Retention of Underrepresented Minority Undergraduates in STEM: Applying Social Cognitive Theory and the SAFE Model

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ABSTRACT

Far fewer undergraduate students pursue and complete STEM degrees compared to humanities degrees, despite high demand for STEM professionals. Among undergraduate STEM majors, individuals from underrepresented racial minority (URM) groups are far less likely to complete their degree than their White or Asian peers, presenting a serious obstacle to diversity within the STEM workforce. Drawing from Bandura's Social Cognitive Theory, researchers have identified factors that affect the retention of URM students in STEM, though there is substantial evidence that such factors are moderated by environmental influences not traditionally included in the theory. In this paper, we argue that many environmental influences can be conceptually unified under the State Authenticity as Fit to Environment (SAFE) model. Further, we review literature suggesting that the constructs of both Social Cognitive Theory and the SAFE model interact extensively when considering retention of URM undergraduates, arguing that understanding the interactions between the two models will provide a more complete picture of how retention of URM students can be improved.

Introduction

Employment in science, technology, engineering, and mathematics (STEM) occupations in the United States is projected to increase by almost 11% between 2021 and 2031, more than twice the growth rate of non-STEM occupations (BLS, 2022). Despite this high demand for STEM professionals, less than a third of undergraduate students declare a STEM major and less than a quarter successfully complete a STEM degree (Mau, 2016). Even when exclusively examining students initially interested in STEM, less than 40% go on to complete a STEM major (Olson & Riordan, 2012). Even more distressing, underrepresented racial minority (URM) students are far less likely to complete a STEM major, with 20% of White students and 29.5% of Asian students completing STEM bachelor's degrees relative to 11.1% of Black students, 15.4% of Native American students and 14.1% of Hispanic students, despite between 25% and 32% of these URM students initially declaring a STEM major (Mau, 2016). These findings suggest that not only are there barriers

to completing a STEM degree, but also that these barriers are significantly higher for URM students. While disparities in income, household education, and quality of secondary education (Fletcher & Tienda, 2010; Hung et al., 2020) are large contributors to academic achievement gaps between URM and white students in the United States, they do not account for the entirety of these gaps. Additionally, these factors may, in part, be indirectly associated with differences in academic achievement via psychosocial factors, highlighting the importance of examining the psychological contributions to these gaps. This paper examines how systemic racism, as well as current lack of diversity within STEM, influences retention of URM students through the lens of two suitable social psychology theories: Bandura's Social Cognitive Theory (Bandura, 1986) and the State Authenticity as Fit to Environment (SAFE) model (Schmader & Sedikides, 2018). This paper will rely on Schunk and DiBenedetto's (2020) review of Bandura's original

theory (Bandura, 1986) as it better captures modern usage of these constructs in research.

Social Cognitive Theory provides a framework for explaining various personal, behavioral, and environmental processes that influence learning (Bandura, 1986; reviewed in Schunk & DiBenedetto, 2020). These processes interact with one another to either hinder or support learning in a reciprocal manner. Environmental influences that affect motivation to learn and outcomes of learning are useful for explaining retention of URM students in STEM, as these factors are most directly affected by systemic racism within STEM. Systemic racism refers to "processes and outcomes of racial inequality and inequity in life opportunities and treatment" resulting from features that are "inbuilt or intrinsic to the operation of a society's structures" (Banaji et al., 2021). In this review, we primarily examine systemic racism in the context of its effects on environmental influences of learning, but these effects are not confined to the realm of environment. Environmental factors often have potent effects on both retention and performance of URM students in STEM through their impact on personal and behavioral processes.

Personal processes are the cognitions, emotions, perceptions, and beliefs held by individuals that help guide and motivate learning (Schunk & DiBenedetto, 2020). While these personal processes are clearly important to learning, they must be viewed in the context of the behavioral processes that they affect and are affected by. Behavioral processes are the choices one makes in terms of activities, effort, persistence, achievement, and environmental regulation which affect learning (Schunk & DiBenedetto, 2020). As suggested above, these personal and behavioral processes interact with one another. For example, changes in personal processes, like motivational factors, can affect completion of learning behaviors which can influence learning outcomes. These changes in learning outcomes can in-turn affect motivation to continue learning, demonstrating a bidirectional relationship. This bidirectional relationship is overall influenced by environmental factors that create barriers for learning as well, such as systemic racism.

While Social Cognitive Theory provides a useful model for understanding the motivation to learn, other factors also influence one's decision to pursue a field of study. The State Authenticity as Fit to Environment (SAFE) model describes how feelings of authenticity predict approach and avoidance of an environment (Schmader & Sedikides, 2018). This model defines authenticity as a composite of three different types of fit: self-concept fit, goal fit, and social fit. Self-concept fit can be described as the cognitive ease with which one can bring valued aspects of the self to mind in a given environment. For example, if an individual identifies themselves strongly as someone who likes to bake, they would feel high self-concept fit in environments which evoke their identity as a baker (e.g. being in a kitchen), increasing their feeling of authenticity within that environment and encouraging them to seek out that environment in the future. Conversely, if an environment evokes a negative aspect of the self, they are likely to feel inauthentic in that environment and avoid it. Goal fit is the extent to which a person feels the pursuit of their goals is encouraged by their environment. For example, a fitness-oriented person might feel more authentic and seek out a workplace that offers access to a gym rather than a similar workplace that does not offer access to a gym. This access would provide them with the means to achieve their fitness goals, promoting goal fit. Finally, social fit is the extent to which an individual feels the people in their environment validate and accept them. For example, a student is more likely to stay at a university in which they have kind, supportive friends who make them feel authentic in that environment, rather than transfer to another university.

Reviews examining Social Cognitive Theory and its derivatives, such as Social Cognitive Career Theory (Lent et al., 1994), have demonstrated the utility of these theories in understanding retention of URM undergraduates in STEM (Flowers III & Banda, 2016; Lee et al., 2023; Lent & Brown, 2019; Yu et al., 2016). However, feelings of authenticity and related factors, such as sense of belonging within STEM, receive less attention than traditionally utilized constructs in these reviews, despite evidence that they play an important role in academic achievement of URM students (Walton & Cohen, 2007). Recent findings in the field have stressed the importance of assessing how classroom environments impact URM undergraduates in STEM (Handelsman et al., 2022), highlighting the need to consider how these environments may interact with Social Cognitive Theory constructs to contribute to retention of URM students. The SAFE model provides a strong framework to examine environmental influences that may contribute to feelings of authenticity within STEM and has already been successfully used to examine the topic of gender inclusion in STEM (Schmader, 2023). As such, this review explores potential interactions between the SAFE model and Social Cognitive Theory to demonstrate how these interactions may contribute to a holistic understanding of how retention of URM students can be improved.

Applying Social Cognitive Theory to Retention of URM Students in STEM

Science Self-Efficacy

Self-efficacy has been shown to play an important role in learning (Lane et al., 2004; Schunk & DiBenedetto, 2020). Self-efficacy refers to the beliefs one holds about one's ability to learn. Someone who has high self-efficacy believes they have the capacity to succeed in learning and performing a given task, while someone with low self-efficacy has low confidence in their abilities (Heslin & Klehe, 2006). However, science self-efficacy seems to be more important to success for URM undergraduates in STEM. In an experimental study conducted in an introductory biology course, during which active learning pedagogy was applied in the second semester and not the first, URM students who exhibited an increase in science self-efficacy were more likely to receive a higher grade in the second semester (Ballen et al., 2017). This effect was not seen in non-URM students. However, it seems that self-efficacy is not just a predictor of URM students' academic performance, but also indirectly predicts URM students' interest in pursuing a STEM career. A retrospective study revealed that among recently graduated STEM students, heightened self-efficacy more strongly enhances the positive effects of research experience and community engagement on URM students' commitment to pursuing STEM careers compared to non-URM students (Syed et al., 2019). Self-efficacy also seems to be related to successful completion of a STEM major among URM students. For example, URM freshman who reported higher academic self-concept, a similar construct to academic self-efficacy, were more likely to persist through a STEM degree (Chang et al., 2014). Overall, these findings suggest that interventions targeting science self-efficacy are likely to be useful in improving achievement, retention, and interest of URM students in STEM. However, to understand why self-efficacy may be more important for URM students in STEM compared to non-URM students, one must consider how environmental factors such as social modeling, feedback, and institutional barriers influence self-efficacy.

Social Modeling and Social Comparison

Social comparisons, specifically for individuals who draw connections between themselves and others closely resembling themselves, are theorized to play a pivotal role in learning by influencing motivational processes (Schunk & DiBenedetto, 2020). For example, if an individual sees someone who is similar to themselves succeed at a task, they are more likely to believe that they too can complete that task, as that similar person's abilities may be perceived as comparable to their own. Conversely, if someone watches someone similar to themselves fail at a task, they are more likely to believe that they too will fail, reducing their motivation to attempt that task. Hence, URM students in STEM are unlikely to benefit from, and in fact may be harmed by, social comparisons due to the underrepresentation of URM in STEM. As mentioned above, URM students are far less likely than their White or Asian peers to seek out a STEM major and even less likely to complete a STEM degree (Mau, 2016). This suggests that URM students have fewer peers in STEM who are similar to themselves, regarding racial/ethnic background, and thus likely have fewer influential social models among their peers who they can compare themselves with. Furthermore, their peers in STEM who do share a racial background are less likely to persist through their STEM degree compared to White or Asian peers which may, through social comparison, contribute to the damaging belief that they cannot succeed in STEM.

Supporting the possibility that lack of social models may contribute to lower retention rates, URM students are more likely to persist through a STEM degree at schools consisting of higher proportions of STEM major students (Chang et al., 2014). It is possible this higher level of persistence through a STEM degree may be due to a greater availability of positive social models who persist in STEM, though this possibility has not been directly assessed. If a higher proportion of one's peers are succeeding in STEM, there are more opportunities to observe peers successfully using skills and to learn those skills through observation due to the greater number of social models. Additionally, seeing a higher proportion of one's peers succeed in STEM may make successful completion of a STEM major seem more attainable through social comparison, motivating URM students to persist in STEM. Further supporting the role of social modeling and social comparison, two of the largest factors associated with URM persistence in STEM are studying with other students and joining a major-related club or organization (Chang et al., 2014). One way these factors may contribute to retention of URM STEM majors is through social comparison and social modeling. For example, studying with peers can help hone one's study skills and understanding of course material through observational learning, potentially presenting opportunities for positive social comparisons. Similarly, participating in a club or organization related to one's major likely provides additional opportunities for positive social comparisons.

The concepts of social comparison and social modeling also fit well amidst serious concerns about how lack of diversity in tenured faculty may affect the success of minority students (Abdul-Raheem, 2016; Allen-Ramdial & Campbell, 2014). URM students are

more likely to have higher GPAs, graduate college, pass courses, and are less likely to drop out of courses when taught by faculty members from similar racial/ethnic groups (Fairlie et al., 2014; Llamas et al., 2021). One explanation for this could be that faculty members who share a racial/ethnic group with their students are more influential as social models, both improving their ability to facilitate observational learning among URM students and provide positive social comparisons. Unfortunately, it seems that the effects of social comparison on URM undergraduate students in STEM have not been directly investigated, despite evidence suggesting social comparisons impact students' performance (Suresh & Heckler, 2023).

Feedback

Feedback from peers and instructors plays an important role in students' learning, helping them assess how they are performing and motivating them to persevere (Schunk & DiBenedetto, 2020). For URM students, feedback may play a particularly important role in their persistence in completing a STEM degree. The extent to which students feel recognized as a scientist by peers and instructors disproportionately predicts level of identification with science (a mediator of both STEM motivation and aspiration to pursue a STEM career) in URM students but not non-URM students (Starr et al., 2020). This suggests that providing feedback that affirms URM students' identity as scientists may help them persist in STEM. Fortunately, this study also hints at an effective way to promote recognition as a scientist: performing science practices in the classroom (Starr et al., 2020).

Applying the SAFE Model to Retention of URM Students in STEM

Self-Concept Fit

An important part of deciding to engage in science, whether it be in the classroom or in your career, is *feeling* like a scientist. Unfortunately, it seems that URM students are less likely to form a strong STEM identity than their White and Asian counterparts. In a short longitudinal study examining change in science identity during an introductory chemistry course, URM students were significantly more likely to exhibit moderate and slightly increasing science identity across the semester than high and stable science identity when compared to their White and Asian peers (Robinson et al., 2019). Highlighting the importance of this difference, students with high and stable science identity were more likely to score highly on the final exam and persist as a STEM major than those with moderate and slightly increasing

levels of STEM identity (Robinson et al., 2019). Supporting these findings, a longitudinal study conducted in an introductory biology course suggested that STEM identity was associated with aspiration to pursue a STEM career and STEM motivation, both of which predict course grade (Starr et al., 2020). While science identity appears to be an equally useful predictor of achievement in STEM and motivation to pursue STEM for URM and non-URM students, URM students are not as likely to develop a strong identity as a scientist, making them less likely to reap the benefits. This suggests that one way to reduce the gap between URM and non-URM students in STEM may be to foster the development of science identity.

One factor which may be important to the development of science identity is self-concept fit. The SAFE model suggests that having a higher self-concept fit – cognitive ease of bringing valued aspects of the self to mind in an environment – promotes feelings of authenticity, leading individuals to seek out environments in which they feel greater self-concept fit. As such, it is possible that facilitating self-concept fit in STEM classrooms may promote the development of a strong science identity by increasing engagement with the course content. Supporting this, an intervention designed with an emphasis on diversity and inclusion that exposed students to real-world applications of science resulted in students' development of stronger and more positive science identities (Singer et al., 2020). While students in both the intervention and control groups were more likely to agree with the statement "I have come to think of myself as a scientist" at the end of the semester, only students in the intervention group were more likely to agree with the statements "I am a scientist" and "being a scientist is an important part of my self-image." It is possible that the intervention's focus on inclusion and diversity improved self-concept fit by signaling that students' identities were welcome within the classroom environment and STEM, allowing them to feel greater authenticity. In concordance with this interpretation, students in the intervention group were more likely to agree that their gender was an important part of their identity as a scientist and marginally more likely to agree that their ethnicity was an important part of their identity as a scientist (Singer et al., 2020).

Though this study provides compelling evidence that self-concept fit may affect development of science identity, it should be noted that the sample size was not sufficient to examine the effects of the intervention on URM students specifically. Additionally, it is possible that changes in the development of science identity result from the incorporation of real-world applications in this intervention rather than the emphasis on diversity and

inclusion. However, the apparent incorporation of ethnic and gender identity into science identity suggests it is less likely that the inclusion of real-world applications drove changes in science identity rather than emphasis on diversity and inclusion. Determining whether self-concept fit contributes to science identity formation, either by using an intervention that emphasizes diversity and inclusion or by using a value-based intervention that incorporates personal values into coursework (see Asher et al., 2023), will be important to evaluating the potential for self-concept fit to improve retention of URM students. Furthermore, examining whether self-concept fit differs between URM and non-URM students in STEM may yield insight into potential causes of the gap in strength of science identity between these groups.

Social Fit

As mentioned above, having a higher proportion of STEM students, participating in a major related club or organization, and studying with peers may improve retention and academic success of URM students due to social comparison and social modeling. However, another way that these factors may benefit URM students is through social fit, or the extent to which a person feels they receive validation and acceptance from those in their environment. All these factors have one thing in common: they facilitate interaction with peers interested in STEM. This may provide URM students in STEM with more opportunities to form social connections within their STEM departments and classes, increasing their feelings of authenticity within STEM. Supporting the role of social networks in persistence in STEM, one study found that an intervention designed to affirm students' values within a biology course increased students' likelihood of taking the next semester of that biology course, but that this effect was mediated by their social network within the classroom (Turetsky et al., 2020). However, whether having a higher proportion of STEM students, participating in a major related club or organization, or studying with peers affects performance of URM students in STEM by way of social networks and/or feelings of authenticity has not been investigated to my knowledge.

One crucial factor that remains to be discussed in this paper is the role of personal racism and discrimination in retention of URM students in STEM. One study found that URM students, particularly female URM students, who have had a professor that made them feel uncomfortable due to race/ethnicity are significantly less likely to persist in STEM (Park et al., 2020). Disturbingly, this study also suggested that the negative influence of this factor on retention was greater than the effect of positive interactions between students and faculty (Park et al., 2020).

Within the context of the SAFE model, these negative interactions can be viewed as threats to social fit, making URM students feel inauthentic and increasing the likelihood that they leave STEM. This highlights the importance of increasing diversity within STEM, not only within the context of social modeling, but also in terms of improving the interactions between URM students and STEM faculty (Allen-Ramdial & Campbell, 2014).

Conclusions

This paper provides evidence that Social Cognitive Theory and the SAFE model are useful for describing how a wide range of factors may predict the retention and achievement of URM students within STEM. Furthermore, the combination of these two theories captures not only factors that affect motivational and cognitive influences on learning, but also how the environments within STEM departments of colleges and universities may influence URM students' choices in choosing to persist in STEM. This may prove useful in unifying the wide range of theories that have thus far been used to examine this topic and in standardizing measures across studies. However, while Social Cognitive Theory has already been utilized in literature on this topic, with concepts such as self-efficacy and feedback making their way into many studies of URM retention in STEM, the SAFE model, to the best of my knowledge, remains untested. To determine whether the SAFE model is useful in explaining STEM retention, studies examining whether self-concept fit, goal fit, and social fit provide additional predictive power in assessing retention of URM students within STEM will need to be performed. Furthermore, given the evidence supporting interactions between elements of Social Cognitive Theory and the SAFE model, examining these models together may yield a more holistic picture of URM retention in STEM. Performing these additional studies will also be important for validating the hypotheses suggested above. The results of studies using constructs within the SAFE model may differ from those obtained in the studies above, which use related, but not identical, constructs. Furthermore, longitudinal studies examining the relationships between the variables discussed in this paper in the absence of interventions should be conducted. Many of the studies cited above examine the relationship between psychological and academic variables after specific forms of interventions. It is possible that these relationships only emerge after specific interventions and do not occur during typical instruction. As such, while there is substantial evidence that Social Cognitive Theory and the SAFE model will be useful in improving predictive power and in designing interventions to improve retention of URM students, further testing will be essential for confirming this.

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