the research question, the methods used to conduct the study, the findings of the study, the framework used, and its relevance to our question. The focus of the research article indicated what the research question was and what the study aimed to discover. The methods used to conduct the study indicated typical methodologies used to inform studies like these. Identifying the frameworks used allowed us to discover the underlying attitudes, focus, and limitations of the researcher and the research. Identifying specifically relevant content provided the thematic results that can be found in the following section.

Results

Our findings indicate that three major themes contribute to the internal attitude to persist and external environment for retention of URMs in STEM graduate degree programs. These three themes are: personal factors, social/relational factors, and institutional factors. Our findings suggest that there are personal factors that contribute to students' retention that include internal motivation, identity development, perception of support, and resilience towards stereotypes, bias, and experiences. The social/relational factors that influence students' retention include sense of belonging, discrimination, advisor and faculty support, mentoring, and work-life balance. Results also showed that institutional factors include department and campus culture, access to URM role models, and networks of academic societies, alumni, and government programs. The three themes are listed in Figure 2 below and in the following sections.

Personal Factors	Social/Relational Factors	Institutional Factors

• Internal Motivation
• Identity Development
• Perception of Support
• Resilience
  • Stereotypes
  • Bias
  • Experiences
	• Sense of Belonging
	• Discrimination
	• Advisor and Faculty Support
	• Mentoring
	• Work-Life Balance
		• Department and Campus Culture
		• Acccess to URM Role Models
		• Network of Academic Socieities, Alumni, and Government Programs

Figure 2: Thematic Analysis for Factors Influencing STEM URM Graduate Student Retention.

Theme 1: Personal Factors

The first theme to emerge from this analysis indicates that it is vital for the individual URM to have individual attitudes and experiences that aid in their retention within their STEM graduate degree program. These personal factors were differentiated as internal motivation, identity development, perception of support, and "resilience toward stereotypes, bias, and previously lived experiences" [1]. These factors presented themselves across several of the articles reviewed during the analysis process.

Internal Motivation

Quite a few URM graduate students indicated that one of the factors of retention for them was an internal motivation to remain in the program for their own personal reasons, which included an early interest in science and math, a greater purpose, individual security, career aspirations, goal commitments, and determination. In a study discovering origins of interest for Black male scholars, Burt and Johnson suggested in their findings that internal motivation was guided by an early interest in math and science concepts that was supported by their familial and academic networks to create ways to matriculate through the STEM ecosystem [11]. Due to this early interest, many graduate students committed to goals and were determined to complete their degrees [12]. Moreover, some research findings indicated that their internal motivation developed from having a greater spiritual purpose that benefited from going through the graduate education process [13]. These spiritual purposes range from an inner feeling of empowerment to promote change to an outward motivation to inspire and encourage the world around us. Tierney suggests that individuals needed to be secure with their own cultural identity in order to increase their potential to succeed [14]. Factors such as these also contribute to another personal attribute that is important for retention: identity development.

Identity Development

The development of a scholar's identity is based on the numerous experiences they encounter and their perceptions of self as they matriculate into and progress through their academic programs. These experiences can have both negative and positive influences on the individual URM's desire to persist in a STEM graduate degree program. Participants in one particular study mentioned that, as women of color, they often grappled with their self-identity when navigating in exclusive academic settings [15]. Due to hostility in racially charged academic environments, minoritized students often faced challenges to developing their identity and even experienced a reduction in their overall well-being [16]. In STEM disciplines, where academic background is seen as critical, many minoritized students experienced situations that damaged their confidence, created feelings of incapability, and decreased their motivation to persist in such an environment [17].

These experiences tended to make URM students conscious of their individual identities within exclusive spaces such as STEM degree programs. They often reported feelings of the following: increased awareness of being a representation for everyone in their race [18], internal perceptions of a learning deficit in math and science studies [19], pressures to work harder because of their race and gender [20], lack of knowledge and exposure [21], difficulty meeting the academic

prerequisites and being admitted [21], and not having their accomplishments acknowledged due to their race [22]. Students even expressed that it was vital to their identity development to have affirmation that they were in the right program and could overcome the obstacles they might face [16]. To cope with these internal pressures and external stresses, students often showcased different parts of their identities in different academic settings. These students often revealed their STEM identity to their department while sharing their social identity with URM groups [23]. Students echoed similar sentiments when they expressed how they use different identities for different situations [15]. Many minoritized students used the support from their social URM groups to strengthen their positive sense of identity, which caused them to not often be swayed by the negative aspects of their environment. This positive development of identity encouraged them to participate in social activities, gave them a sense of cultural pride, provided them with a confidence boost, and increased their determination to persist despite any systemic oppressions [12].

Perception of Support

Perception of support is a vital factor that influences the retention of URM scholars. The more that students feel supported, the more that they increase their motivation and persistence to complete their respective programs. Support for this group of individuals comes in a variety of forms. One form is the encouragement from their family members. Many students, especially at predominately white institutions, described being able to persist due to the frequent and continuous encouragement they received from family [16].

Regardless of the family's educational background, many of them provided strong support networks and reinforced values that helped sustain the minoritized students in STEM [23]. Due to principles learned within their familial networks, these students are equipped with the resilience and emotional tools that they need to persist in their programs [23]. Minoritized women indicated that they were blessed with family resources that encouraged them to pursue their goals, regardless of societal ideals on who can do what in their careers [23]. URMs from lower socioeconomic statuses explained that their household was filled with love and support and their mothers instilled in them the importance of academic attainment [16]. URM scholars often attributed their determination and resilience to the life lessons that they acquired while growing up in their communities [16]. Households like this provided supportive frameworks for persistence and achievement for URM students.

URM scholars also mentioned receiving support from community networks outside of the home. This includes spiritual and faith-based communities that provide minoritized students with multiple sources of strength, encouragement, and support [16], and universities that implement practices that promote a sense of familial connections amongst peers, faculty, and staff. These inclusion practices serve as informative tools for departments to recognize the importance of social connections, for persons who many not be familiar with university processes, for reducing feelings of isolation from family, and for extending a resource line from family to students to provide support through their degree programs [24]. This perceived support is important to the persistence of URMs in STEM graduate degree programs.

Resilience Towards Stereotypes, Bias, and Previously Lived Experiences

In the articles we reviewed, we found that a number of studies showed that a great percentage of URM graduate students in STEM degree programs have developed a resilience towards adversity. One of the streams of adversity come from stereotypes placed on URMs. In fact, scholars have researched stereotype threats and the impact it has on the individual themselves. In these studies, many students were well aware of societal stereotypes, especially for minorities at the intersection of race and gender [15]. For example, many Black women expressed that others assumed they were loud and unruly when things did not work out in their favor [15]. Minoritized students felt that others make them well aware of their differences and consider them as lazy, which caused them to have feelings associated with race-based stereotype threat [20]. And for those who were high achievers, others constantly compared their level of success based on the societal stereotypes of Black students traditionally being seen as low achievers [16]. These pressures made Black students respond with self-protective measures, which included coping strategies [16]. Studies like these show that URM graduate students, especially Black students, must develop a resilience towards stereotypes as a personal attribute that positively impacts their desire to persist.

Resilience towards bias is a personal attribute that is prevalent in persisting URM scholars at the graduate level. Although bias is often combined with stereotype, it carries its own set of obstacles that URMs must overcome. While a stereotype is a preconceived idea that attributes certain characteristics to all members of a certain group, a bias is a personal preference that interferes with a person's ability to be impartial and unprejudiced. Although it is not always directly identified in research, it is important to mention because it has a direct impact on URMs as well. Scholars often indicated that they recognized the misperceptions of their skills and abilities were based on the bias related to their identity [15]. Minoritized students reported having their academic competencies questioned by the majority and even been demoted based on bias [15]. Frequently, URM graduate scholars had to learn how to successfully navigate and cope with the biases of their peers, faculty, and staff based on the complexities and intersections of race, class, and gender.

Another building block of resilience forms from the past experiences that have helped shaped their inclination to persist within their programs. They are motivated to work harder and prove the naysayers wrong, especially when the nays are coming from faculty members that they are not fond of [20].

But, in some instances, the experiences at their respective institutions resulted in them exploring more avenues that helped yield a greater resilience. Some students left their programs to self-reflect [19], some transferred to more supportive departments or universities [20], and some immersed themselves in religious practice or spiritual faith when there was no one to turn to [16]. These ways of building resilience served as tools to equip URM graduate scholars with the personal attributes needed to persist in STEM programs.

Theme 2: Social/Relational Factors

The second theme to emerge from this analysis indicates that there are social/relational factors that have a great influence on the retention of URMs in STEM graduate programs. These factors were identified as: sense of belonging, discrimination, advisor and faculty support, mentoring, and work-life balance.

Sense of Belonging

Underrepresentation in STEM, itself, is a barrier to students' persistence [16]. Without a variety of diverse individuals in this academic space, there is a lack of inclusiveness, which interferes with a person's sense of belonging. URM scholars felt academic judgment and personal judgement from their respective peers because of their race [20]. Prior to going into graduate school, some students indicated that they received encouragement from their academic network to pursue STEM degree [16]. This type of support proved to not be prevalent in their graduate endeavors as they experienced a variety of simultaneous messages that caused them to feel that they did not belong there [16]. Minorities often expressed not being prepared for the isolation and exclusion that occurs in their classes, labs, etc. [17].

Others in various studies within the selected articles identified issues with isolation as well. Many of the minoritized students in these results shared that there was an extreme difference in what they expected of their graduate endeavors and what they actually experienced, which translated into them feeling alone and exiled [13]. Isolation or exclusion is one of the prime factors for a decrease in retention of URM students [19]. Others acknowledged the impact that these issues had on their ability to function as a normal member of STEM society. The alienation from faculty and peers often resulted in a lack of confidence and comfort with communicating in order to gain understanding, attend meetings, request help, or even participate [19][12]. Due to a lack of STEM faculty and peers that represent similar life narratives and cultural norms [18], many minoritized students see these previously listed factors as adversities that needed to be overcome to persist.

When students are not integrated into the culture of their doctoral programs to gain a sense of belonging, they can be deterred from completing their degree [19]. However, based on the articles reviewed, establishing cultural comfort to promote a sense of belonging served as a positive influencer of URM graduate student retention. Departments that provided application support [14], social support [21], financial support [18], and cultural engagement activities [25]. Peer interactions and orientation also served as ways to establish cultural comfort because they allowed students the opportunity to develop a supportive community that cares about their well-being and professional growth [12]. Cultural engagement activities served as another effective way to establish cultural comfort; these activities included service learning, career shadowing, professional seminars, and the promotion of diversity [25].

Discrimination

Racial discrimination is the unjust or prejudicial treatment of an individual based on the color of their skin, or racial or ethnic origin. This type of discrimination is prevalent in the unethical

treatment that URM graduate students experience in STEM. The majority of minoritized students expressed that their faculty and peers held preconceived notions about them because of their race, and it reflected in their experiences with them [20]. They noted that faculty and peers made negative assumptions about their intellect and identity in the forms of bias, derogatory remarks, toxic stereotypes, and microaggressions [16]. Due to their assumptions about minoritized students, they often interacted with them assuming that they had poor work ethic or lack in academic ability [22]. Discrimination includes stereotypes, biases, isolation, unwelcoming cultures, and many of the other factors examined in this review.

Advisor and Faculty Support

Minoritized students' relationships with their advisor and faculty can prove to be a double-edged sword that can have a negative or positive influence on retention [12]. Graduate students cannot progress through their respective programs without the constant support of their advisor. This type of mentorship extends past academic concerns and generates opportunities for personal and professional development [25]. This relationship is crucial to their success and should be a very close, tight-knit bond between the student and the advisor, but this is not always the case [12]. Therefore, the potential of the advisor-advisee relationship itself should be thoroughly investigated [14] and interactions between faculty and students should be viewed with the utmost importance. Many participants across articles included in this review complained about the limited interactions with their faculty outside of the classroom [20], absence of support [19], and judgment they have felt [20]. Due to the discriminatory and biased nature of some faculty and staff members, URM scholars were frequently denied the academic validation and encouragement [16] that they need to do doctoral-level work. Some students even experienced explicitly discouraging messages that ranged from passive-aggressive to explicit challenges regarding their ability to persist in doctoral programs [16]. This lack of faculty and institutional support also caused URM scholars to reevaluate their decisions regarding their academic endeavors in their STEM graduate program [15].

Institutions must strive to have a critical mass of culturally diverse administrators, faculty, and students to foster support and inclusion. With this being said, there has to be an investment made to facilitate a more diverse, equitable, and inclusive STEM doctoral workforce that can address the social/relational factors that URMs in graduate school encounter [26].

Mentoring

Mentoring has been indicated as a key component for the successful completion of graduate level degrees for URMs in STEM. Studies show that there is a positive correlation between students of color's satisfaction and their mentoring relationships with faculty [19]. Other educators acknowledged that mentoring relationships provide a blueprint for success for career attainment, especially in academia [19]. URM scholars acknowledged these types of high-quality mentoring relationships as helpful, reassuring, and encouraging because of the cadre of supportive faculty combined with the graduate research experiences [18]. A high quality mentorship relationship, in this context, is one where an experienced professional helped a graduate student successfully matriculate through their degree program to achieve career goals while assisting them with their inclusion within the departmental culture [18]. This definition of quality differs from that at the

undergraduate level, who have more frequent mentoring relationships with their older peers At the graduate level, it is likely that the quality of these interactions rather than the frequency of them had a higher impact on URMs perceiving themselves as being recognized as professionals within their STEM field. Therefore, mentoring is a vital factor in the retention of STEM URM graduate students.

Work-Life Balance

Persisting through a STEM graduate degree program consists of making trade-offs and sacrifices that have a direct impact on URM students' lives. Most people view the STEM ecosystem as a socially isolating environment that causes strain and distress in their relationships with others [15]. Trade-offs are not uncommon. Often times, scholars have to make the choice between family or career due to the following factors that impact the entire family: relocation, rebuilding networks, work priorities, and work opportunities [22]. The family dynamic even expands to trade-offs between financial security, caring for the family, and advancement [22]. Weighing the pros and cons for graduate school, family, and career can have a positive or negative influence on URM STEM graduate student persistence.

Theme 3: Institutional Factors

The last theme to emerge showcased the institutional factors that can impact the retention of URM graduate students in STEM. These institutional factors were identified as campus and departmental culture, access to URM role models, and networks of societies and organizations.

Campus and Departmental Culture

The culture of the department and campus is another social/relational factor that has a heavy influence on the retention of minoritized graduate students in STEM. Many underrepresented students of color do not have favorable perceptions of their program's climate [18]. These unfavorable perceptions are of no fault of the student either. In fact, cultural capital theory as applied to understanding graduate student experiences illustrates that those admitted into STEM graduate programs already possessed the cultural capital needed to feel like they belonged in STEM fields [18]. However, students assessed the external affirmation and reinforcement of that capital to determine their chances for succeeding in their chosen STEM program [18]. Through their own analysis of the cultural resource rewarded and the climate around them, minoritized students viewed their chances of obtaining their doctoral degree as slim due to the lack of affirmation and reinforcement from their STEM program and social networks that did not promote a sense of belonging and a feeling of competency [18].

Outside of a student's perceptions and beliefs about the culture, there are social experiences that they encounter that influence persistence. Microaggressions in everyday practices in STEM continued to have drastic impacts on the experiences of URMs [23]. There are interpersonal relations that caused more difficulty for those at the intersection of race and gender than the structural barriers that tend to persist [23]. Interpersonal relations included isolation, racism, sexism, being identified by race, and faculty and peer relationships [23]. With little or no interaction with peers who shared the same values and outlooks on life, minority students are not

exposed to interpersonal relationships that bring about reassurance and confirmation that "all is well." [12]. This makes it extremely difficult for a student to successfully navigate a campus or department culture that has a lack of relatable role models [22] and a surplus of discouraging professors [21], a shortage of minority enrollment due to recruitment [16], and an increase in isolation through unfavorable practices [16]. Cultural attitudes from faculty that view minorities as not having talent and being in certain programs due to their race and ethnicity also influence the perception of the departmental culture [15].

When department faculty and peers or campus culture share these similar sentiments, they create an exclusive culture, and it is difficult for URM graduate students to try to include themselves in it. Students confirm this when they mention things related to difficulty in being included in traditional academic societies and organizations. This makes organizations like the National Society of Black Engineers vital to creating a space that validates and affirms students of racial and gendered discrimination [16]. The traditional STEM ecosystem often proves to be unwelcoming by not fostering an atmosphere that encourages students to ask questions, work together, and actively participate [12]. Many of the participants throughout these studies indicate that race, gender, and social conflicts and relationships perpetuate power and discrimination that is enacted through social practices through varying sources on campus [27].

Access to URM role models who have doctoral degrees

It is vital for minoritized students to have access to minorities who have obtained their doctoral degrees and are persisting in the STEM ecosystem. Therefore, institutions must have a widely diverse set of faculty who can serve as role models for students and provide them with the interpersonal relationships that aid in the success of that student [12]. URM scholars believe that these types of role models go above and beyond to provide support, encouragement, understanding, and opportunity for their students [12]. This can help boost confidence in the minoritized students and even influence them to consider roles in academia or other occupations where they have interacted with successful URM role models [19].

Networks of academic societies, alumni, and government programs

It is important for URM graduate scholars to be involved in several academic societies and programs that expand their networks to include role models, support, alumni, and opportunities. Capital cultural theory suggests that support for student persistence can be provided from family and non-STEM friends who know, peers with whom they have developed a familial connection, and faculty with whom they have developed a familial connection [18]. Using these networks to get involved in in professional academic associations allowed URM scholars to become activists with their research and gain career opportunities when finished with their degree [21]. These professional associations provide URM scholars with a supportive environment and community to build their research network with an encouraging group of similar individuals outside of their academic network [14]. There are a few specific programs designed to broaden participation in STEM for URM scholars at the graduate level. The McNair Scholar Program is an initiative by the United States Department of Education that serves to increase the number underrepresented minorities who have attained doctoral degrees [20]. A large percentage of McNair Scholars indicated that the program helped them in the following areas: entrance to graduate school,

preparation of graduate level research, formulation of social interactions, and gaining financial support [20]. The Meyerhoff Program is another program geared towards promoting cultural diversity in the sciences at the graduate level for URM scholars. This program accomplishes this by their programmatic initiatives, course redesign, partnerships, impact on institutional culture, and impact on change beyond campus [17]. PROMISE: Maryland's Alliance for Graduate Education and the Professoriate is another noteworthy program. This program makes efforts on all levels to promote URM scholars from undergraduate degrees to doctoral degrees to faculty positions. The program recommends the professional development of graduate students that includes a critical mass of URMs and extends beyond experiences that are provided by courses and research laboratories [28]. The program believes that all of their graduate students should have accessible and functioning support systems to help them develop professional skills, network, get career advice, and strengthen their emotional well-being [28]. This shows that having access to a vast number of diverse networks is just as important to the success of URM graduate students as their academic development.

Discussion

Engineers have the power to shape society as they develop innovative and efficient ways to improve the community, aid in the nation's global competitiveness, and create lasting legacies that will positively impact our economic growth. Those who have obtained graduate degrees and are trained with the expertise and integrity to make professional engineering decisions for the greater good of the public are enabling the STEM workforce to provide products and services that allows the United States to retain its elite status and economic and political power. Diversity of representation within those leadership roles characterizes the value of this status. Currently, there is a severe lack of URM representation within both the engineering workforce and academia, especially at the leadership level. This under-representation can be traced back to the dearth of URM graduate students of STEM programs.

Although there is a steady increase in the participation of URM early career engineers holding baccalaureate degrees, there is a continuing shortage of graduate degreed engineers in the ecosystem that can fill these leadership positions quickly. This shortage is attributed to the small percentage of URMs with a master's or doctoral degree who qualify for these roles. Because engineering has such a great impact on our society's growth and advancement, it is important to have a diverse array of people with differing worldviews and perspectives who have been trained to think innovatively to tackle the world's problems within the STEM workforce and academia. For this reason, it is vital that more racially minoritized individuals pursue education beyond the baccalaureate degree to ensure that we can fill the engineering ecosystem, increase minority representation in academia and the workforce, and provide our nation with the most effective solutions to tackle the world's biggest concerns.

However, in order for us to tackle the world's biggest problems, we must address one of the most prolonged, unethical, and immoral issues of our own nation: the treatment of racial minorities by those belonging to, and fitting in to, the dominant STEM culture. The culture of STEM itself creates a multitude of factors that can influence the retention of URM graduate students based on the attitudes, mindsets, values, and beliefs of those operating in the dominate group. This culture can influence the strengthening or wavering of internal motivation and the positive or negative

development of one's identity. Unfortunately for URMs, the perceived advisor and faculty support, sense of belongingness amongst peers, and discriminatory treatment received from this culture is not empowering or uplifting, but hindering and demeaning, usually resulting in resilience, reactive coping, emotional distress, or departure.

Implications and Recommendations

Based on the themes that were revealed in this systematized review of the literature, many of the factors influencing retention were external to the URM student's being. There are times when we can acknowledge that there may be individual attitudes and experiences that should be addressed, but then there are times when we MUST acknowledge that there is a deeper need, a more complex issue that needs to be addressed with the system. Many of these factors have something to do with the URM's interactions with the STEM ecosystem, whether it be unwelcoming climates, lack of URM role models, few networking opportunities, or discrimination. When these situations are occurring, there needs to be systematic change, not just an intervention. In these situations, it is not good to cover the sore with a band aid, but to clean the wound from the inside out so that it may heal properly. We must not shy away from the challenge that we need to change the attitudes and mindsets of those in leadership who do not value diversity as a key stakeholder in the overall advancement of the engineering ecosystem. We need to address the unfair recruitment measures that we have that showcase bias in the places we seek talent and the ways in which we seek them. When we start to properly heal the wound ourselves, we will begin to see that interventions work out favorably for the retention of URM graduate students. The primary objective of any graduate department or school, should be to make systematic and cultural change in the department so that effective interventions can be implemented to aid in the resourceful retention of URM students in the engineering ecosystem.

We acknowledge that universities have mandatory diversity and inclusion training for faculty, staff, administration, and students; however, it seems to be highly ineffective, given some of the results that pointed out issues like microaggressions, biases, and lack of belonging. Problems are usually addressed as they arise, on an ad hoc basis; but this literature review illustrates that these measures prove to be superficial as research continues to point out discriminatory and alienating issues that practices like this should address. To promote success in increasing the number of URM scholars in graduate degree programs, further work needs to be done to understand these factors individually and to address them in a more integrated, proactive, and systematic way. This would result in effective interventions, trainings, and systematic improvements that will decrease the amount of malaise that racial minorities feel and increase the amount of support and guidance they receive. For example, racial minorities reported that they often had issues with proper identity development due to experiences such as feeling consumed in an unwelcoming environment, having their abilities questioned by faculty and peers, and seeing the small quantity of other URM peers and role models. A solution that could result from this would be that institutions leverage URM + STEM identity research to create intentional safe spaces that allow students to connect with trusted minority peers and leaders to help support their identity development. The trusted URM leaders can then advocate for systemic change that negatively influences proper identity development. This intervention may seem simple, but it would work to address issues related to sense of belonging, mentoring, networking, perception of support, and resilience. If institutions can strive to implement interventions like this, we would begin to

see a positive change in STEM graduate program demographics, culture, ideals, and values. This would truly advocate for diverse and inclusive practices that would lead to an increase in their overall array of diverse ideas, climate, students, and faculty in their programs.

Limitations

The amount of information that was available on these minoritized groups in STEM graduate degree programs was a limitation for this study, but it also pointed to an important gap in the literature, which must be addressed in order to create effective interventions that broaden participation in STEM graduate studies. Another limitation is that only Education Source, ERIC, and Scopus databases were used to conduct a thorough search. In this review, URMs who exited STEM graduate degree programs were not explicitly studied, and therefore the findings did not focus on factors that influenced their departure. However, it would be beneficial to study this group due to their direct experience with factors that negatively impacted their retention in STEM degree programs to result in their departure. There were also a variety of articles that focused on students at the intersection of multiple identities based on race, class, gender, etc. It would be valuable to gather more information on them. Based on the analysis in this systematized literature review, it seems that they had more dealings with negatively impactful barriers, yet most persisted. It would be important to speak with them directly to identify what helped them persist and implement interventions to address those issues.

Conclusions

This systematized literature review revealed three themes that include a set of 12 factors that influence the retention of minoritized graduate students in STEM. In order to broaden participation for URMs on all educational, academic, and industrial levels, institutions must understand the factors that impact graduate students and implement change. By reviewing the literature results from our searches, we recognized three major themes amongst factors that influence retention for these groups: personal factors, socio/relational factors, and institutional factors. Internal motivation, identity development, perception of support, and resilience comprised the list of personal factors. The social/relational factors included sense of belonging, discrimination, advisor and faculty support, mentoring, and work-life balance. Campus and departmental culture, URM role model access, and networking through organizations and societies covered the institutional factors. It is important that we understand these factors so that we can implement effective strategies that will encourage and support more racially minoritized individuals in their pursuit of higher degrees, to populate the engineering ecosystem in academia and industry, and to help cultivate ideas, products, and services that aid in the overall progression of the United States as an elite country.

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