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Enhancing STEM Career Pathways: Outcomes of a Pre-Professional Workshop Series at a Historically Black College

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ABSTRACT

This study evaluates the impact of a STEM pre-professional workshop series (STEM PPWS) designed to enhance self-efficacy, persistence, and graduate school readiness among underrepresented minority (URM) students at a historically Black college. Grounded in Social Cognitive Career Theory, the intervention consisted of sequential workshops on career development topics, including interviewing, personal statements, and identifying suitable research opportunities. A pretest–posttest design was employed with three cohorts (N = 71) across multiple years. Results showed statistically significant gains in self-efficacy, persistence, and career aspirations. The greatest improvements were noted in personal statement and interviewing workshops. These findings underscore the importance of targeted, skill-based, and identity-affirming cocurricular programming in preparing URM students for postbaccalaureate STEM pathways.

Keywords: career development, graduate school readiness, HBCU, persistence, professional preparation, self-efficacy, STEM, underrepresented minorities

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INTRODUCTION

The persistent underrepresentation of racially and ethnically diverse populations in science, technology, engineering, and mathematics (STEM) continues to pose a national challenge. As the United States strives to maintain its global competitiveness in an increasingly innovation-driven economy, ensuring inclusive participation in the STEM workforce is imperative. However, disparities in access, retention, and advancement in STEM for underrepresented minority (URM) students remain pronounced (Hurtado et al., 201; National Science Foundation [NSF], 2007).

Historically, black colleges and universities (HBCUs), while serving only approximately 3% of the U.S. higher education population, produce more than 20% of science and engineering degrees awarded to black students (NSF, 2019). This disproportionate contribution underscores the vital role that HBCUs play in expanding STEM participation among marginalized populations, particularly African Americans. Despite this success, many HBCU students face challenges in translating strong academic performance into competitive applications for graduate education and research-based careers owing to insufficient professional development and mentoring experience.

To address these gaps, this study evaluates the impact of a STEM preprofessional workshop series (STEM PPWS) designed to increase career readiness, graduate school preparedness, and self-efficacy among STEM majors attending an HBCU. Grounded in social cognitive career theory (SCCT), the STEM PPWS aims to bridge the divide between academic performance and professional advancement by fostering both research readiness and the soft skills necessary for postbaccalaureate success.

This paper has two central aims: (1) to describe the implementation and structure of the STEM PPWS and (2) to assess its effectiveness in increasing STEM self-efficacy, persistence, and graduate school readiness among participating students. It is hypothesized that students who engage in STEM PPWS will report higher levels of (a) self-efficacy in STEM, (b) intention to persist in STEM fields, and (c) preparedness for graduate education.

LITERATURE REVIEW

Barriers to URM Participation and Persistence in STEM

URM students face multiple systemic barriers that hinder their progression in STEM disciplines (Khalid & Ting, 2025; Nweje et al., 2025). These include disparities in institutional resources, a lack of faculty mentorship, financial constraints, and exclusionary academic cultures (Cole, 2007; Hurtado et al., 2011; Mehmood, 2024; Nichols, 1997; Seymour & Hewitt, 1997; Steele, 1997). Cultural and psychosocial barriers, including stereotype threat and social isolation, further impede URM students' persistence in STEM, especially at predominantly white institutions (PWIs) (Hurtado et al., 2011; Steele & Aronson, 1995).

In addition, hidden curricula and informal norms in STEM environments often privilege students from dominant racial and socioeconomic backgrounds, leaving URM students at a disadvantage when navigating academic and professional pathways (Miller, 2016; Skelton, 1997). These dynamics underscore the need for targeted interventions that support not only academic performance but also identity development and a sense of belonging in STEM fields (Chang et al., 2008).

Institutional and Federal Interventions

In response to these challenges, federally funded STEM intervention programs (SIPs) have been developed to improve URM representation. Initiatives such as the NIH's MARC and NSF's HBCU-UP have provided critical support through mentoring, research training, and financial assistance (NIH, 2007; NSF, 2019). These programs have demonstrated effectiveness in improving retention, academic achievement, and interest in STEM careers among URM students (Fakayode et al., 2014; Strayhorn, 2010; Tsui, 2007).

Research Engagement and Professional Development

Research experience is consistently linked to enhanced STEM self-efficacy, science identity, and persistence (Carlone & Johnson, 2007; Lopatto, 2004). However, many URM students at HBCUs may lack structured opportunities for professional development that complements their academic achievements. Programs such as the Project Strengthen and the RAMS Scholar Program at Winston-Salem State University offer models for supporting graduate school preparation and research participation (Barongan et al., 2023).

Despite these efforts, more attention is needed to cocurricular interventions that target the "hidden curriculum"—such as graduate school application skills, time management, and understanding graduate

culture—which are crucial for navigating postbaccalaureate pathways (Hodges, 2018; Keith-Spiegel et al., 1994).

Social Cognitive Career Theory (SCCT) as a Theoretical Framework

SCCT (Lent, Brown, & Hackett, 1994) provides a useful lens for examining URM students' academic and career trajectories. SCCT posits that career development is influenced by self-efficacy, outcome expectations, and contextual support or barriers. The theory underscores the importance of supportive environments, mentoring, and early research exposure in shaping students' confidence and persistence in STEM fields (Hackett et al., 1992; Lent et al., 2003).

Studies show that students with strong self-efficacy are more likely to pursue and persist in STEM fields (Tellhed et al., 2017). At HBCUs, this is further supported by culturally affirming mentorship and institutional climates that emphasize belonging and identity (Gasman et al., 2017; Williams et al., 2021).

HBCUs as Models of STEM Support for URMs

HBCUs are uniquely positioned to support URM students in STEM through collaborative academic environments, same-race mentoring, asset-based teaching, and culturally affirming pedagogies (Jett, 2013; Winkle--Wagner & McCoy, 2018). Unlike the competitive and exclusionary "weed-out" cultures common in STEM at PWIs, HBCUs often transform gatekeeper courses into gateway opportunities (Perna et al., 2009), fostering persistence and resilience.

Programs such as the RAMS and Project Strengthening exemplify the capacity of HBCUs to create effective STEM pathways (Fakayode et al., 2014). These programs integrate research training, graduate school preparation, and cultural affirmation, thus promoting both academic success and career development (Barongan et al., 2023; Gasman & Perna, 2011).

Rationale

As discussed throughout the literature review, there have been numerous efforts to increase the number of URMs in the STEM pipeline. Funded efforts center primarily on providing research exposure and experiences to minority students at PWIs. The evidence demonstrates that structured research programs lead to increased self-efficacy and STEM persistence in URMs. HBCUs have also provided students with funded research opportunities and training programs. However, they have also incorporated additional components, including same-race mentoring, a

supportive science culture, and professional development. Unfortunately, few studies have described these efforts.

The overall goal of this paper is to evaluate a STEM preprofessional workshop series (STEM PPWS), which was developed and implemented for STEM majors attending an HBCU. This paper has two aims. The first is to describe a STEM preprofessional workshop series that, alone or in conjunction with student training programs, increases the number of URMs in the STEM pipeline. The second aim is to evaluate the effectiveness of the STEM PPWS.

The research questions are as follows:

1. Will participation in a STEM PPWS increase STEM efficacy, persistence, and career aspirations in STEM majors attending an HBCU?
2. Will students who participate in a STEM PPWS report increased levels of graduate school readiness skills?

RESEARCH METHOD

A quantitative pretest–posttest design was used to examine the impact of a structured STEM Professional Preparation Workshop Series (PPWS) on undergraduate students' STEM self-efficacy, persistence, career aspirations, and graduate school readiness. The five-session series was delivered over the academic year, with data collected through general and workshop-specific pretests and posttests administered before and after each session, as well as a final posttest. Key constructs were measured on a 5-point Likert scale, and descriptive and inferential analyses were conducted to assess changes over time.

Participants

The participants (N = 71) were undergraduate students attending a historically Black university, representing three cohorts from the Fall 2017, Fall 2018, and Fall 2020 semesters. The majority identified as African American (91.13%), followed by students who identified as other (4.96%), Hispanic (2.48%), or Caucasian (1.42%). With respect to gender, 67.61% identified as female and 32.39% as male.

The participants' academic majors were primarily in STEM fields, with biology (37.73%) being the most common, followed by computer science (19.22%), psychology (11.03%), chemistry (6.05%), engineering (5.69%), physics (3.20%), and mathematics (0.71%). An additional 16.37% of the students were enrolled in other disciplines.

The following hypotheses were proposed:

H_1: Students who participate in STEM PPWSs will report increased levels of STEM efficacy, STEM persistence, and STEM career aspirations.

H_2: Students who participate in STEM PPWSs report increased graduate school readiness.

H_3: Increased self-efficacy is a predictor of STEM persistence, STEM career readiness, and STEM graduate school readiness.

Procedures

The STEM Professional Preparation Workshop Series (PPWS) was implemented during the academic year and consisted of five sequential workshops. Each session was designed to build upon the content and assignments of the previous session. Assignments given in each session (except the final one) were reviewed at the beginning of the following session.

Recruitment was conducted through collaborations with university faculty, staff, and stakeholders. Outreach included email and in-person flyers, with incentives such as sponsored dinners or course credit provided to encourage participation. The initial workshop, titled "How to Become a Competitive Applicant," served as a foundational session.

Data collection instruments and measurements

The following constructs were measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree):

1. STEM self-efficacy (e.g., "I am confident that I can understand procedures relevant to research and/or engineering.")
2. STEM Career Aspirations (e.g., "I desire to pursue graduate education in STEM.")
3. STEM Persistence (e.g., "My desire to become a researcher/engineer is strong enough to help me overcome barriers.")

Data analysis

Descriptive and inferential statistics were used to analyze changes in participants' pretest and posttest responses. The primary focus was on evaluating differences in STEM self-efficacy, persistence, career aspirations, and specific knowledge gains across workshop content areas.

RESULTS

A series of dependent samples t-tests were conducted to evaluate the effectiveness of a suite of career readiness workshops on participants' skills and psychosocial outcomes. Across all the domains, the posttest scores were significantly higher than the pretest scores, indicating positive impacts of the workshop series.

Table 1: Pre- and Post-Test Mean Scores, t-values, and Effect Sizes for Workshop Effectiveness and Psychosocial Outcomes

Outcome Area	Pre-Test M	Post-Test M	t(df)	p	r
Workshop Effectiveness					
Interviewing & Elevator Pitch	12.02	18.00	-10.00 (42)	< .001	.13
Marketing	13.83	18.09	-8.02 (42)	< .001	.19
Internship	15.09	17.46	-6.38 (64)	< .001	.37
Personal Statement	11.82	16.13	-8.85 (51)	< .001	.46
Psychosocial Outcomes					
Career Aspirations	38.71	41.90	-4.70 (70)	< .001	.13
Self-Esteem	30.42	32.76	-4.59 (70)	< .001	.19
Persistence	11.57	12.50	-3.88 (70)	= .002	.37

Note. *M* = mean. All comparisons reflect statistically significant improvements from pre-test to post-test. Effect size *r* interpretations: .10 = small, .30 = medium, .50 = large (Cohen, 1988).

Workshop Effectiveness

Significant improvements were observed in all four workshop areas. The scores of the participants in the Interviewing and Elevator Pitch Workshop significantly increased from pretest (M = 12.02) to posttest (M = 18.00), $t(42) = -10.00$, $p < .001$, $r = .13$. Similarly, the marketing

workshop showed significant gains, with mean scores increasing from 13.83 to 18.09, $t(42) = -8.02$, $p < .001$, $r = .19$. The internship workshop yielded a significant improvement in scores from pretest (M = 15.09) to posttest (M = 17.46), $t(64) = -6.38$, $p < .001$, $r = .37$. Finally, the scores of the participants in the Personal Statement Workshop significantly increased, from 11.82 to 16.13, $t(51) = -8.85$, $p < .001$, $r = .46$.

These results suggest that the workshops were practical in enhancing students' applied skills related to career development, with the most potent effects observed in the Personal Statement and Interviewing workshops.

Psychosocial Outcomes

Improvements in participants' psychosocial metrics were also evident. The scores for Career Aspirations increased significantly from the pretest (M = 38.71) to the posttest (M = 41.90), $t(70) = -4.70$, $p < .001$, $r = .13$. The self-esteem scores rose from 30.42 to 32.76, $t(70) = -4.59$, $p < .001$, $r = .19$. Notably, persistence demonstrated a moderate effect size, increasing from 11.57 to 12.50, $t(70) = -3.88$, $p = .002$, $r = .37$.

Collectively, these findings indicate that the workshops were effective not only in improving participants' practical skills but also in fostering positive psychosocial development. These gains suggest enhanced readiness for graduate school, career-related tasks, and greater confidence in pursuing professional opportunities such as internships and graduate school.

DISCUSSION AND CONCLUSIONS

The implementation of the STEM PPWS builds upon the long-standing mission of HBCUs to produce competitive, career-ready STEM graduates who are prepared for both graduate and professional degrees (Jefferson et al., 2024). The effectiveness of the PPWS reinforces the impact of prior HBCU-led initiatives aimed at improving STEM outcomes, such as supplemental instruction (Brown & Winbourne, 2025) and co-curricular programming focused on graduate school and career development (Barongan et al., 2023). While many current programs at HBCUs have emphasized undergraduate research experiences and mentoring to build technical competency and academic persistence (Fakayode et al., 2014; Owens et al., 2012), less attention has been paid to systematic professional development efforts that explicitly prepare students for post-baccalaureate transitions. The PPWS addresses this gap by combining content-focused

workshops with psychosocial support mechanisms, resulting in a comprehensive developmental approach.

Research experiences and mentoring provide a strong foundation for scientific identity formation and persistence in STEM; however, these interventions are most effective when integrated with opportunities to build professional skills and clarify career pathways (Mangar et al., 2025; Zuniga-Teran et al., 2025). The workshops examined in this study targeted second-order admission criteria, such as writing personal statements, articulating experiences through interviews and elevator pitches, and marketing oneself through resumes and networking. These competencies are often underemphasized in undergraduate STEM education, yet are pivotal to graduate admissions and job placement success (Briihl, 2001). Despite widespread student awareness of GPA and GRE requirements, fewer students understand the weight that admissions committees assign to qualitative application components such as letters of recommendation, personal narratives, and relevant experiential learning (Keith-Spiegel et al., 1994).

The current evaluation demonstrated that the PPWS significantly enhanced students' practical competencies and psychosocial attributes related to career development. The most substantial skill-based gains were seen in the Personal Statement and Interviewing workshops, which may be attributed to the reflective and iterative nature of these tasks. These activities require structured feedback and individual attention—elements that were embedded in the design of the workshops. Improvements in marketing and internship readiness further affirm that even traditionally overlooked areas can yield measurable progress when targeted intentionally.

Beyond technical skills, the workshops also had a positive influence on students' psychosocial development. Statistically significant improvements were found in self-esteem, persistence, and career aspirations—all critical constructs that contribute to academic motivation, resilience, and long-term goal attainment. The moderate effect size observed for persistence is especially notable, as it reflects a meaningful shift in students' ability to remain committed to long-term career objectives despite potential barriers. These results align with existing literature that underscores the interdependence between cognitive development and psychosocial well-being in supporting underrepresented students in STEM fields (Barongan et al., 2023; Elkhider et al., 2025; Gasman & Perna, 2011).

Importantly, the results also reinforce the role of culturally responsive, student-centered programming at HBCUs. HBCUs are responsible for graduating more than 25% of Black students who eventually earn doctoral

degrees in STEM (Fiegener & Proudfoot, 2013; Gasman & Nguyen, 2014). The PPWS contributes to this legacy by preparing students not only to enter advanced programs but also to thrive in them. The deliberate inclusion of professional and career readiness as part of the academic experience ensures that students are equipped to navigate the complex landscape of graduate admissions and workforce entry with confidence and clarity.

Looking ahead, the PPWS model offers a promising framework for replication and scaling. Future initiatives should consider embedding this model into federal grant-funded programs, including student research training and workforce development efforts. By aligning professional development with existing research and mentoring infrastructure, institutions can provide students with a comprehensive ecosystem of support that addresses both preparation and access to opportunity.

Limitations and Future Directions

While the results are promising, several limitations must be acknowledged. The reliance on self-report measures introduces the possibility of response bias, as participants may overestimate improvements or respond in socially desirable ways. The absence of a control group limits the ability to attribute observed gains solely to the intervention, as external factors (e.g., academic progression, peer influence) may have contributed. Additionally, the study did not assess the long-term retention of skills or psychosocial improvements. Longitudinal follow-ups would provide critical insight into whether these gains persist and translate into tangible outcomes, such as graduate school admissions, internship placements, or employment in STEM fields.

Future research should examine the differential impact of the PPWS across student subgroups, including by gender, academic discipline, and transfer status, to better tailor interventions. Mixed-methods evaluations, incorporating both quantitative outcomes and qualitative narratives, would provide a richer understanding of students' experiences and the specific workshop components they find most transformative. Further, exploring institutional implementation barriers and faculty engagement strategies would aid in the program's sustainability and scalability

IMPLICATIONS

In sum, the STEM Pre-Professional Workshop Series demonstrates a compelling model for improving both the practical skills and psychosocial readiness of underrepresented students in STEM. The workshops

contributed to significant gains across key indicators of career preparation, including self-confidence, persistence, and aspiration. These findings underscore the importance of intentional, targeted programming in ensuring equitable access to graduate and professional opportunities. As HBCUs and similar institutions continue to advance their role in diversifying the STEM pipeline, initiatives like the PPWS serve as a critical mechanism for empowering students to succeed beyond the classroom.

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