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Terence Hicks and J. Luke Wood STEM Meta-synthesis article

Terence Hicks

WHAT DO WE KNOW ABOUT DIVERSE COLLEGE STUDENTS IN STEM?

A meta-synthesis of academic and social characteristic studies

First-generation college students in STEM disciplines at HBCUs

Terence Hicks
East Tennessee State University, Johnson City, Tennessee, USA, and
J. Luke Wood
San Diego State University, San Diego, California, USA

Abstract

Purpose – Given that a relatively large percentage of college students entering historically black colleges and universities (HBCUs) are first-generation students and considering the low completion rate among this group in the science, technology, engineering and mathematics (STEM) discipline, the purpose of this preliminary meta-synthesis study is intended to facilitate a greater understanding of the academic and social adjustment among college students, particularly first-generation college students enrolled in STEM disciplines at HBCUs. Therefore, this meta-synthesis will shed light and offer important recommendations for university administrators and faculty members in supporting the academic and social adjustment of these students in STEM fields at HBCUs.

Design/methodology/approach – This review of literature was conducted using a meta-synthesis approach (also referred to as integrative review). A meta-synthesis is based on a process by which findings across multiple studies are organized and presented (Turner *et al.*, 2008; Wood, 2010). This approach is used to provide insight into academicians and practitioners alike on the status of research on a given phenomenon (Bland *et al.*, 1995; Patterson *et al.*, 2001; Wood, 2010). This technique is similar to a meta-analysis and meta-ethnography, where findings from quantitative and qualitative studies are synthesized. In contrast, a meta-synthesis presents thematic findings from studies that are both qualitative and quantitative in nature (Bair and Haworth, 2004). The authors were engaged in a cyclical process of collecting, annotating and synthesizing research over a 45-year time-frame (1970-2015).

Findings – Factors present in the literature that affect students enrolled in a STEM program at an HBCU are grouped into three contexts: (a) first-generation academic and social characteristics, (b) first-generation college dropout and transition and (c) first-generation STEM retention. Within these general groupings, four interrelated themes emerged from the literature: prior academic adjustment and STEM discipline, college adjustment and STEM discipline, social integration and STEM discipline and academic integration and STEM discipline.

Originality/value – This information may help professors and university professionals in the STEM fields to be more aware of the challenges faced by incoming college students. More empirical work is needed in this area in a way that is useful for understanding and enhancing professors' and university professionals' knowledge. To this end, research that carefully describes what HBCU professors and

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university professionals know or their ideas about teaching college students, especially first-generation students enrolled in the STEM discipline, is needed.

Keywords Multicultural, Education, Ethnicity, Race

Paper type Research paper

Introduction

According to data from the National Science Board's Science and Engineering Indicators 2008, 34 per cent of African-American freshmen intended to major in science, technology, engineering and mathematics (STEM) fields. This number is larger than the percentage of incoming White freshmen (29.5 per cent) who planned to major in science and engineering. Researchers have indicated that the lack of African-American students choosing to pursue majors and careers in science and technology at the undergraduate level is partially due to educational inequities and academic under-preparedness throughout the K-12 system and partially due to insufficient academic and social opportunities within STEM and ineffective academic and career counseling (Atwater, 2000; Jibrell, 1990; Ladson-Billings, 1997). Additionally, researchers have indicated that the most critical component in ensuring excellence among minority students in the STEM discipline is having great STEM teachers with both content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well (President's Council of Advisors on Science and Technology 2011). National Science Foundation (NSF, 2011) found that 39 per cent of African-American and 42 per cent of Hispanic fifth graders were taught math by a teacher with a master's or advanced degree in the subject compared to more than half for Caucasians. Additionally, eighth-grade students from low-income families were less likely to have science teachers with regular or advanced teacher certificates, a degree in science, and more than three years of experience in teaching science (NSF, 2011).

Despite the wealth of literature on academic and social adjustment among college students, there are a limited number of studies that have focused exclusively on understanding the factors that impact the academic and social adjustment of college students in a STEM discipline at a historically black college and university (HBCU). Moreover, there is an apparent gap in the knowledge of college administrators and faculty concerning the academic and social expectations that are held by these students and how these expectations may relate to first-generation college students' persistence, or lack thereof, in a STEM discipline at an HBCU. A few studies have focused on interventions intended to improve academic and social under-preparedness for minority students enrolled in a STEM discipline (Hicks, 2012; Rodriquez-Kiino, 2014; National Science Foundation, National Center for Science and Engineering Statistics, 2013). Hicks (2012) examined differences in the levels of academic and social engagement and college self-efficacy between first-generation and other college students enrolled in a STEM discipline at an HBCU. His study indicated that significant differences among first-generation and other college students who were enrolled in a STEM discipline at an HBCU were found in three academic integration and four social integration categories and that HBCUs play a vital role in providing academic and social educational opportunities to minority students enrolled in a STEM discipline.

Given that a relatively large percentage of college students entering HBCUs are first-generation students and considering the low completion rate among this group in

the STEM discipline, this preliminary meta-synthesis is intended to facilitate a greater understanding of the academic and social adjustment among college students, particularly first-generation college students enrolled in STEM disciplines at HBCUs. Therefore, this meta-synthesis will shed light and offer important recommendations for university administrators and faculty members in supporting the academic and social adjustment of these students in STEM fields at HBCUs.

Methodology

This review of literature was conducted using a meta-synthesis approach (also referred to as integrative review). The purpose of this meta-synthesis was to examine research about HBCU students and STEM. A meta-synthesis is based on a process by which findings across multiple studies are organized and presented (Turner *et al.*, 2008; Wood, 2010). This approach is used to provide an insight into academicians and practitioners alike on the status of research on a given phenomenon (Bland *et al.*, 1995; Patterson *et al.*, 2001; Wood, 2010). This technique is similar to a meta-analysis and meta-ethnography, where findings from quantitative and qualitative studies are synthesized. In contrast, a meta-synthesis presents thematic findings from studies that are both qualitative and quantitative in nature (Bair and Haworth, 2004).

We engaged in a cyclical process of collecting, annotating and synthesizing research over a 45-year timeframe (1970-2015). Academic resources were collected primarily through the use of EBSCOhost, a component of the Online Computer Library Center search. This electronic search of databases enables researchers to utilize three primary research indexes: EBSCOhost Electronic Journal Service, Digital Dissertation Abstract International and Educational Research and Information Center. A Boolean search under college or university, along with the following key words, was used to develop an appropriate reference list for the literature review and encompassed the following terms: first-generation; college transition; retention; academic and social characteristics; and STEM. The identification of resources focused on obtaining saturation, a process by which data collection continues until emergent themes and patterns become repetitious (Auerbach and Silverstein, 2003). This produced over 50 cited resources with more than 100 scholars, including peer-reviewed articles, reports, books, book chapters and conference papers. Table I shows our search results in ten-year increments. All references were annotated with attention to the following areas of interest: research purpose, research questions, methodology, theoretical framework, findings, recommendations and conclusions. Emerging themes from the annotations were synthesized and subjected to an iterative process of theme identification and confirmation/re-evaluation. This process was both hermeneutic and dialect in nature in

Table I. Review of literature related to academic and social characteristics, first-generation college students and STEM by type of publication in 10-year increments

	1970-1979	1980-1989	1990-1999	2000-2015	Total
Journal articles	2	4	13	10	29
Reports	–	–	2	7	9
Books	–	1	3	1	5
Book chapters	–	3	1	2	6
Conference presentations	–	–	–	1	1
Dissertations	–	–	–	1	1
Total	2	8	19	22	51

that our goal was to accurately understand and depict constructions from individual studies. Moreover, we compared and contrasted studies to present a new (consensus-laden) construction (Jensen and Allen, 1996).

Results

Factors present in the literature that affected students enrolled in a STEM program at an HBCU are grouped into three contexts:

(1) First-generation academic and social characteristics:
   - Braxton *et al.* (2004), Braxton and Hirschy (2004), Christie and Dinham (1991), Hicks (2005, 2012), Levitz and Noel (1989), Murphy and Hicks (2006), National Science Foundation, National Center for Science and Engineering Statistics (2013), Pascarella and Terenzini (2005), Rodriquez-Kiino (2014), Spady (1970), Stieha, (2010), Terenzini et al. (1994), Tinto (1975, 1987, 1988, 1993).

(2) First-generation college dropout and transition:
   - Billson and Terry (1982), Choy (2002), Christie and Dinham (1991), Fitzgerald and Russell (2002), Grayson (1997), Hicks (2003, 2005), York-Anderson and Bowman (1991), Hicks (2002), Levitz and Noel (1989), London (1989), Mitchell (1997), Murphy and Hicks (2006), Nunez and Cuccaro-Alamin (1998), Padron (1992), Pascarella *et al.* (2004), Rodriguez *et al.* (2003), Terenzini *et al.* (1996), Terenzini *et al.* (1994), Tinto (1985, 1998).

(3) First-generation STEM retention:
   - American Institutes for Research (2015), Atwater (2000), Brown and Clewell (1998), Gainor and Lent (1998), Gandara and Maxwell-Jolly (1999), Hall and Post-Kammer (1987), Jibrell (1990), Ladson-Billings (1997), National Academies of Sciences, National Academy of Engineering and Institute of Medicine (2007), National Research Council (2011), National Science Foundation (2011), Oakes (1990), President's Council of Advisors on Science and Technology (2011), Russell and Atwater, 2005), Seymour and Hewitt (1997).

These categories provide contexts by author and year of publication. Within these general groupings, four interrelated themes emerged from the literature:

(1) prior academic performance and STEM discipline;

(2) college adjustment and STEM discipline;

(3) social integration and STEM discipline; and

(4) academic integration and STEM discipline.

Prior academic performance and science, technology, engineering and mathematics discipline

The effects of prior academic performance, experiences and habits are recurrent themes in the studies examined. To be sure, many studies discussed how K-12 schooling experiences affected performance in college. This body of literature also addressed how high school factors affected enrollment in STEM disciplines. For example, Murphy and Hicks (2006) noted that mathematics in high school may be the key to understanding student success in college. They stated that by not engaging in higher-level

mathematics in high school, students' academic progress in college typically is hindered, particularly for first-generation students who are already at risk of departure. Despite these data, some research indicates that even African-American students with strong academic credentials under-perform in STEM disciplines, which suggest that other factors, outside of pre-college preparation and ability, may hamper minority student achievement and persistence (Gandara and Maxwell-Jolly, 1999).

Prior academic performance is a key factor associated with participation and persistence in STEM education, especially for under-represented groups such as women and ethnic minorities (Betz, 2005). According to the National Research Council (2011), early exposure to STEM supports children's overall academic growth, develops early critical thinking and reasoning skills and enhances later interest in STEM study and careers. According to the American Institutes for Research (2015), a study conducted in 2009 by the National Assessment of Educational Progress (NAEP) indicated that compared to males, lower percentages of female high school graduates reported that they liked mathematics or science and that mathematics or science was one of their favorite subjects and that higher percentages of female high school graduates took algebra II, pre-calculus, advanced biology, chemistry and health science/technology courses. Furthermore, the report notes that among 2009 high school graduates who had earned credits in specific mathematics and science courses, males had higher average NAEP mathematics and NAEP science scale scores than females.

In one 2008 study, high school and freshman year grade point average (GPA) was shown to impact the persistence of female and male students majoring in science and engineering (Mendez *et al.*, 2008). Other studies showed a positive relationship between women's persistence in non-traditional majors and careers and indicators of performance. For example, academic performance as measured by standardized test scores and GPA was related to persistence, whereby people who achieve higher scores and grades persist longer. Van Laar (2000) found that African-American students valued college education more than White students prior to entering college at predominately white institutions (PWIs). Moreover, despite having expectancies for future economic success and for academic performance prior to college entrance that were equal to or higher than those of their White counterparts, by the end of their first year in college, unlike White students, African-American students experienced a significant drop in their expectancies for economic and academic success.

The findings from the meta-synthesis indicated that prior academic performance influences persistence in STEM disciplines for under-represented students at HBCUs. According to Oakes (1990), the widest entry point to the STEM pipeline occurs during the first year of high school for most students. Therefore, effective academic guidance and facilities are needed to strengthen the STEM pipeline. Furthermore, the lack of effective academic and career advising has been recognized as a central factor in the small number of African-Americans pursing STEM degrees and careers (Hall and Post-Kammer 1987; Seymour and Hewitt, 1997). Gainor and Lent (1998) argued that interest in mathematics is the most crucial factor for African-American students deciding to major in a STEM discipline. They found that African-American students with high mathematics self-efficacy also possessed higher expectations regarding their performance within the STEM discipline. This high level of self-efficacy and self-expectations led to enrollment in higher-level mathematics courses, resulting in a

greater interest in STEM. They argue that it is this interest that ultimately results in students selecting a STEM major.

College adjustment and science, technology, engineering and mathematics discipline

A large number of students (approximately one-third) enrolling in college in the twenty-first century are first-generation college students (Choy, 2002). First-generation college students are generally defined as those for whom both parents and guardians have a high school education or less but not a post-secondary degree (Billson and Terry, 1982). Although the definition of first-generation college students may vary, and few institutions track their first-generation college students, there is general agreement that their numbers are increasing on US college campuses (Mitchell, 1997; Padron, 1992; Terenzini *et al.*, 1996). Accordingly, a large majority of researchers have studied the effects that parental influence and parental education attainment have on the college student. During the past 25 years, researchers have discovered significant differences between first-generation college students and other college students in academic, personal and social expectations (Hicks, 2003, 2005); academic characteristics (Murphy and Hicks, 2006); college readiness (Christie and Dinham, 1991); financial and emotional support from families (Hicks, 2002; Levitz and Noel, 1989; York-Anderson and Bowman, 1991); and attrition (Billson and Terry, 1982; Tinto, 1985, 1998). The transition to college has been viewed as especially difficult for first-generation students (London, 1989; Terenzini *et al.*, 1996). Terenzini *et al.* (1994) described the process through which first-generation students adapt to college as a disjunction or a breaking of family tradition. Because the college experience was not in their families' backgrounds, first-generation students must adjust to a new culture – the academic and social culture of college life.

Compared to their peers with more highly educated parents, first-generation students are more likely to be disadvantaged in accessing and understanding information and attitudes relevant to making beneficial decisions about things such as the importance of completing a college degree and what kinds of academic and social choices to make while in attendance (Pascarella *et al.*, 2004). Past studies have documented the academic and social integration of African-American students at HBCUs. There have been relatively few studies, however, that have examined the academic and social characteristics among first-generation African-American students in STEM disciplines at HBCUs (especially in comparison to non-first-generation students). HBCUs are essential in providing an environment to African-American students regardless of their academic or social deficits. Furthermore, HBCUs have been known to provide the kind of academic and social environment that many African-Americans need for surviving that crucial first year of college. A number of studies have discussed the effects of psychological variables on the success of first-generation and non-first-generation students. Murphy and Hicks (2006) investigated the differences in academic expectations of African-American first-generation and non-first-generation college students. Interesting findings were found among these two groups of students. Both first-generation and non-first-generation college students were found to be less confident about their academic abilities in mathematics and may not be prepared for the rigorous demands of college-level mathematics, which in turn can cause academic and social problems for these students.

Many of the findings of this meta-synthesis echo the results of previous research not specifically focused on college students, particularly first-generation students enrolled in a STEM discipline at an HBCU. However, students enrolled in a STEM discipline at an HBCU may face significant and multiple obstacles to enrollment and persistence in the curriculum. Some college students, particularly first-generation students at HBCUs, pursue college education with little support from family members. The findings suggest that a lack of parental experience identified by other researchers also plagues students majoring in STEM disciplines; in fact, this barrier may be compounded for these students because of the stringent demands of the STEM curriculum. Another common obstacle present for these students enrolled at an HBCU is the lack of a role model in the university setting, specifically in the STEM field. Bandura (1986) discusses the effectiveness of "coping" role models in developing self-efficacy – that is – role models who have struggled and overcome obstacles to succeed. The presence of coping models not only prior to entering college but also during undergraduate studies may be particularly effective for college students studying in a STEM discipline at an HBCU.

Social integration and science, technology, engineering and mathematics discipline

In the early 1970s, theories to guide the study of college student withdrawal began to emerge (Spady, 1970; Tinto, 1975). Academic and social integration are the two most important concepts in Tinto's model. Integration is a process in which an individual identifies with or shares and incorporates the normative attitudes and values of his or her instructors and classmates and becomes a member of the college community (Tinto, 1987, 1988, 1993; Pascarella and Terenzini, 2005). Tinto (1975) postulated that academic and social integration influence a student's subsequent commitment to the institution and to the goal of college graduation. The greater a student's level of social integration, the greater the level of subsequent commitment to the goal of college graduation. Social integration pertains to the extent of congruency between the individual student and the social system of a college or university. Social integration occurs at the level of both the college or university and a subculture of an institution (Braxton *et al.*, 2004; Braxton and Hirschy, 2004). Nunez and Cuccaro-Alamin (1998) noted that first-generation students were less likely than students whose parents had some college or attained at least a bachelor's degree to have high levels of social integration (17 versus 29 per cent). These students worked more hours and did not take advantage of resources/social outlets offered by the institution. The overall results of the Nunez and Cuccaro-Alamin's study validated other research on first-generation students being at risk of attrition (Billson and Terry, 1982; Fitzgerald and Russell, 2002; Grayson, 1997; Stieha, 2010; Nunez and Cuccaro-Alamin, 1998; Pascarella *et al.*, 2004; Rodriguez *et al.*, 2003).

In terms of social integration, first-generation students are less likely to socialize with faculty or students outside of class, less likely to develop close friendships with other students and less likely to participate in extracurricular activities (i.e. academic or social clubs) on campus (Pascarella *et al.*, 2004). Similarly, Murphy and Hicks (2006) suggest that first-generation college students tend to spend less time socializing with their college peers than do those who come from families where parents have college experience. Terenzini *et al.* (1994) found that first-generation students tend to delay participation in extracurricular activities and campus life until they feel they have "their academic lives under control". To that effect, HBCUs should provide support to African-American first-generation college students and other minority students to

assist them in successfully attaining their desired degree in the STEM field. For example, based on similar studies, universities could provide support to these students by offering individual and group counseling and an intensive orientation program for freshman college students, especially first-generation. In addition, implementing a first-year experience course would be a great retention strategy and ideal for HBCU students enrolled in a STEM discipline. According to Hicks (2002), this course would allow the students to learn about the resources that a university has to offer and about course expectations of faculty members. He suggests that the curriculum of this course should include topics that may benefit the students in understanding the goals of the college or university, choosing a STEM major and planning a career in the STEM fields, making ethical decisions and learning time management skills to support academic success. Innovative approaches such as the implementation of learning communities designed specifically for students enrolled in a STEM discipline would benefit both the university and the students. Learning communities would help these students form supportive peer groups that extend beyond the classroom. Learning communities could include integrated STEM course clusters. For example, a first semester calculus course would be linked to a study skills course and a tutorial.

Academic integration and science, technology, engineering and mathematics discipline

Tinto (1975) distinguished between the academic and the social systems of college. Academic integration results from sharing information, perspectives and values common to other members of the community. According to Tinto, academic integration consists of structural and normative dimensions. Structural integration entails the meeting of the explicit standards of the college or university, whereas normative integration pertains to an individual's identification with the beliefs, values and norms inherent in the academic system (Braxton *et al.*, 2004; Braxton and Hirschy, 2004). Tinto (1975, 1987) noted that students who are academically and socially integrated into the campus environment are more likely to persist than those who are not well integrated. For example, Hicks (2005) found that African-American first-generation pre-college students at an HBCU who participated in a program providing positive early-academic components such as course selection, intrusive advising, developmental instruction, study groups, tutoring and labs were well prepared and tended to experience greater academic, personal and social success and had higher persistence and graduation rates than other first-time freshmen.

Nunez and Cuccaro-Alamin (1998) found that first-generation students showed lower levels of academic and social integration with the campus compared to students whose parents had college degrees. Some of the differences documented in their report were that first-generation students were less likely than students whose parents had at least some post-secondary experience to have high levels of academic integration (23 versus 33 per cent) and were more likely to report low levels of academic integration (30 versus 10 per cent). When the average scores were examined, among all students, first-generation students had a lower average score (2.3 GPA) than non-first-generation students (2.5 GPA) because first-generation students were less likely to seek assistance from faculty and take advantage of office hours. In regard to minority college students, Brown and Clewell (1998) noted that students in the STEM disciplines who attend large universities face many academic barriers, such as demanding coursework and large classrooms. However, there has been little focus on why these students remain in the

pipeline and how academic and social characteristics may affect their persistence in STEM disciplines at an HBCU. The findings from this meta-synthesis indicate that first-generation college students from all educational status backgrounds may be less confident about their academic abilities in the STEM field and may not be prepared for the rigorous demands of the courses in a STEM field, which in turn can cause academic problems for this population of students. Furthermore, the analysis from the meta-synthesis indicates that by not engaging in higher-level mathematics in high school, students' academic progress in college is hindered. However, academic integration can be enhanced through a number of support services and interventions for college students enrolled in a STEM discipline at an HBCU. Skill-building workshops offered to students enrolled in a STEM discipline at an HBCU may be aimed at improving study skills, time management and academic prioritization.

Discussion

College students who may be first-generation and who are enrolled in a STEM discipline at an HBCU have unique challenges that can sometimes put them at risk for academic and social difficulty. They are the first in their families to pursue education beyond high school, and they may need counselors or role models who are proactive with them early in their primary education. There has been little focus on why and how these students are able to remain in the pipeline and how academic and social interventions that support these students' persistence in STEM at HBCUs can be replicated. To that end, common themes that exist from this meta-synthesis of research are the impact of academic integration and social integration on how minority students persist in college. Tinto's integration framework has been well documented for its usefulness to explain the student longitudinal process of persistence for minority students. In his integration theory, Tinto hypothesized that persistence is a function of the match between an individual's motivation and academic ability and the institution's academic and social characteristics. More specifically, his framework helps institutions to identify characteristics of students at risk of withdrawing (1975). To this effect, university administrators and faculty members are challenged to build upon the strengths of this population and work with these college students who want to continue their education in a STEM discipline at an HBCU while helping them meet their unique academic and social needs. Murphy and Hicks (2006) noted that mathematics in the high school may be the key to understanding student success in college. They stated that by not engaging in higher-level mathematics in high school, students' academic progress in college typically is hindered, particularly for minority students who are already at risk of departure. This may also be true for students who are enrolled in a STEM discipline at an HBCU. To that effect, there has been little focus on why and how students at HBCUs remain in the pipeline and how low math scores in high school may affect their persistence in STEM disciplines. According to Hicks (2012), prior academic performance in the mathematical and data analysis discipline is an important influence in attraction to and persistence in STEM disciplines for under-represented students at an HBCU. Furthermore, understanding how to enhance academic performance in the math courses during high school is a key element in addressing the low representation of ethnic minority students in STEM fields and the concerns of US labor shortages in STEM fields. Gaining insight into this important factor can aid educators and policymakers by illuminating strategies for recruiting and retaining students from

under-represented groups in the STEM fields. Therefore, academic integration that deals with math and data analysis skills can be enhanced through a number of support services and interventions both at the high school and university levels. To that end, math computation and data analysis skill-building workshops offered to college students enrolled in a STEM discipline at an HBCU may be aimed at improving study skills, time management and academic prioritization. In addition, academic advising and data analysis tutoring also may play a critical role in improving this college success factor for college students enrolled in an HBCU.

Administrators and faculty members in the classroom setting could use these findings regarding college students who may be first-generation and who are enrolled in a STEM discipline to demystify the college experience, to dispel some of the misconceptions about the difficulties of the STEM courses and to assist them with effectively integrating into the university environment. Specifically targeting these students after matriculation could relieve additional stress for the students and foster expectations that are more realistic. For example, encouragement by instructors, student mentors and parents may be recommended. According to Russell and Atwater (2005), instructors are pivotal in black students' perseverance in the STEM pipeline. Teachers and professors alike possess the ability to positively affect a student's achievement and attitude toward mathematics and science. Positive instructor relationships with students enhance the expectations teachers have in their students, which results in increased student motivation and self-concept of ability (Russell and Atwater, 2005).

Another common theme in the review of literature was the differences found between first-generation and other college students. First-generation college students represent a unique demographic group, and their level of commitment and attitudes toward achieving a college degree are different from students whose parents have attended college. Research indicates that first-generation students differ from their peers in many ways prior to college enrollment, including their demographic characteristics, the importance they place on college, their aspirations, their perceived level of family support for attending college, their institutional choice and commitment, their pre-college knowledge and behaviors and their entering academic skills and confidence levels. (McConnell, 2000). Furthermore, the research on first-generation students reveals that some of their academic and personal characteristics may affect their success in college, such as being less academically prepared for college, having lower rates of completion in higher-level mathematics courses in high school and coming from families in lower socioeconomic levels (National Center for Educational Statistics, 2005). With the increased accessibility of higher education to first-generation students, especially first-generation students enrolled in the STEM disciplines at an HBCU, and with the growing percentages of matriculating first-generation college students, improving their academic and social achievement (i.e. retention rates) has important implications for HBCUs. Therefore, it is important for administrators and faculty members to use these data to continue to develop additional programs to better facilitate retention, and, ultimately, degree attainment for these students enrolled in a STEM discipline at an HBCU.

Implications for practice and policy

There are several implications for practice that exist for this population of students. The expansion of STEM education and career opportunities is a national priority. Many

HBCUs have worked to create an environment and have developed programs on their campuses that are supportive of students enrolled in a STEM discipline. The findings from this meta-synthesis may help improve practice and policies at HBCUs as they pertain to student outcomes. In addition, the academic and social connections students make in their first year of college are critical to their persistence decisions (Tinto, 1993). The identification of some of the factors that contribute to the initial sense of belonging of first-generation students in STEM majors provide educators with additional information on how to facilitate the persistence of first-generation college students, particularly first-generation students of color, in these disciplines. The findings from this meta-synthesis may assist in the development of policies and programs geared toward summer opportunities and training support for parents. As a preventive measure, HBCU administrators could implement summer orientation programs aimed directly at the parents of these students who are enrolling in a STEM discipline. Such programs could educate both parents and students in adapting to the new academic and social environments of a university setting. The summer program could educate the parents on the importance of their active involvement in their children's continued education.

There are also implications for policymakers at the federal and state levels; there must be continued efforts to advance STEM initiatives at HBCUs. A call for STEM education reform may be beneficial. In *Rising Above the Gathering Storm*, the National Academies of Sciences, National Academy of Engineering and Institute of Medicine (2007) sought to answer a question posed by the Congress about future American competitiveness: What are the top ten actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the USA can successfully compete, prosper and be secure in the global community of the twenty-first century? The report highlights four major areas critical to future competiveness at all levels of government: K-12 education, research and development, higher education and policy incentives. This report emphasizes that STEM education is a critical component to future American competitiveness. It is the foundation upon which all other innovation elements rely, and states play a major role in shaping the system. One of the most visible actions states have taken in STEM education is increasing the number of math and science classes students need to graduate from high school. To that end, the states should strengthen the skills of its current STEM teachers by supporting master's programs, summer training institutes and advanced placement training opportunities. As teachers spend more time in professional development, higher percentages of their students meet science and math standards. According to the National Research Council (2011), policymakers and education leaders at all levels can take the following actions to bring STEM K-12 education closer to fulfilling the goals that the country expects:

- policymakers at the national, state and local levels should elevate science to the same level of importance as reading and mathematics;
- districts should devote adequate instructional time and resources to science in grades K-5;
- districts should ensure that their STEM curricula are focused on the most important topics in each discipline, are rigorous and are articulated as a sequence of topics and performances;

- districts need to enhance the capacity of K-12 teachers to teach STEM. National and state policymakers should invest in a coherent, focused and sustained set of supports for STEM teachers to help them teach in effective ways;
- districts should provide instructional leaders with professional development that helps them to create the school conditions that appear to support student achievement (e.g. professional learning communities, response to intervention, extended learning opportunities, differentiation, etc.);
- states and national organizations should develop effective systems of assessment that are aligned with the next generation of science standards and that emphasize on science practices; and
- federal agencies should support research that disentangles the effects of school practice from student selection, recognizes the importance of contextual variables and allows for longitudinal assessments of student outcomes.

Implications for future research

In addition to the implications for practice and policy, we see several directions that would help advance research in this area. First, in response to the literature reviewed, we see a need for future research to empirically evaluate the academic and social challenges faced among HBCU college students in the STEM discipline. Perhaps future research could examine and disaggregate the effects of academic and social participation as it relates to college dropout and transition for first-year students considering a STEM major at HBCUs. In this collection of studies, there were very few longitudinal studies addressing STEM students and college dropout and transition. As a result, a longitudinal approach to quantitative data collection along with the collection of qualitative data may prove to be beneficial in further advancing the research base of information about academic and social challenges faced by college students, particularly first-generation students enrolled at an HBCU.

It would be of interest to investigate what achievement and self-efficacy approaches work well for first-generation college students enrolled in a STEM discipline and how this population experiences sense of belonging to both the overall campus and STEM communities. In addition, further exploration could also focus on the role that professors and administrators play in enhancing these students' learning of science and mathematics concepts. This information may help professors and university professionals in the STEM fields to be more aware of the challenges faced by incoming college students. More empirical work is needed in this area in a way that is useful for understanding and enhancing professors' and university professionals' knowledge. To this end, research that carefully describes what HBCU professors and university professionals know or their ideas about teaching college students, especially first-generation students enrolled in the STEM discipline, is needed.

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About the authors

Dr Terence Hicks is the Dean of the Claudius G. Clemmer College of Education at East Tennessee State University. Dr Hicks is a noteworthy scholar who has conducted important research analysis on self-efficacy, STEM research, college retention, high school to college transition, spirituality/psychological well-being of first-generation college students. He has been interviewed and cited in the USA Today; the Research Alert National Yearbook; Detroit News; Fayetteville Observer and many university websites. Dr Hicks has published six books and over 85 combined research publications/presentations. Dr Hicks holds a bachelor and a master's degree from Virginia State University. He has earned two doctorate degrees, a doctorate in education degree from Wilmington University, Delaware, and a PhD from North Carolina State University, Raleigh, North Carolina. Terence Hicks is the corresponding author and can be contacted at: hicks1906@yahoo.com

Dr J. Luke Wood is an Associate Professor of Administration, Rehabilitation and Postsecondary Education at San Diego State University. He also is the co-director of the Minority Male Community College Collaborative (M2C3), a national project that partners with community colleges across the USA to enhance access, achievement and success among minority male community college students. He is also the founder and current editor of the *Journal of African American Males in Education*, chair of the Multicultural and Multiethnic Education Special Interest Group of the American Educational Research Association and chair-elect of the Association for the Study of Higher Education (ASHE) Council on Ethnic Participation (CEP). Dr Wood has authored nearly 70 publications, including more than 30 peer-reviewed journal articles. He is the author of three textbooks: *Community College Leadership & Administration: Theory, Practice, and Change* (2010), *Leadership Theory in the Community College: Applying Theory to Practice* (2013), and *Ethical Leadership and the Community College: Paradigms, Decision-Making, and Praxis* (Stylus, in press). He also is the editor of *Black Men in College: Implications for HBCUs and Beyond* (2012), *Black Males in Postsecondary Education: Examining their Experiences in Diverse Institutional Contexts* (2012), *STEM Models of Success: Programs, Policies, and Practices in the Community College* (in press) and *Community Colleges and STEM: Examining Underrepresented Racial and Ethnic Minorities* (2013). Dr Wood received the 2013 Barbara K. Townsend Emerging Scholar Award from the Council for the Study of Community Colleges and the 2010 ASHE CEP Mildred Garcia Award for Exemplary Scholarship.