Increasing the trickle

A proposed critical multiculturalist conceptual model to increase the pipeline to a more diverse STEM doctorate population

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Abstract

Purpose – For several decades, human and financial resources have been the focus of academic institutions in Science, Technology, Engineering and Mathematics fields of study because of low matriculation and graduation involving diverse student populations. However, there is a paucity of research about pathways to doctoral-level education and completion for these underrepresented populations. The purpose of this paper is to explore conceptually how STEM doctoral programs can implement a critical multiculturalist framework to recruit, increase persistence and completion to abate the attrition rate of women and students of color in doctoral programs.

Design/methodology/approach – Through a critical multiculturalist framework, issues of access and attainment central to the pipeline of traditionally underrepresented populations in to the STEM fields are addressed in this paper in an effort to support equity and inclusion at the doctoral level. Approaching this issue through critical multiculturalism takes the issue of access and attainment beyond sheer numbers by addressing the limited opportunity of women and students of color to see themselves in graduate faculty within STEM.

Findings – This paper reviews literature regarding the STEM pipeline's "glass ceiling" that exists at the graduate level for students from marginalized communities, including gender and race. This paper proposes a multicultural doctoral persistence model.

Originality/value – Despite the efforts of many institutions of higher education to diversify the STEM fields, a "glass ceiling" remains at the doctoral level. There appears to be a pipeline for women and minorities from K-12 to the undergraduate level, but the doctoral level has been largely left out of the conversation.

Keywords Gender, Diversity, Graduate education, Access, STEM doctoral education, Students of color

Paper type Conceptual paper

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Introduction

For several decades, institutions of higher education have and continue to make efforts, stated or real, to recruit students from diverse backgrounds into Science, Technology, Engineering and Mathematics (STEM) fields of study with limited success (Baber, 2015). We are focusing on doctoral education in this article, but we do not lose sight of the cyclical nature and interconnectedness of increasing diversity within STEM at all levels. To increase the visibility and viability of a career in STEM, we focus on the need of more diverse tenured and tenure-track faculty so that students of color and women can see role models in their

undergraduate and graduate courses, which in turn allows them to potentially become teachers/faculty in K-20. By examining the doctoral pipeline in STEM, we can help ameliorate the racial and gender discrepancies within STEM at all levels by presenting a conceptual model that specifically supports success at the doctoral level.

Colleges and universities are increasing enrollment of diverse students (Harris and Gonzalez, 2012). For example, in 1997, students of color comprised 25 per cent of all college enrollments and rose to 30 per cent in 2007 (Ryu, 2010). Not only are students becoming more diverse at the undergraduate level, but a recent article by American Council of Education states the following optimistic statement regarding graduate-level student diversity:

> In relation to gender, women primarily were responsible for the growth in number of graduate degrees conferred. The total number of master's degrees awarded to African American and Hispanic women has more than doubled during the past decade. Doctoral degrees conferred to women of all races/ethnicities grew by four times the rate of growth for men. Women now receive more doctoral degrees than men. (Kim, 2011, p. 3)

However, full-time faculty are still primarily White male and female (Harris and Gonzalez, 2012). Indeed, full-time faculty of color comprised 13 per cent of full-time faculty and rose to 17 per cent from 1997 to 2007 (Ryu, 2010). This phenomenon is amplified within STEM fields where the faculties of color and women are less represented (Su *et al.*, 2015). Despite the efforts of many institutions of higher education, a "glass ceiling" remains at the doctoral level of STEM education for women and people of color (Espinosa, 2011) and in many other fields of study. In general, there has been progress in some areas of STEM, such as biology, but little in others (National Science Foundation, National Center for Science and Engineering Statistics, 2015). Research focused on the access and attainment of doctoral degrees in STEM by traditionally underrepresented populations in those fields remains limited (Espinosa, 2011). There appears to be increasing access to the pipeline for women and minorities from K-12 to the undergraduate level, but the doctoral level has been largely left out of the conversation (Ong *et al.*, 2011; Reyes, 2011). This is an area of concern because of the importance of students seeing themselves in the representative faculty (Nieto and Bode, 2011; Su *et al.*, 2015), which increases motivation to pursue and persist in the STEM field of study (Hodson and Dennick, 1994). A diverse university faculty that includes traditionally underrepresented populations serve as role models for students who have typically been marginalized in the STEM workforce (i.e. women, students of color, first-generation students and students with a low socio-economic status). Research has clearly demonstrated that when there are role models in place, students are more likely to persist and retention rates increase (Reyes, 2011). Having role models that are visible in K-20 and beyond is critical in addressing the STEM shortage in academia.

Women and students of color are highly underrepresented in STEM graduate programs (Hodson, 1998; Hodson and Dennick, 1994; Su *et al.*, 2015):

> Despite earning roughly half of STEM doctorates in the United States, women have a very limited visibility among STEM faculty bodies and account for only 16 per cent of full professorship and 23 per cent tenure line positions in research extensive universities (Su *et al.*, 2015, p. 840).

It is apparent that a disparity exists between men and women and intersectionality of race and ethnicity in STEM fields. The rate of advancement and promotion within the faculty ranks for women and underrepresented groups of color are dismal.

Although women are well-represented in biology programs at the undergraduate level, they still have not reached parity with their male counterparts at the doctoral and professoriate levels. While the overall numbers are bleak, it is still worth noting that women

have made gains in receiving doctoral degrees in STEM. For instance, a recent 2015 report from the National Science Foundation, using the Survey of Earned Doctorates data, indicates that from 2003 to 2013 women have increased by 75 and 125 per cent in the awarding of physical sciences and engineering, respectively. Of course, a small incremental change from an already small number can have dramatic increases in percentages, but the changes are still significant and worth mentioning. Thus, although the numbers are still problematically low, there is a gradual increase in the number of underrepresented students making their way to doctoral programs in STEM (Kim, 2011). Therefore, in this paper, we will explore conceptually how STEM doctoral programs can implement a critical multiculturalist model to recruit, increase persistence and completion to abate the attrition rate of women and students of color in doctoral programs. By increasing the doctoral completion rates, we can potentially increase the STEM pipeline at all levels ensuring that women and students of color obtain adequate mentoring and support at the post-secondary level by teachers and faculty who look like them.

Through a critical multicultural conceptual model, this paper provides an analysis on broadening participation and increasing the STEM pipeline within the doctoral level for students who are often marginalized (McDowell and Fang, 2007). We maintain that a critical multiculturalist model addresses power dynamics (Rimmington and Alagic, 2008) and approaches this topic from the vantage point of supporting racial, ethnic, gender and cultural equity within STEM (Banks, 2006). Definitions of the scope of multiculturalism vary among scholars (Steinber and Kincheloe, 2001), but for this paper, multiculturalism encompasses gender and race. Previous diversity initiatives and efforts have focused on individual factors, or self-empowerment, that aim to disrupt the racial hierarchy such as: increasing recruitment efforts, increasing interest and supporting STEM throughout PK-12 schools (Baber, 2015; Foor, *et al.*, 2007; Mayo and Larke, 2011). However, these efforts have not focused largely on institutional power that normalizes and legitimizes racial and gender biases at the doctoral level.

The patterns and practices that support a normalization of Whiteness and male-dominance at the doctoral level within STEM can be attributed to institutional racism and sexism. This systematic oppression negatively impacts people from traditionally underrepresented populations in STEM and positively impacts White men, by virtue of disadvantaging people of color and some White women, and directly, by specifically advantaging White people and mostly men (Gutiérrez y Muhs *et al.*, 2012; Smith *et al.*, 2014). Institutional racism and sexism is often discussed as something difficult to "prove" because it is so ingrained in our normative practices (Better, 2007; Cross, 2010; Knowles and Prewitt, 1970; Phillips, 2011; Taylor, 2009) and differences attributed to "the way things are". Consequently, a racial and gender disparity remains present despite the efforts to increase interest among underrepresented populations into the STEM fields (Baber, 2015).

Also, apparent within higher education is the propagation of White privilege in both forms: spared injustice and unjust enrichment. However, this is seen more dramatically within STEM and especially at the doctoral level. Spared injustice is apparent through data showing minimal numbers of people of color at the doctoral level and professoriate, thus giving White men and, to a certain extent, White women more opportunity to fill those positions and secure higher-level positions in STEM professions over men and women of color. Indeed, White women are more represented in STEM fields than African American and Latino males (Espinosa, 2011), which in some ways demonstrate that White women have been the largest benefactors of Affirmation Action and programs of equality. Conversely, unjust enrichment is also apparent within STEM at the doctoral level because White people are more likely to pursue positions in STEM and at the professoriate as a

result of being better prepared and socialized to attain and persist in the field from their increased opportunity and natural enculturation because of the euro-centrism within STEM (Hodson, 1998; Lott, *et al.*, 2009; Jackson, 2004; Millett and Nettles, 2006). Increasing, maintaining, and supporting diversity at the doctoral level necessitates a closer look at current trends and research on diversity initiatives, as well as cultural connections in research and teaching at the doctoral level. Strategically considering issues that enhance the ability of faculty and departments to support a diverse student body are paramount to increasing the trickle.

Proposed conceptual model

As discussed earlier, we argue that a conceptual model addressing the "glass ceiling" in the STEM pipeline that exists at the graduate-level for students from marginalized communities and aims to support racial, ethnic, gender and cultural equity is necessary. The conceptual model for implementation of critical multiculturalism in doctoral programs provides implications for future support systems, initiatives and research. Through a critical multicultural conceptual model, issues of access and attainment essential to increasing the pipeline of traditionally underrepresented populations, including race and gender, into the STEM fields are addressed in this article in an effort to enhance equity and inclusion. Supporting minorities and women in STEM has been central to research initiatives and funding allocation. However, there is a paucity of research about pathways to doctoral-level education and completion for these underrepresented populations. Derek Hodson (1998) discusses the role of critical multiculturalism and antiracist approaches to STEM education. This focus emphasizes, recognizes and acknowledges the social impacts of racism and sexism on STEM fields in the education institution and the intersectionality with other forms of social oppressions, based on class, gender, race, sexual orientation and White privilege (Baber, 2015; Hodson, 1998; May and Chubin, 2003). Approaching this issue through critical multicultural lens takes the issue of access and attainment beyond sheer numbers by addressing the limited opportunity of women and students of color to see themselves in graduate faculty within STEM and the important role of departmental support and institutional climate.

As noted by many researchers, women and people of color face multiple barriers to access and attainment at all levels of education (Ong *et al.*, 2011). In a more dramatic fashion, the doctoral-level of higher education within STEM boasts even smaller numbers of people of color and women because of a myriad of societal and educational barriers such as under-resourced compulsory schools for students of color and the perpetual stereotype that women cannot do math. The demystification of this underrepresentation phenomenon could be one of the most impactful pieces of the pipeline because of the potential to inspire and encourage other people of color and women to enter and persist in STEM fields. Critical multiculturalism aims specific attention to this issue on institutional racism, sexism and White privilege, operating within society as a whole and insidiously manifested in cultural practices and embedded in social norms within STEM (Better, 2007; Cross, 2010; Knowles and Prewitt, 1970; Phillips, 2011). This "norming" of systemic oppression could explain why despite increased funding, interest and intention to increase people of color and women in STEM education; there still exists a gap because of implicit bias issues and the language that is provided early in schools that people of color and women are poor in mathematics. Diversifying the pool of potential teachers in compulsory education and professors within post-secondary institutions to serve as role-models and mentors can dispel myths that certain subgroups cannot perform or succeed academically in STEM.

Accordingly, we have developed a critical multicultural conceptual model to address the persistent "glass ceiling" at the doctoral-level. Through a model that emphasizes the individual needs within a culturally diverse social environment and contrasting homogenous doctoral/professoriate environment, an increased awareness of issues of equality, justice and power can be used to increase persistence of minorities and women in STEM (Banks, 2006; Hodson and Dennick, 1994). A critical multicultural conceptual model also emphasizes the link between theory, policy and practice (May, 1999). Based on Weidman *et al.* (2001) framework, *Conceptualizing Graduate and Professional Student Socialization* (p. 37), our model considers critical multiculturalist factors to improve student success rate at the doctoral-level for women and students of color.

Our critical multicultural conceptual model enhances current efforts to diversify STEM fields by focusing on the doctoral-level and moving beyond an assimilation approach. We believe this to be a critical component to successfully diversifying STEM because it is not enough to simply teach women and people of color to operate within and perpetuate the normed beliefs and cultures of the dominant community within STEM. Instead, a paradigm shift must take place to accept, support and proactively promote diversity within STEM in higher education, particularly at the doctoral and professoriate levels.

Proposed multicultural doctoral persistence model

Much of the literature on student persistence focuses on undergraduate education (Tinto, 1993; Reason, 2009) with a growing body of literature on graduate socialization (Weidman *et al.*, 2001) and graduate student attrition (Bowen and Rudenstine, 1992; Lovitts, 2001; Nettles and Miller, 2006). Smallwood (2004) suggests that the attrition within doctoral programs is a "scandal" and a major concern in American higher education. Although attrition rates at the doctoral-level is inevitable (Council of Graduate Schools, 2004), research has shown the dropout rates of doctoral students are higher for students of color (Nettles and Miller, 2006), women (Bowen and Rudenstine, 1992), and students who are less connected to faculty and peers (Lovitts, 2001).

Our conceptual model (Figure 1) illustrates the necessity to consider unique attributes at the personal level, as well as the institutional level, to increase matriculation and retention among diverse students (Nieto, 2011; Sleeter and Grant, 1988). These attributes include:

(1) social location of student;

(2) personal communities specific to the stage of life;

(3) characteristics of prior higher education experience; and

(4) institutional efforts to support equity and inclusion.

These four attributes are then considered at the departmental level and support given in accordance to the individual profile of the student.

Social location

Social location refers to the place groups of people are positioned based on historical and societal contexts. A person's specific social location can be defined by their gender, race, social class, age, ability, religion, sexual orientation and geographic location. The intersectionality of these attributes may promote or hinder opportunities within STEM. Understanding one's own social location and the social location of students can foster increased awareness and anti-oppressive policies and practices within the department, the university and the STEM fields. Increasing awareness of social locations leads people in leadership, those maintaining the system and those going through the system to have a

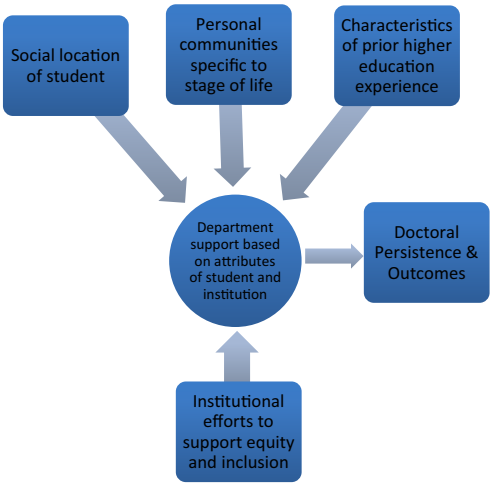

Figure 1.
Proposed multicultural doctoral persistence model

more critical understanding of the oppressions students of color and women face, as well as how that relates to the power and privilege of others. Each student, department and university is uniquely situated and, as such, needs to work from a personalized support system rather than an overarching diversity plan used at other institutions or institution-wide. An ecological and departmental focus on diversity serves a critical role in supporting women (Su *et al.*, 2015) and students of color among STEM fields of study.

Personal communities

Often, individuals who pursue a doctoral degree are usually over the age of 24; tend to commute to campus; and many are married and/or may have children. Thus, their past experiences and future expectations of graduate programs are very different than traditional undergraduate students. For students of color, women in particular, family status plays a critical role in their doctoral program. Because STEM programs require a large amount of time in scientific laboratories conducting research, PhD students are away from their families throughout the week. Some may be required to come in on weekends to conduct experiments in preparation for the upcoming week which hinders family time. As Etzkowitz *et al.* (2000) have observed, the academic tradition typically requires a scientist to choose between an academic or family life, which lends itself to a traditional male dominated culture. As Herzig (2004) states:

> While career and family are no longer assumed to be in conflict for men, this is not the case for women. Consequently, women graduate students in science who marry or have children have been viewed as not serious about their studies, or as unreliable and not worth the investment (p. 189).

Thus, a female graduate student who marries during her doctoral program, or becomes pregnant, may be viewed as not committing herself to the academy. This warped view of intentions or commitment to graduate school only hampers the ability to persist or join the professoriate ranks.

Thus, how STEM doctoral programs are supportive of either married or single mothers with children is important for students' success. This is a salient issue for female PhD

students who are attempting to show their advisors/committee members and department that they are taking their academic work seriously while at the same time ensuring they do not neglect their family. As Gardner (2009) states:

> About one third of the students discussed personal problems as their main attribution for student departure. Unlike their faculty counterparts who also attributed this cause to attrition, the students' explanations of what these personal problems entailed were much more descriptive and much more precise. Indeed, the majority of the personal problems that the students discussed as a reason for student departure related to marriage, children, or family responsibilities. (p. 106)

Furthermore, Latinas who may not be married or have children may still have responsibilities at home to help support their parents and siblings. The literature discusses how Latinas are consistently involved and supporting their family affairs (Segura, 1990; Vasquez, 1997). Vasquez (1997) discussed how Latinas have a "double-bind" conundrum in that they are attempting to appease both home and college environments when families are supporting of them attending college and being academically successful, yet expecting them to maintain the familialism of their cultural background. Thus, Latinas may find it challenging to play the role of college students and traditional Latina gender role (Vasquez, 1997). Thus, understanding a student's personal communities is essential to promoting success of women and students of color.

Proximity of doctoral program to family/friends. Prior research has shown that the majority of undergraduate students usually attend a local institution. This familiarity of attending a local four-year institution allows for family and peer support to complete their undergraduate degrees. However, when it comes to graduate education, students of color may deviate from their home state to attend an institution that may provide better financial support to complete their doctoral education. Thus, how STEM programs help students of color and women moving away from their families and communities deal with their transition from the various regions/states they come from can impact how they transition and persist in the doctoral program. Indeed, research has shown that supportive family networks and *familismo* help abate the challenges of higher education of Latino students (Coohey, 2001; Llamas and Morgan Consoli, 2012; Zambrana *et al.*, 1997). It is paramount that graduate programs provide communities that may replicate the support systems students of color and women leave behind.

Characteristics of prior education experience

Doctoral students of color and females' trajectory and path to the PhD may not be as linear as their White male counterparts who have traditionally enrolled directly into a PhD program after the completion of their undergraduate education. Students may matriculate directly from their undergraduate institutions, while others delay their pursuit of doctoral degrees for a few years. This delay occurs for several reasons including taking a break from studies, helping support their families financially, starting a family of their own or working for a few or several years in industry to gain work experience. Others enroll in a master's degree program at a comprehensive or research university and then pursue their doctoral degree to demystify the graduate student experience before fully enrolling in a doctoral program. Others may decide to work and have children before they embark in a long PhD journey. Clearly, the trajectory of underrepresented students in doctoral programs may not be linear. Thus, taking into account marginalized students' prior educational experiences and trajectories is critical for persistence and graduation once in a doctoral program.

Undergraduate selectivity and institutional type

It is evident that students of color are underrepresented at the most selective private and flagship public institutions of higher education (Carnavale and Rose, 2004). Attending these institutions for an undergraduate education is extremely beneficial because of the "added value" they provide to students and alumni (Bowen and Bok, 1999). For example, Bowen and Bok (1999) state that:

> Attending a highly rated undergraduate school is helpful, first of all, because of the quality of the education made possible by well-regarded faculty, well-equipped libraries, and laboratories, and the presence of the other high-achieving students (p. 101).

In addition, students who attend these elite public and private institutions are more likely to attend graduate and professional schools (Bowen and Bok, 1999; Carnavale and Rose, 2004). As stated succinctly by Bowen and Bok (1999):

> Graduate and professional schools are more likely to prefer candidates who they know have already undergone a competitive screening process and who are thought to have a solid academic grounding, including practice in writing and research (Bowen and Bok, p. 101).

Furthermore, highly selective liberal arts institutions have a long history of sending many of their graduates to prestigious graduate schools. One of the ways in which highly selective and well-resourced undergraduate institutions accomplish this is by allowing students to closely work with faculty on research projects. These research collaborations with faculty help demystify what to expect as doctoral students and impacts the admissions process, as admissions committees are aware the prospective students have been exposed to research. Thus, these students have the anticipatory socialization to transition from undergraduate to graduate more seamless than those who do not. Therefore, one of the primary concerns is the continuous underrepresentation of first-generation students at selective four-year colleges and universities.

Impeding access to more selective graduate programs for students of color, first generation in particular, is attributed to enrollment in community college. Prior research has shown that most students of color who do enroll in post-secondary institutions matriculate at open access community colleges over four-year postsecondary institutions (Arbona and Nora, 2007; Cohen and Brawer, 2003; Fry, 2002; Garza, 2006; Laanan, 2001; Ornelas and Solórzano, 2004; Solórzano *et al.*, 2005). Community colleges offer open-admission which allows students who are over the age of 18 to enroll with or without a high school diploma. These policies, along with the fact that public two-year institutions offer a college education for a fraction of the cost of senior institutions, are major reasons for the overrepresentation of students of color and first-generation students (Cohen *et al.*, 2014). The literature illustrates the drawbacks of enrolling at community colleges (Cohen, *et al.*, 2014). Because community college are not research institutions, students do not have the opportunity to participate in research projects with faculty or take courses with instructors who possess PhDs in their fields or disciplines, such as STEM. Once community college students transfer to a four-year institution, they may not have the peer or faculty networks or experience to work in a research laboratory to engage in rigorous research that may promote access to a PhD program. For those who are successful in gaining admission to a doctoral program, the lack of research experience may hamper their ability to transition to a PhD in STEM if they decide to pursue graduate study.

Clearly, students' initial institutional entry to their postsecondary pathway impacts their transition and how they are socialized to their doctoral program. As stated above, PhD students who attended a highly selective research (public or private) university at the

undergraduate level are more likely to have been exposed to research opportunities than their peers who first attended community colleges or less research-oriented four-year institutions. Indeed, undergraduate students attending research-oriented institutions may interact with faculty and PhD students who provide "insider knowledge" (Stanton-Salazar, 1997, 2011) by acting as "institutional agents" (Stanton-Salazar, 1997, 2011) to illuminate what research is and how enrolling in a PhD program may promote their professional and academic career. Non-research-focused institutions may neither have the same resources nor funding to provide research opportunities to undergraduate or master's students as top-tier research institutions. Thus, students who have historically not been successful in PhD STEM programs and attended a less selective or less resourced undergraduate postsecondary institution should receive added support and monitoring. For example, understanding if a Latina first embarked in her post-secondary education at the community college and transferred to a teaching institution to obtain her bachelor's degree, it would behoove the doctoral program to provide extra support to this student compared to a student who went straight from high school to a highly endowed selective research university and had been conducting research since their second year. However, not all students who are successful attend highly selective predominantly White institutions to be successful in graduate school.

Special purpose institutions such as Historical Black Colleges and Universities (HBCU) (Allen, 1992; Blackwell, 1987; Brazziel, 1983; Garibaldi, 1997; Gasman and Tudico, 2008; Perna, 2001; Willie, *et al.*, 1991) and women's institutions (Tidball, 1976, 1980, 1986; Smith, 1990; Smith *et al.*, 1995; Wolf-Wendel, 1998) have a long distinguished history in producing future doctoral students. Tidball's (1976, 1980, 1986) research reminds us of the powerful impact women's colleges and universities have had on producing a large number of women STEM doctoral students. Furthermore, Black women's colleges have produced the highest proportion of African-American women doctoral recipients (Wolf-Wendel, 1998). As Astin (1962) suggests, it is important to account where students' originate from if we are to support doctoral students properly.

The seminal work conducted by Attinasi (1989) can be very illuminating for our purposes. He examined how perceptions regarding "getting in" to college was a process that was developed before and after matriculation in college. He describes how Latino persisters obtained college-going behaviors and attitudes by modeling their behavior after their mentors. Attinasi (1989, p. 258) found that student participants who persisted in college discussed how high school teachers shared their college-going experience with them, providing "indirect simulation" of what it meant to be college student. He referred to this process as "mentoring modeling" which promoted the students' understanding of what college would be like if they enrolled. The indirect simulation via mentor modeling occurred through two-subcategories: formal and informal simulative experiences. Formal indirect simulation occurred when students took college-level courses such as Advanced Placement (AP) and International Baccalaureate (IB) at their high school. Students who took these courses indicated that they were aware of the college-going behaviors and attitudes because of more rigorous academic work and high expectations by the teachers. Informal experiences occurred when teachers would inform them of the expectations college professors would have of them if they continued their education after high school. Thus, students in the indirect simulations formally took college-level courses in high school and informally received information regarding what the college culture would expect of them. Stanton-Salazar (1997, 2011) suggests that this information would help students in acquiring *funds of knowledge* regarding the college organizational context; it would also inculcate a college-going behavior and attitude.

Attinasi highlights two very salient processes that enable students of color and women to obtain the attitudes and behaviors before and after college matriculation to transition, persist and be academically successful in a PhD STEM program. This process can be applied to pre-doctoral students as well. Pre-doctoral students in undergraduate or master's programs can be informed about what research is and what role graduate students play in a doctoral program. This process of demystifying the PhD in STEM can help promote a better understanding of the culture of graduate programs and the role actors in the hierarchal structures play.

Institutional efforts

Many universities are tasked with developing institution-wide diversity initiatives (Smith, 2009). Entire university departments and offices are devoted to supporting diversity on campus and their work is to support students from all backgrounds to enter and succeed at the university. These initiatives include hiring chief diversity officers, having diverse search committees and ensuring that committees have a diverse pool of applicants to interview for faculty and staff position (Smith, 2009).

While these systems may help improve diversity within STEM, they also have the potential to inhibit or not fully embrace students from traditionally underrepresented groups in specific departments. Diversity issues in STEM are not necessarily the same issues experienced throughout the university. Even within STEM fields, differences can be seen in each subgroup, such as the increase of women in biology but not in mathematics, engineering or technology.

Moreover, there are also effort differences at each level of education. Diversity issues could be extremely different at the undergraduate, masters, doctoral and professoriate levels. As such, blanket diversity plans support focus and attention on diversifying and improving equity in higher education, which is entirely necessary to increase awareness, but do not necessarily support diversity in specific disciplines, such as STEM, and the different levels within higher education.

In our critical multicultural conceptual model, we indicate the institutional efforts as a factor to consider, as it impacts outcomes and persistence for women and minority doctoral students. However, this factor is not the only determinant of success at the doctoral level. As Su *et al.* (2015) indicate, diversity strategies are most impactful at the departmental level. We maintain the institutional efforts should be foundational and function to inform environmental department support for students from traditionally underrepresented populations.

Departmental support based on attributes of student and institution

The aforementioned personal and institutional factors that contribute to the persistence and outcomes of traditionally underrepresented students (i.e. women and students of color) in STEM critically inform support structures, systems and policies at the departmental level. Indeed, it is critical that STEM departments understand their students' social locations, personal communities and stage of life and prior educational experiences to better understand students' needs. In addition, having a clear understanding of the institution's efforts to diversify provides institutions with more structure to leverage institutional resources to recruit and help support students. Most institutions of higher education would argue that they have invested funds and resources to ensure recruitments efforts are successful. However, recruitment without proper personalized support systems embedded within the organization could foster challenges to promote success. Thus, STEM

departments need to be aware of how their institution can fully support their students who are pursuing STEM disciplines.

Often university departments are in direct contact with faculty and students in their disciplines. As such, the influence of departments are much greater than the institution as a whole. Deans, departmental chairs and faculty have the power to ensure students, who have traditionally been underserved and underrepresented in STEM, feel culturally supported by implementing programs, resources, funding and mentorship that is unique to their female and minority students. By cultivating a critical multicultural perspective, institutions of higher education can abate barriers to the doctoral attainment of women and students of color.

Conclusion

The pipeline to doctoral STEM programs for students of color and women has been a trickle for decades, even after concerted efforts were made to increase the flow. Incorporating a critical multicultural lens helps to support recruitment, retention and success among graduate students who have been historically underrepresented in STEM programs. We believe a better understanding of doctoral students' social location, personal communities specific to the stage of their life and characteristics of prior higher education experiences, buttressed with an understanding of the institutional context of diversification efforts is essential to supporting minority and female success in doctoral STEM programs.

By increasing individualized support, with attention to personal and institutional factors, we can increase the diversity and career options in STEM by ensuring they are successful in obtaining academic and non-academic positions. A more diverse tenured and tenure-track faculty affords representation of faculty for students of color and women to serve as mentors and role models. When students of color and women see individuals like themselves, they are more likely able to envision themselves in such positions (Nieto and Bode, 2011; Su *et al.*, 2015). We can abate the discrepancies within STEM at all levels by ensuring we have a strong flow of diverse students enrolling, persisting and graduating with their doctoral degrees.

References

Allen, W.R. (1992), "The color of success: African-American college student outcomes at predominantly white and historically black public colleges and universities", *Harvard Educational Review*, Vol. 61 No. 1, pp. 26-42.

Astin, A.W. (1962), "Productivity of undergraduate institutions: new analyses show that a college's output of doctors of philosophy depends largely on its input of students", *Science*, Vol. 136 No. 3511, pp. 129-135.

Attinasi, L.C. Jr (1989), "Getting in: Mexican Americans' perceptions of university attendance and the implications for freshmen year persistence", *Journal of Higher Education*, Vol. 60 No. 3, pp. 247-277.

Baber, L.D. (2015), "Considering the interest-convergence dilemma in STEM education", *The Review of Higher Education*, Vol. 38 No. 2, pp. 251-270.

Banks, J.A. (2006), *Race, Culture, and Education: The Selected Works of James A. Banks*, Routledge, New York, NY.

Better, S. (2007), *Institutional Racism: A Primer on Theory and Strategies for Social Change*, Rowman & Littlefield, Lanham, MD.

Blackwell, J. (1987), "Mentoring and networking among Blacks", in Pruitt, A.S. (Ed.), *In Pursuit of Equality in Higher Education*, General Hall, Dix Hills, NY, pp. 146-162.

Bowen, W. and Bok, D. (1999), *The Shape of the River*, Princeton University Press, Princeton, NJ.

Bowen, W.G. and Rudenstine, N.L. (1992), In Pursuit of the PhD, Princeton University Press, Princeton, NJ.

Brazziel, M.E. (1983), "Baccalaureate college origins of black doctoral recipients", *Journal of Negro Education*, Vol. 52 No. 2, pp. 102-109.

Carnavale, A.P. and Rose, S.J. (2004), "Socioeconomic status, race/ethnicity, and selective college admissions", in Kalenberg, R.D. (Ed.), *America's Untapped Resource: Low-Income Students in Higher Education*, The Century Foundation Press, New York, pp. 101-156.

Cohen, A. and Brawer, F. (2003), *The American Community College*, Jossey-Bass, San Francisco.

Cohen, A.M., Brawer, F.B. and Kisker, C.B. (2014), *The American Community College*, 6th ed., Jossey-Bass, San Francisco, CA.

Council of Graduate Schools (2004), PhD Completion and Attrition: Policy, Numbers, Leadership, and Next Steps, Council of Graduate Schools, Washington, DC.

Cross, B.E. (2010), "New racism, reformed teacher education, and the same ole' oppression", *Educational Studies: A Journal of the American Education Studies Association*, Vol. 38 No. 3, pp. 263-274.

Espinosa, L.L. (2011), "Pipelines and pathways: women of color in undergraduate STEM majors and the college experiences that contribute to persistence", *Harvard Educational Review*, Vol. 81 No. 2, pp. 209-240.

Foor, C.E., Walden, S.E. and Trytten, D.A. (2007), "I wish that I belonged more in this whole engineering group: achieving individual diversity", *Journal of Engineering Education*, Vol. 96 No. 2, pp. 103-115.

Fry, R. (2002), *Latinos in Higher Education: Many Enroll, too few Graduate*, Pew Hispanic Center, Washington, DC.

Gardner, S.K. (2009), "Student and faculty attributions of attrition in high and low-completing doctoral programs in the United States", *Higher Education*, Vol. 58 No. 1, pp. 97-112.

Garibaldi, A.M. (1997), "Four decades of progress. . . and decline: an assessment of African American educational attainment", *Journal of Negro Education*, Vol. 66 No. 2, pp. 556-576.

Gasman, M. and Tudico, C.L. (2008), *Historically Black Colleges and Universities: Triumphs, Troubles, Taboos*, Palgrave MacMillan, New York.

Garza, H. (2006), "Forward", in Castellanos, J., Gloria, A.M. and Kamimura, M. (Eds), *The Latina/o Pathway to the PhD: Abriendo Caminos*, Stylus Publishing, Sterling, VA, pp. 15-21.

Gutiérrez y Muhs, G., Niemann, Y.F., Gonzalez, C.G. and Harris, A.P. (Eds) (2012), *Presumed Incompetent: The Intersections of Race and Class for Women in Academia*, Utah State University Press, Utah.

Harris, A.P. and Gonzalez, C.G. (2012), "Introduction", in Gutiérrez y Muhs, G., Niemann, Y.F., Gonzalez, C.G. and Harris, A.P. (Eds), *Presumed Incompetent: The Intersections of Race and Class for Women in Academia*, University of Colorado Press, Boulder, CO, pp. 1-14.

Herzig, A.H. (2004), "Becoming mathematicians: women and students of color choosing and leaving doctoral mathematics", *Review of Educational Research*, Vol. 74 No. 2, pp. 171-214, doi: 10.3 102/ 0034654307 4002171.

Hodson, D. (1998), "Going beyond cultural pluralism: science education for sociopolitical action", *Science Education*, Vol. 83 No. 6, pp. 775-796.

Hodson, D. and Dennick, R. (1994), "Antiracist education: a special role for the history of science and technology", *School Science and Mathematics*, Vol. 94 No. 5, pp. 255-262.

Jackson, J. (2004), "The story is not in the numbers: academic socialization and diversifying the faculty", *NWSA Journal*, Vol. 16 No. 1, pp. 172-185.

Kim, Y. (2011), "Minorities in higher education: twenty-fourth status report 2011 supplemental", American Council on Education, Washington, DC.

Knowles, L. and Prewitt, K. (Eds) (1970), *Institutional Racism in America*, Prentice Hall, Upper Saddle River, NJ.

Laanan, F.S. (2001), "Transfer student adjustment", in Laanan, F.S. (Ed.), *Transfer students: Trends and Issues. New Directions for Community Colleges*, Jossey-Bass, San Francisco, Vol. 114, pp. 5-13.

Llamas, J. and Morgan Consoli, M.L. (2012), "The importance of familia for Latina/o college students: examining the role of familial support on intragroup marginalization", *Cultural Diversity and Ethnic Minority Psychology*, Vol. 18 No. 4, pp. 395-403, doi: 10.1037/a0029756.

Lott, J.L., Gardner, S. and Powers, D.A. (2009), "Doctoral student attrition in the STEM fields: an exploratory event history analysis", *Journal of College Student Retention: Research, Theory & Practice*, Vol. 11 No. 2, pp. 247-266, doi: 10.2190/CS.11.2.e.

Lovitts, B.E. (2001), *Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study*, Rowman and Littlefield, Lanham, MD.

McDowell, T. and Fang, S. (2007), "Feminist informed multiculturalism: considerations for family research", *Journal of Family Issues*, Vol. 28 No. 4, pp. 549-566.

May, G.S. and Chubin, D.E. (2003), "A retrospective on undergraduate engineering success for underrepresented minority students", *Journal of Engineering Education*, Vol. 92 No. 1, pp. 27-39.

May, S. (1999), *Critical Multiculturalism: Rethinking Multicultural and Antiracist Education*, The Falmer Press, London.

Mayo, S. and Larke, P.J. (2011), "Multicultural education transformation in higher education: getting faculty to 'buy in', *Journal of Case Studies in Education*, Vol. 1, pp. 1-9.

Millett, C.M. and Nettles, M.T. (2006), "Expanding and cultivating the Hispanic STEM doctoral workforce research on doctoral student experiences", *Journal of Hispanic Higher Education*, Vol. 5 No. 3, pp. 258-287.

National Science Foundation, National Center for Science and Engineering Statistics (2015), "Women, minorities, and persons with disabilities in science and engineering: 2015", *Special Report NSF 15-311*, available at: www.nsf.gov/statistics/wmpd

Nettles, M.T. and Miller, C.M. (2006), *Three Magic Letters: Getting to PhD*, The Johns Hopkins University Press, Baltimore, MD.

Nieto, S. (2011), "It's whom you teach, not just what you teach: lessons from successful culturally competent teachers", *Teachers of Color Magazine*, Vol. 6 No. 1, pp. 40-42.

Nieto, S. and Bode, P. (2011), *Affirming Diversity: The Sociopolitical Context of Multicultural Education*, 6th ed., Pearson, Boston, MA.

Ong, M., Wright, C., Espinosa, L.L. and Orfield, G. (2011), "Inside the double bind: a synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics", *Harvard Educational Review*, Vol. 81 No. 2, pp. 172-209.

Ornelas, A. and Solórzano, D.G. (2004), "Transfer conditions of Latina/o community college students: a single institution case study", *Community College Journal of Research and Practice*, Vol. 28 No. 3, pp. 233-248.

Perna, L. (2001), "The contribution of historically black colleges and universities to the preparation of African American for faculty careers", *Research in Higher Education*, Vol. 42 No. 3, pp. 267-294.

Phillips, M. (2011), "Ethnic and social class disparities in academic skills: their origins and consequences", in Stulberg, L.M. and Weinberg, S.L. (Eds), *Diversity in American Higher Education: Toward a More Comprehensive Approach*, Routledge, New York: NY, pp. 7-24.

Reason, R.D. (2009), "An examination of the persistence research through the lens of a comprehensive conceptual framework", *Journal of College Student Development*, Vol. 50, pp. 659-682.

Reyes, M.E. (2011), "Unique challenges for women of color in STEM transferring from community college to universities", *Harvard Educational Review*, Vol. 81 No. 2, pp. 241-263.

Rimmington, G.M. and Alagic, M. (2008), *Third Place Learning: Reflective Inquiry into Intercultural and Global Cage Painting*, Information Age, Charlotte.

Ryu, M. (2010), "Minorities in higher education: twenty-fourth status report", American Council on Education, Washington, DC.

Segura, D.A. (1990), "Chicana and triple oppression in the labor force", in Córdova, T., Cantú, N., Cardenas, G., Garcıa, J. and Sierra, C.M. (Eds), *Chicana Voices: Intersection of Class, Race, and Gender*, Center for Mexican American Studies, University of Texas, Austin, TX, pp. 47-65.

Sleeter, C.E. and Grant, C. (1988), "An analysis of multicultural research in the United States", *Harvard Educational Review*, Vol. 57 No. 4, pp. 421-445.

Smallwood, S. (2004), "Doctor dropout", *The Chronicle of Higher Education*, p. 19A.

Smith, A., Crothwaite, J. and Clark, C. (2014), "White privilege", in Thompson, S. (Ed.), *The Encyclopedia of Diversity and Social Justice*, Rowman & Littlefield, Lanham, MD, Vol. 2, pp. 743-744.

Smith, D., Wolf, L.E. and Morrison, D. (1995), "Paths to success: factors related to the impact of women's colleges", *Journal of Higher Education*, Vol. 66 No. 3, pp. 245-266.

Smith, D.G. (2009), *Making Diversity Work*, Johns Hopkins Press, Baltimore.

Smith, D.G. (1990), "Women's colleges and coed colleges: is there a difference for women?", *Journal of Higher Education*, Vol. 61 No. 2, pp. 181-195.

Solórzano, D., Rivas, M. and Velez, V. (2005), "Community college as pathway to Chicana/o doctorate production", Latino Policy & Issues Brief No. 11, UCLA Chicano Studies Research Center.

Stanton-Salazar, R.D. (1997), "A social capital framework for understanding the socialization of racial minority children and youths", *Harvard Educational Review*, Vol. 67 No. 1.

Stanton-Salazar, R.D. (2011), "A social capital framework for the study of institutional agents and of the empowerment of low-status youth", *Youth & Society*, Vol. 43 No. 3, pp. 1066-1109.

Steinber, S.R. and Kincheloe, J.L. (2001), "Setting the context for criticalmulti/interculturalism: the power blocs of class elitism, white supremacy, and patriarch", in Steinberg, S.R. (Ed.), *Multi/Intercultural Conversations: A Reader*, Peter Lang, New York, pp. 3-30.

Su, X., Johnson, J. and Bozeman, B. (2015), "Gender diversity strategy in academic departments: exploring organizational determinants", *Higher Education*, Vol. 69 No. 5, pp. 839-858.

Taylor, D.L. (2009), 'Set up to fail': institutional racism and the sabotage of school improvement", *Equity and Excellence in Education*, Vol. 42 No. 2, pp. 114-129.

Tidball, M.E. (1976), "Of men and research: the dominant themes in higher education include neither teaching nor women", *Journal of Higher Education*, Vol. 47 No. 4, pp. 373-389.

Tidball, M.E. (1980), "Women's colleges and women achievers revisited", *Signs: Journal of Women in Culture and Society*, Vol. 5 No. 3, pp. 504-517.

Tidball, M.E. (1986), "Baccalaureate origins of recent natural sciences doctorates", *Journal of Higher Education*, Vol. 57 No. 6, pp. 606-620.

Tinto, V. (1993), *Leaving College: Rethinking the Causes and Cures of Student Attrition*, 2nd ed., The University of Chicago Press, Chicago.

Vasquez, M.J.T. (1997), "Confronting barriers to the participation of Mexican American women in higher education", in Darder, A., Torres, R.D. and Gutierrez, H. (Eds), *Latinos in Higher Education: A Critical Reader*, Routledge, New York, NY, pp. 454-468.

Weidman, J.C., Twale, D.J. and Stein, E.L. (2001), "Socialization of graduate and professional students in higher education: a perilous passage?", *ASHE-ERIC Higher Education Report, 28*, Jossey-Bass, San Francis.

Willie, C.V., Grady, M.K. and Hope, R.O. (1991), *African American and the Doctoral Experience: Implications for Policy*, Teachers College Press, New York.

Wolf-Wendel, L.E. (1998), "Models of excellence: the baccalaureate origins of successful European women, African American women, and Latina", *Journal of Higher Education*, Vol. 69 No. 2, pp. 141-186.

Zambrana, R.E., Scrimshaw, S.C.M., Collins, N. and Dunkel-Schetter, C. (1997), "Prenatal health behaviors and psychosocial risk factors in pregnant women of Mexican origin: the role of acculturation", *American Journal of Public Health*, Vol. 87, pp. 1022-1026.

Further reading

Antony, J. (2002), Reexamining doctoral student socialization and professional development: moving beyond the congruence and assimilation orientation, *Higher Education: Handbook of Theory and Research*, Springer, Berlin, doi: 10.1007/978-94-010-0245-5_8.

Ellis, E.M. (2001), "The impact of race and gender on graduate school socialization, satisfaction with doctoral study, and commitment to degree completion", *The Western Journal of Black Studies*, Vol. 25, pp. 30-45.

Felder, P.P., Stevenson, H.C. and Gasman, M. (2014), "Understanding race in doctoral student socialization", *International Journal of Doctoral Studies*, Vol. 9, pp. 21-42, available at: http://ijds.org/Volume9/IJDSv9p021-042Felder0323.pdf

Golde, C.M. (2005), "The role of the department and discipline in doctoral student attrition: lessons from four departments", *The Journal of Higher Education*, Vol. 76 No. 6, pp. 669-700, doi: 10.1353/jhe.2005.0039.

Gonzalez, J.C. (2006), "Academic socialization experiences of Latina doctoral students: a qualitative understanding of support systems that aid and challenges that hinder the process", *Journal of Hispanic Higher Education*, Vol. 5 No. 4, pp. 347-365, doi: 10.1 177/15381927062911 41.

Maher, M.A., Ford, M.E. and Thompson, C.M. (2004), "Degree progress of women doctoral students: factors that constrain, facilitate, and differentiate", *The Review of Higher Education*, Vol. 27 No. 3, pp. 385-408, doi: 10.1353/rhe.2004.0003.

Malcolm, S.M., Van Horne, V.V., Gaddy, C.D. and George, Y.S. (1998), *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans*, American Association for the Advancement of Science, Directorate for Education and Human Resources Programs, Washington, DC.

Quintana, S.M., Vogel, M.C. and Ybarra, V.C. (1991), "Meta-analysis of Latino students' adjustment in higher education", *Hispanic Journal of Behavioral Sciences*, Vol. 13 No. 2, pp. 155-168.

Weidman, J.C. (1979), "Nonintellective undergraduate socialization in academic departments", *Journal of Higher Education*, Vol. 50 No. 1, pp. 48-62.

Weidman, J.C. (1989), "Undergraduate socialization: a conceptual approach", in Smart, J.C. (Ed.), *Higher Education: Handbook of Theory and Research*, Agathon Press, New York, NY, Vol. 5, pp. 289-322.

Weidman, J.C. and Stein, E.L. (2003), "Socialization of doctoral students to academic norms", *Research in Higher Education*, Vol. 44 No. 6, pp. 641-656.

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