3

RETENTION VERSUS PERSISTENCE

A Self-Determination Analysis of Students Underrepresented in STEM

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Concerns over the underrepresentation of students of color and women in STEM fields are far from new. From issues of recruitment to retention and degree completion, the (in some cases) extreme underrepresentation of African Americans, Hispanics and Native Americans has drawn the attention of researchers, administrators and practitioners from across K–12 and throughout higher education (Cromley et al., 2013; Gasman & Perna, 2011; Hurtado, Cabrera, Lin, & Arellano, 2009). Further, the research on retention and persistence in STEM has been mostly very consistent in its findings and suggestions to institutions moving forward. Institutions, broadly speaking, and specifically STEM programs within the university and college structure are consistently told that they must create an environment that is conducive to meaningful faculty–student interactions (Hurtado et al., 2011; Johnson, 2007) and that student–student interactions must likewise be available and authentic (Joseph, 2012; Perna et al., 2009). Academic resources should be plentiful, and institutions and programs have been informed that students of color, particularly those from African American, Hispanic, and Native American backgrounds, many of whom are still first-generation college students, may need to have their interest in STEM piqued and their attention drawn to the career options that a STEM degree may afford (Linley & George-Jackson, 2013).

Despite this somewhat intense and hardly new focus, the disparities persist. In 2011, 8.8% of bachelor's degrees in STEM fields were awarded to Black students, 10.3% to Hispanic students, 9.3% to Asian/Pacific Islanders, and a microscopic .06% to Native Americans. These percentages also represent only moderate gains for most minority groups. Though Hispanic students saw an increase from 7% to 10%, Asians saw only an increase from 9% to 10%, and other groups saw no increase from 2000 to 2011 (NSB, 2014). Asians, a group traditionally overrepresented in STEM, are also an exception in that both Asian males and females

each earned about 9% of the bachelor's degrees in STEM, while for other minority groups, women generally outpaced men. At the graduate level, the numbers are even more troublesome, with Black, Hispanic, and Native American students earning only 6.6, 4.7, and 0.5%, respectively, of the master's degrees in STEM fields and only 2.5, 2.9, and 0.2% of doctoral degrees granted in these fields, with the men in each group become increasingly absent (NSF, 2010). This trend may be reflective of a wider issue in which Black, Hispanic, and Native American women attend college at higher rates than do their male counterparts (U.S. Department of Education, 2012).

These data illustrate the need to examine this old problem with new eyes. Accordingly, in the following sections, I take a look at the motivational issues underlying retention and persistence of college students of color in science, technology, engineering, and mathematics programs. Specifically, I examine the ideas of persistence, a student-centered variable, versus retention, an institution-centered variable, situating them within a self-determination framework to understand the motivation of students of color in STEM fields and how this motivation influences their decisions to persist and institutions' and STEM programs' ability to retain them. I discuss factors shown to be integral to both retention and persistence in STEM, with a focus on those factors relevant to students of color who have historically been underrepresented in STEM, namely African American, Hispanic/Latino, and Native American students. I conclude the chapter with a discussion of key ideas and directions for future research.

Motivation Theory, Retention, and Persistence

Academic motivation theory has been used to understand the behaviors that lead to outcomes such as student engagement and achievement. Such theory, however, like much of what we think we know about what drives students, both inside and outside the classroom, is based on the assumption that these motivational processes apply cross-culturally. This assumption may be faulty at best. Rodgers and Summers (2007), considering retention broadly, suggested that institutions, administrators, and practitioners should begin to question the applicability of what we think we know about retention to students who are typically not largely represented in the studies from which our current theories have derived. It is therefore important to reconsider our knowledge of retention and, as Rodgers and Summers (2007) suggest, question whether such models really tell the whole story of what is important for retention and persistence for these students.

When motivation theory has been applied to students of color, attribution theory (Graham, 1992; van Laar, 2000) has been used most often, with Deci and Ryan's (1985) expectancy-value theory garnering more recent attention (Anderson & Ward, 2014). However, self-determination theory, due to its dependence on the idea of the self and issues of control, both factors that have been zeroed in on as critical cultural components in understanding students of color (Cokley, 2003; Flowers,

Milner, & Moore, 2003), offers a unique look into the motivational patterns that can inform these students' intentions to persist in their STEM programs and institutions' and programs' ability to retain them.

Persistence Versus Retention

The research literature on college student continuity is replete with two terms: retention and persistence. These terms are sometimes used interchangeably, but to do so ignores a critical characteristic of their emphasis. In the context of the current discussion, *retention* refers to institutions' or programs' ability to keep or retain students. Persistence, on the other hand, refers to students' tendency or decision to continue or not continue along their current course. That is, retention can be thought of as an institution-controlled variable and persistence as a student-controlled variable. This distinction matters if we are to understand all of the barriers to completion in STEM and who controls those barriers. Indeed, they are connected and, in the most ideal circumstances, they work in concert. By fostering a supportive environment, an institution or program can create an atmosphere that is conducive to student persistence, leading the student being more likely to be retained. At the same time, they are two distinct processes in that a program may have proper supports in place and yet students may still choose not to persist for any number of reasons. So in choosing the correct terminology, it is important to consider from where the control originates: from within the student, within the institution, or both.

Vincent Tinto (1975, 1988) proposed that persistence (and, by extension, retention) is influenced by the extent to which students are able to *separate* from previous academic and social associations, *transition*, and ultimately become fully *incorporated* into the academic and social communities of the institution. Tinto refers to this incorporation as *academic integration* and *social integration*. That is, if students are socially and academically integrated into the institution or program, they will be more likely to persist and thus be retained.

However, Rodgers and Summers (2007), in questioning the applicability of traditional models of retention to Black students attending predominantly White institutions (PWIs), proposed that, unlike suggested by Tinto (1975), academic and social integration should be conceptualized as outcomes in the retention equation rather than as precursors that influence behaviors such as academic help seeking and formation of social friendships. Stressing the idea of "fit" between student and institution (the institution offers what the student needs), the authors contend that students' perceptions of the accessibility of faculty and other students, the comfort of the culture of their STEM program, and the overall sense of feeling welcomed by the program and fellow students all combine to influence students' motivation, which in turn influences their academic and social integration and ultimately leads to retention and persistence. For students of color, particularly those operating on predominantly White campuses and STEM programs,

academic and social integration may take on a different appearance than was originally suggested by Tinto (1975), and the effects that these have on students' persistence or institutions' ability to retain them may also be different. In the following sections, I provide an overview of self-determination theory (SDT). I then situate retention and persistence issues within the context of SDT, with a specific focus on the role of intrinsic motivation in the retention and persistence process.

Self-Determination Theory

Self-determination theory is based on the belief that individuals have needs to feel competent, autonomous, and related (Deci & Ryan, 1985). Therefore, individuals are motivated by the desire to have these needs met, and this motivation comes generally in one of three forms: amotivation, extrinsic, and intrinsic. Deci and Ryan (1985) emphasize that, rather than think of motivation as either being controlled by the individual or not, it is more prudent to view intrinsic versus extrinsic motivation as less about from where the control comes and more about whether or not one is being controlled. *Amotivation* refers to a nondirectional lack of motivation, neither to have a need met nor to not have a need met. Comparatively, individuals who are driven more by extrinsic motivation tend to be controlled or compelled to act due to outside forces (e.g., approval of family members, admiration of classmates), while those who are more intrinsically motivated tend to be more free from outside control and can focus on needs that exist within the self (enjoyment, personal fulfillment). The focus on the self and systems of control make SDT a very relevant framework through which to examine retention and persistence in underrepresented students in STEM. In this way, we can consider to what extent the student is controlled by outside forces, which, for the purposes of the current discussion, are elements of the STEM program and the institution.

Ryan and Deci (2000) further describe SDT as a study not just of individuals' tendency or lack thereof to seek agency or control and to meet psychological needs, but SDT also considers the aspects of situations that foster these motivations. To this end, Deci and Ryan (1985) proposed cognitive evaluation theory (CET) as a subtheory to SDT, wherein CET specifically addresses the environmental and contextual factors that influence intrinsic motivation. Thus CET offers an additional subframework through which to further examine a self-controlled (internal) variable, *persistence*, and an institution-controlled (external) variable, *retention*, and how the two can interact to support students to degree completion.

Persistence

Persistence has been typically treated as a student-level or student-controlled variable (e.g., Marra, Rodgers, Shen, & Bogue, 2012; Morrow & Ackermann, 2012). Institutions can retain students, but students must also make the decision to persist.

Certainly, programmatic efforts to retain students can influence the likelihood that students will persist. As previously described, these student-level variables tend to fall into two categories: academic and social. Thus, there is some overlap between that which is considered to be necessary for institutions and programs to retain students and that which increases student persistence.

On the academic side, students who actively seek involvement in their courses, interact with faculty, display help-seeking behavior (contacting faculty, using academic support resources such as tutoring, etc.) in the face of trouble and are otherwise engaged in the academic life of their programs would be considered academically integrated. Academic preparation in high school and continued development during the program are also of great importance, as one would likely assume, and has been consistently found to be a predictor of student persistence in STEM (Russell & Atwater, 2005; Tyson, Lee, Borman, & Hanson, 2007). This academic preparation and the success, or lack thereof, that they might experience also informs students' feelings of competence, which has been shown to play into intention to persist in STEM (Marra, Shen, Rodgers, & Bogue, 2009). In Proctor and Truscott's (2012) study of African American students in school psychology, students identified poor relationships with faculty and classmates and lack of fit between personal career goals and the program as factoring into persistence decisions. Further, given that many students of color may be first-generation college students, economic support has also emerged as a critical piece in the persistence puzzle (Proctor & Truscott, 2012; St. John, Paulsen, & Carter, 2005; Tuttle & Musoba, 2013).

On the social side, sense of belonging has been a consistent predictor of intention to persist in college in general and in STEM in particular (Morrow & Ackermann, 2012; Marra, Rodgers, Shen, & Bogue, 2009). This social element is so strong that Hu (2011) found that, without similarly high levels of social engagement, high academic engagement negatively affected persistence. The importance of social interactions was underscored in Marra et al.'s (2012) study of persistence in engineering. The authors identified three factors that informed students' decisions to leave their engineering majors. Two factors were aspects of academic integration, curriculum difficulty, and faculty interactions, while the third factor, sense of belonging, was more attributable to social integration. Further, non-White students indicated that curriculum difficulty and belongingness factored more into their decision to leave engineering than they did for White students.

Underrepresented students' identity maintenance and development have also emerged as important to social interactions and ultimately to academic achievement, both broadly and specifically in STEM. In line with Rodgers and Summers's (2007) assertion that students of color operating in spaces where they are the minority must develop a bicultural identity, one that remains connected to one's culture and another that connects to their student lives, those in STEM must likewise develop a "science identity." Perez, Cromley, and Kaplan (2014) examined the relationship between students' STEM identity, defined as their sense of the fit between how they view themselves and how they perceive these things as being

in accordance with what STEM offers and persistence. The authors found that students with more reflective STEM identities felt more competent and perceived fewer costs associated with pursuing STEM careers. Further, the development of this "scientist identity" has been linked to the achievement goals that are most closely associated with achievement and persistence (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013).

Retention

Given that retention and persistence, though separate constructs, are tied, suggestions for retention of students of color in general and in STEM necessarily follow the supportive needs of these students. As with persistence, Tinto (1975) suggested that these supports should attend to two goals: academic integration and social integration.

Seymour and Hewitt (1997) identified two categories of students who ultimately left their science/engineering programs: those who became bored or disengaged with the curriculum and those who suffered a blow to their self-confidence, likely as the result of some academic struggles or interactions with other students and faculty. Accordingly, in order to facilitate academic integration, institutions are typically advised to provide academic supports such as tutoring and effective advising and to foster positive interactions between faculty and students (Williamson, 2010).

Within STEM programs, especially at PWIs, fostering social integration might be more difficult. As with the campus as a whole, interactions between students from similar cultural backgrounds are likely to be few and far between, with Black, Hispanic, and Native American students often finding themselves in classes with just a few others, if any, of the same cultural or racial background. To facilitate social gatherings between students, many campuses also offer cultural centers, such as Black or Hispanic cultural centers, where students from similar cultural backgrounds can meet and participate in activities that they may find more relevant.

The potential for a sense of alienation may be exacerbated in programs that require students to work in labs or assist in research, such as is expected in many STEM disciplines. In these situations, not only are students of color operating in a space where they will still be the minority, but research labs are where academic and social integration collide. Those spaces, probably more than the traditional classroom format, promote an atmosphere of collaboration and, potentially, competition. Thus a student who has not built relationships with both faculty and other students may find themselves limited in a critical area of academic and social development. Further, failure to socially connect may undermine students' intrinsic motivation, which can, in turn, negatively impact their persistence.

Russell and Atwater (2005) found that intrinsic motivation was positively related to African American student science persistence. Consequently, next I take

a closer look at the tenets of intrinsic motivation with a critical eye toward understanding how these aspects inform what we know about retention and persistence patterns for students of color pursuing degrees in STEM fields.

Intrinsic Motivation

Deci and Ryan (2000) describe intrinsic motivation as "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore and to learn" (p. 70). In terms of control, a student who is intrinsically motivated in STEM is one who is not, at least solely, controlled by external factors and is therefore driven in part or whole by their own desires. The authors go on to describe intrinsic motivation as a natural curiosity that environmental contexts can either promote or undermine. This is where we can readily observe the synergy that can exist between retention and persistence. According to CET, there are ways that institutions and programs can free students from the control of outside forces by offering them opportunities to meet the need for competency, relatedness, and autonomy. That is, students are more likely to maintain the intrinsic motivation with which they began their STEM programs as long as the program and the institution as a whole offers them a chance to feel competent, connected, and self-sufficient.

Competence

Classroom settings offer students several clues by which to judge their competence, the most obvious of which are coursework, past success, and academic preparedness (Cromley et al., 2013). However, beyond these, students also receive messages regarding their academic competence from other students, from faculty, and from society at large. Societal impressions can trigger issues related to stereotype threat (Cromley et al., 2013; Steele, 1997).

Interactions with faculty and fellow students in particular have the potential to shape the ways in which students of color see themselves as students in STEM. The students of color in Hurtado et al.'s (2009) study of underrepresented students in the sciences cited not only their confidence in their own abilities in science but also the encouragement from teachers and professors as important contributors to their interest and pursuit of STEM careers. Hurtado et al. (2011) echoed these findings in their examinations of underrepresented students' interactions with faculty. Utilizing a sample of mostly students of color in STEM attending five institutions (two predominantly White, two Hispanic serving, and one HBCU), the authors found that school selectivity and size were important factors, with students at larger and more selective schools being more likely to interact with faculty. Overall, Black students interacted with faculty less often than did White students, although students at the HBCU interacted more frequently

than did their counterparts at other institutions. In the final section of this chapter, I discuss the unique position and success that HBCUs and other minority-serving institutions have in promoting retention and persistence in their STEM students of color.

These findings are important in the current discussion for a couple of reasons. First, they highlight the role that teachers and university faculty play in encouraging students of color to pursue careers in STEM. Second, because faculty are an important link, likely the main link, to the academic culture of an institution, students who do not find faculty to be accessible, whether it is because of time constraints, culturally related discomfort, or a lack of racially or culturally congruent faculty, may find themselves locked out of opportunities to succeed. These students may not be chosen to do research with faculty or simply be able to seek additional academic help at times of struggle, which can affect their overall sense of competence.

Connectedness

The importance of connectedness to students from particular ethnic backgrounds has been somewhat extensively covered in the literature (Green & Glasson, 2009; Hurtado et al., 2007). Some of this work relates the need for connectedness to collectivist cultural orientation, which is one in which members of the cultural group view themselves as interconnected (Triandis, 1989). Though much of the literature on this cultural orientation has utilized Asian American samples, Hispanic Americans as well as African Americans have been noted as having collectivistic communities. Research points to the importance of family and friendship networks in supporting African American and Latino students through college (Oyserman, Coon, & Kemmelmeier, 2002; Russell & Atwater, 2005). Sayed, Azmitia, and Cooper (2011) describe the role of these friendship and familial connections as that of "identity agents," because they allow students to maintain a cultural identity and a connection to home, which facilitates adjustment into the university culture.

Within STEM fields, many of which are dominated by White males, the support of identity agents becomes especially critical. As generally male-dominated spaces, the culture of many STEM programs has been described as aggressive, competitive, and consequently very supportive of an individualistic mindset (Seymour & Hewitt, 1997). Further, faculty in these fields are likely to be mostly male, which means that not only is the culture of the classroom male oriented, but interactions outside of the classroom can also take on this complexion. In her study of women of color in science, Johnson's (2007) participants described a science culture in which success depended in part on the extent to which one was visible and vocal, behavioral expectations that run counter to the ways in which many women are raised. An African American student in Hurtado et al.'s (2009)

study who had transferred from a predominantly White university to an HBCU described the importance of connectedness to his overall motivation:

> I felt so disconnected from everybody, not necessarily because it was a racial difference, but just the motivational factor. I didn't feel motivated, I felt as if I was just a social security number, so I decided to come to [HBCU] and that's when I felt at home, you know, because I got individual attention, I got motivation, I was able to see professors that were African American, bio-chemistry PhD professors, people that look like me, which motivated me to say, "OK, I can do this. It's possible for me not only to get an undergraduate degree, but also to pursue a higher level degree," so it's the motivational factor that I would say an HBCU provides.
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> *(p. 207)*

In addition to highlighting the importance of connectedness to motivation, the student also hints at another aspect of the minority STEM experience addressed by self-determination theory, autonomy.

Autonomy

According to Deci and Ryan (2000), feelings of competence only positively influence intrinsic motivation if these feelings are accompanied by an internal locus of causality. However, Chirkov, Ryan, Kim, and Kaplan (2003) questioned autonomy as an actual need in the quest for self-determination. From a collectivist standpoint, the self is tied to others in the group. Thus to be self-determined requires not that one has individual control over one's destiny, but as a group you have control over your collective destiny. Iyengar and Lepper (1999) found that, among collectivistic groups, adopting the choices of respected others can have the same positive effect on intrinsic motivation as others may gain in making autonomous decisions, suggesting a cultural variation in this perceived "need." These findings run counter to Deci and Ryan's (1985) initial supposition that environments that stifled autonomy by overly controlling or removing individuals' choice undermined their intrinsic motivation.

This underscores the importance of faculty again in the process of retaining students of color in STEM. Iyengar and Lepper's (1999) findings suggest that respected others, such as the African American faculty described by the student at the HBCU, may be seen by some students as extensions of themselves, thereby helping maintain students' sense of autonomy, positively influencing their intrinsic motivation and increasing the likelihood that the student will be retained to degree completion. Hence, the underrepresentation of Black, Hispanic, and Native American faculty in STEM (Towns, 2010) offers definite cause for concern. In the earlier quote from Hurtado et al.'s (2009) study, the African American male student expresses how important it is to have faculty who looked like him,

who had similarly achieved what he hoped to achieve, and who would provide him with more personal interaction. Hence, in this way, he was able to draw a sense of power and control over his outcomes from respected others (in this case, faculty), just as the Asian American students in Iyengar and Lepper's (1999) study did, thereby increasing his intrinsic motivation.

Closing Discussion

I began this chapter making the point that the concerns relating to the continued underrepresentation of students from certain racial or ethnic backgrounds in STEM disciplines was hardly new, especially given the rather consistent findings about the supposed "keys" to retention and persistence of students of color in these disciplines. Throughout this chapter, I have covered the main issues and suggestions, from both persistence and retention perspectives, as well as from institutional and programmatic perspectives. I will not further rehash them here. Instead, I want to conclude this discussion by addressing a couple of key takeaways that are critical in this process.

Cokley (2003) noted that the task that sits before us is about understanding the psychology of African American students, how these students view themselves, their motivation, and how this all connects to achievement and, relative to the current discussion, their degree completion. Many years after Cokley published his study, I believe we can say the same of the need for truly understanding the psychology and motivation of students of color as they make their way through their STEM programs.

Beyond what we already know about retention and persistence of underrepresented students in STEM, the first takeaway I gather from a review of the literature is that students' conceptualizations of the self matter. I chose self-determination theory to illustrate the motivational responses of students of color in STEM because I believe that it centers on a very important piece of the persistence and retention puzzle, which is the self and how students situate themselves in their understanding of themselves and in their environments. In this retention/persistence interplay, you have the individual student "self" and you have institutions attempting to serve that "self." However, this might be an incomplete approach. Institutions and programs have typically been assumed to be serving the student by serving what they view as the individual student's self. Yet if the self extends beyond the student, then serving the student alone will be insufficient. For underrepresented students in STEM, the literature tells us that this self includes the family, the faculty, other students, and generally the students' identification with others of their same ethnic or racial background. Thus, STEM programs hoping to increase retention of underrepresented students must affect in some way all aspects of the student self, and not just tend to students' individual academic needs. In addition to offering academic resources and even encouraging social interactions on campus, programs might seek, for example, to

engage the family by offering a sibling day in the lab or a parent day of research presentations.

Programs and institutions should also always be striving for diversity in their faculty and be purposeful in their hiring of other social and academic support staff, as well as in seeking the same diversity in its student body. Such diversity is imperative if there is to be change to the climate and culture of many STEM disciplines so that the student experience is not one note in that only one cultural approach is practiced and respected. If students of color are to believe that the institution is committed to them, then they must see evidence of that commitment not only in the people with whom they interact but also in the way the program functions.

This brings me to my second takeaway, which involves the success that minority-serving institutions (MSIs), such as HBCUs and Hispanic-serving institutions (HSIs), have had in attracting and graduating large numbers of underrepresented students. In data that was collected in 2006, 20% of Black students attended HBCUs, but graduates of these institutions accounted for nearly 22% of bachelor's degrees awarded to Black students in STEM, including 20.1% of engineering degrees and a staggering 45% and 49% of degrees in biology and physics, respectively. A possible argument against this success is that since these institutions, by mission, serve mostly students of color, then it would make sense that they also graduate large numbers of students in STEM. However, though most Black students attend PWIs, you can see that, from the previously stated data, graduates of HBCUs account for a disproportionately high percentage of degrees awarded to Black students in STEM in general, and this is especially true in certain STEM fields, such as biology and physics, where, despite educating only 20% of Black college students, HBCUs account for about half of graduates in these disciplines. I do not believe that this is by accident.

By their very nature, MSIs offer a learning environment that tends to the self-needs of their students of color. They offer more diverse faculty and higher numbers of faculty who share racial or ethnic backgrounds with their students, a presence that cannot be undervalued. Hence, as suggested by Gasman and Perna (2011), PWIs and other institutions seeking to increase retention and encourage persistence should take a page from how many HBCUs run their STEM programs, oftentimes without the financial resources available at more selective PWIs. Indeed, as cuts in federal funding have impacted most public institutions, as described by Rivard (2014), HBCUs and other MSIs have been especially hard hit. These institutions tend to serve higher percentages of students dependent on need-based aid, and with the rising costs of higher education and fewer economic resources, STEM programs at MSIs may soon feel the sting even more (Arnett, 2014).

Both of these take-aways suggest a few new directions that we should take in the quest to understand and continue to effectively address the barriers facing students of color pursuing STEM careers. First, new research should seek to understand the differences in STEM disciplines, acknowledging that some disciplines

have been more successful at attracting and retaining both women and students of color. Engineering and technology programs, which continue to be overwhelmingly White and male, may have much to gain from examining the culture and structure of biology programs, which have been among the most successful in attracting and retaining students of color (National Science Board, 2014). In the spirit of continuing to understand what drives Black, Hispanic, and Native American students, future research should also examine the role that identity plays in integrating students into their STEM programs while also allowing them to maintain those necessary familial and cultural connections. Additional work on many of these same issues is also sorely needed for Hispanic and especially for Native American students, who are all but absent from higher education in general and extremely so in STEM. On the other hand, if institutions and programs are to make the important adjustments to what their programs have traditionally valued and how they have operated, future research should also examine faculty agency in implementing these changes. In this way, we can, as I initially suggested, look at an old problem with new eyes.

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