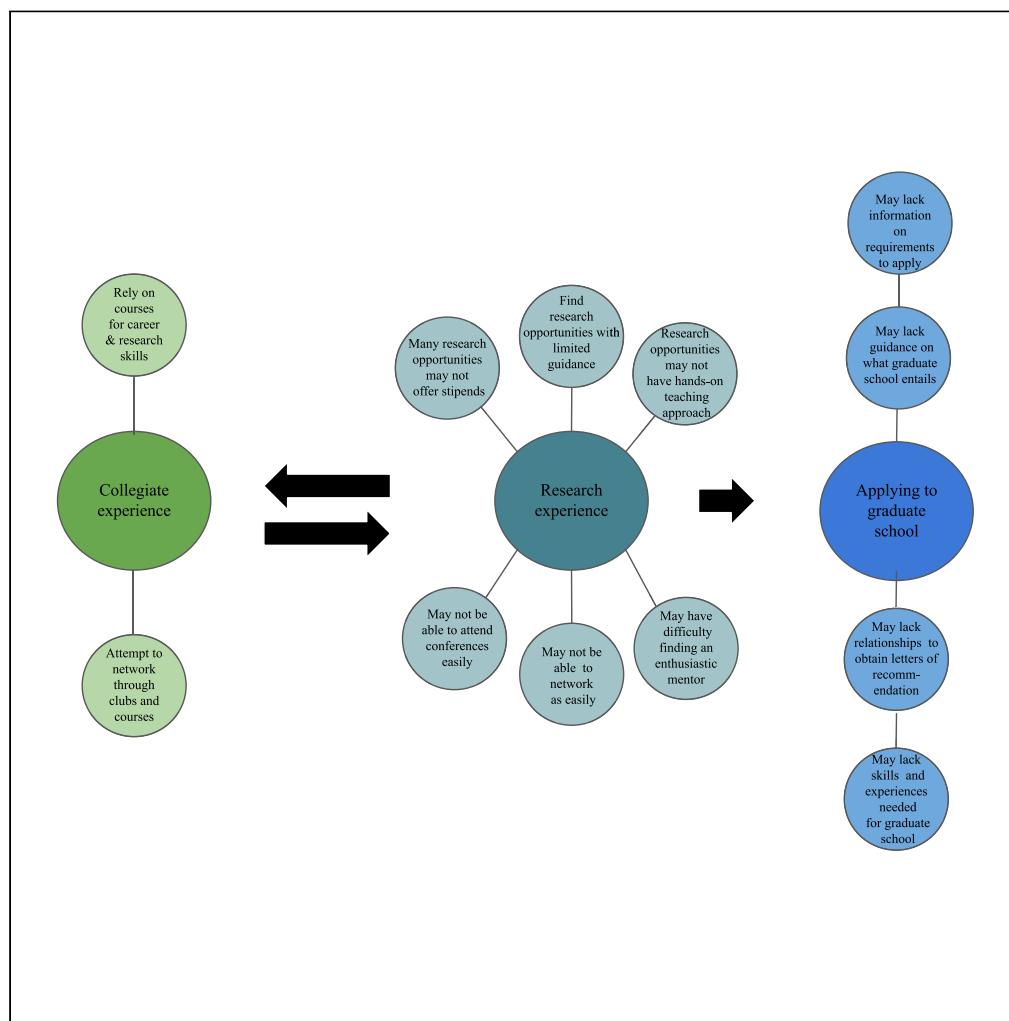**Article**

Project Strengthen: An STEMM-focused career development workshop to prepare underrepresented minority students for graduate school

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Highlights

Project Strengthen improves minority graduate school preparedness at a low cost

Project Strengthen is similar to the Maximizing Access to Research Careers program

Need for other low-cost programs to increase minority student retention

All workshops included in *Project Strengthen* are available for future use here

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Article

Project Strengthen: An STEMM-focused career development workshop to prepare underrepresented minority students for graduate school

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SUMMARY

Maximizing Access to Research Careers (MARC) programs are aimed to increase diversity in science, technology, engineering, math, and medicine (STEMM) fields. However, limited programs and eligibility requirements limit the students who may apply to similar programs. At Winston-Salem State University, we piloted a series of workshops, collectively termed *Project Strengthen,* to emulate some of the key aspects of MARC programs. Following the workshop, *Project Strengthen* students showed a significant increase in their understanding of essential educational development skills, such as writing personal statements, applying to graduate school, studying for the GRE, and seeking summer internships. This suggests *Project Strengthen* may be a potential lower cost comparable option than MARC to make up for current deficiencies in preparedness for graduate school. We also provide educational materials from *Project Strengthen,* including a clear framework for this seminar series, six ready-made PowerPoints to share with trainees that have been demonstrated to be effective.

INTRODUCTION

Diversity in science, technology, engineering, math, and medicine (STEMM) has an enormous positive impact on the quality of research conducted across the sciences.[1-3] Although research is heavily impacted by the lack of diversity, this lack of diversity also barriers and challenges to education for specific groups like underrepresented minorities (URMs). For example, many URM students are deterred from applying to graduate/professional programs in STEMM as they frequently face additional challenges, such as economic hardships, imposter syndrome, microaggressions,[4] and a lack of access to supportive academic mentors.[5,6] Furthermore, URM students have historically represented a lower enrollment percentage than their white counterparts in STEMM graduate programs.[7] It is projected that the STEMM job market is expected to rise significantly, at almost twice the rate of overall job growth in the United States by 2026.[8] Therefore, ignoring the aforementioned challenges affecting URM students can lead to widening racial disparity gaps within STEMM. This gap will continue to widen unless genuine,

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intentional, and measurable efforts are put forward to diversify the STEMM landscape and promote equitable opportunities for URM students in meaningful numbers.

To help address this disparity, the National Institutes of Health (NIH) has created opportunities, such as the Maximizing Access to Research Careers (MARC) program, that aims to support URMs while completing a bachelor's degree and help them transition into the STEMM pipeline. Typically, MARC students often have stronger academic success rates in STEMM (Beech et al. 2013; Carter 2006, Hall 2017). In contrast, URM undergraduates who do not meet the MARC criteria, or whose institution does not have a MARC program, are not afforded the same opportunity thereby resulting in a lower probability of success and creating higher attrition in the STEMM pipeline. While these non-MARC undergraduates can apply to similar MARC-like programs, like the MARC Undergraduate Research Training Initiative for Student Enhancement (U-RISE), previously known as the MARC U-STAR Fellows program, even these programs may be limited.

Our study sought to discover the difference in graduate school preparedness and success outcomes between MARC and non-MARC students. We believe that one factor involved in the MARC program that catapults their success is the mandatory requirement to engage in weekly career development opportunities. Based on past studies that have shown the important role of consistent meetings in student retention, we used a workshop framework that could be prioritized for a lower-cost, more widely available version of MARC programs.[9–11] Similar to Ghazzawi et al., we considered past successes of workshop-based models, but used the Advisement-Retention Model to create a program that is focused on student-workshop coordinator interaction.[12,13] Thus, we created a workshop series for STEMM participants at Winston-Salem State University (WSSU) in North Carolina, named *Project Strengthen*. While our workshop at WSSU was designed for all STEMM undergraduate students, especially those who are not familiar with the MARC program, all students were presented with graduate school preparation information. Some of the participants in *Project Strengthen* were also part of the MARC program. We hypothesized that these workshops would increase the confidence levels for graduate school preparedness for non-MARC students to similar levels of MARC students.

Literature review

According to the NIH, the MARC program aims to develop groups of underrepresented minority undergraduates (URMs) to complete a bachelor's degree and help them transition into the STEMM pipeline.[25] MARC program participants must meet certain criteria before they are accepted, including a minimum 3.0 grade point average (GPA), an STEMM major, and be a junior or senior at a four-year institution. The results of previous studies indicate that MARC programs aid URMs in having greater educational outcomes,[14] as well as assisting with the economic hardships that URMs may encounter. Other forms of assistance include creating welcoming spaces to reduce adversity, such as imposter syndrome and microaggressions.

Institutions that host MARC programs develop and implement approaches to STEMM training and provide mentoring opportunities to prevent URM students from dropping out of the STEMM pipeline.[15] MARC programs are one of the most well-known program that exist to improve underrepresented minority retention, as previously reviewed.[16] MARC programs and other similar programs (Table 1) fulfill an important role as there are significant disparities in the recruitment and retention of undergraduate URMs, including women and racial/ethnic minorities, which are national challenges that need to be addressed.[5,23,24] Diversity in STEMM has an enormous impact on the quality of research being conducted and has been shown to increase rates of scientific success and problem-solving capacity through diverse thought, new exchanges of ideas, and a range of backgrounds.[1–3]

Established by the National Institute of General Medical Sciences (NIGMS) and the NIH, the MARC program is defined by the NIH as an undergraduate program that seeks "to develop a diverse pool of undergraduates who complete their baccalaureate degree, and transition into and complete biomedical, research-focused higher degree programs (e.g., Ph.D. or M.D./Ph.D.)".[25] There are various MARC programs hosted at colleges and universities throughout the country, 54 as of 2022.[25] To be eligible to host a MARC program, institutions must be accredited baccalaureate degree-granting, research-intensive institutions that have NIH research project grant funding with a minimum of $7.5 million total costs over a span of three consecutive fiscal years. MARC programs specifically target URM students and aid them by offering various support systems to MARC participants, including faculty mentorship, financial stipends, tuition assistance, travel funds to attend scientific and professional meetings, and academic support to equip them for the rigor and challenges of graduate and post-graduate work.[25] This is particularly helpful as URM students commonly face issues with finding STEMM opportunities, resources, and funding. Funded by the NIH NIGMS T34 grant (T34 program MARC-USTAR), undergraduate URM students are accepted into a MARC program during their junior year of study and remain in the program until they graduate. The MARC program offers career development, mentor opportunities, and cohort-building activities.[25]

Many URM students are deterred from applying to graduate/professional programs in STEMM as they face additional challenges such as: economic hardships,[26] imposter syndrome,[4] microaggressions,[4] lack of access to supportive academic mentors,[5,6] and role models, amongst others. Currently, the job market in STEMM fields is expected to rise significantly, at almost twice the rate of overall job growth in the United States by 2026.[8] Therefore, ignoring these disparities among URM students can lead to the amplification of racial disparity gaps unless genuine, intentional, and measurable efforts are put forward to diversify the STEMM landscape and promote equitable opportunity for URM students in meaningful numbers.

Past studies show that MARC programs aid URMs in having greater educational outcomes,[14] potentially through aiding URMs in overcoming issues, such as economic hardships, imposter syndrome, and microaggressions. However, while the MARC program is a great resource for undergraduate STEMM students, it is not available to every student, especially URMs. There are currently 54 institutions nationwide that support MARC programs through T34 funding,[25] just a small subsection of about 4,360 institutions across the United States.[27] Critically, while MARC students often go on to have stronger outcomes,[14,28] overall URMs outcomes still remain much lower than their

Table 1. Common research programs similar to MARC

Program	Description	Reference
Amgen Scholars Program	Amgen Scholars Program: Funded by the Amgen Foundation, highly competitive majority-White summer program at prestigious institutions which prioritizes networking opportunities and full-time lab experience.	Brown et al.[17]
IMSD	Initiative for Maximizing Student Development: NIH/NIGMS-funded program to fund underrepresented PhD students and offer financial support, an individualized development plan, mentored research experiences, and professional development to promote persistence in biomedical research careers.	Jones et al.[18]
LSAMP	Louis Stokes Alliance for Minority Participation: NSF-funded multi-institutional program centered on collaborative learning communities which begins in high school, and provides Financial Support and Assistantships to undergraduates, as well as specialized advising with high retention for undergraduate studies.	Ghazzawi et al.[12]
MURF	American Society for Microbiology Undergraduate Research Fellowship: Example of one of several fellowships offered by professional societies which are open to all undergraduates who a member of the society and typically offer field-specific funding to work in a laboratory as well as travel funds to attend annual conferences.	Chang[19]
REU	Research Experience for Undergraduates: NSF-funded summer programs at a variety of institutions with varied formats, but generally focused on research across 8-week periods. Effective in improving student's understanding of research and improved student's interest in science.	Sheng et al.[20]
RISE	Research Initiative for Scientific Enhancement: NIH/National Institute of General Medical Sciences with annual costs of around $30 million USD per year. Mixture of direct mentoring, laboratory research experiences, and professional development training for undergraduates across the year.	Taylor et al.[21]
UROP	Undergraduate Research Opportunity Program: Program ran by select institutions including University of Michigan and MIT, offering credit or pay for students to work in laboratory with principal investigators in a broad program that is specifically targeted at racial minorities typically.	Locks and Gregerman[22]

overrepresented counterparts.[29] We also noted that oftentimes MARC programs do not prioritize the training of mentors in the program, so we sought to provide more robust training in accordance with Guskey's framework of teacher change.[30] Given ongoing financial concerns, *Project Strengthen* applies several aspects of the MARC program with a smaller scope, and thus cheaper cost (Table 2).

Framework

All Project Strengthen participants attended 12 in-person or online, 90-min workshops, occurring over the course of 10 weeks.[6,31–33] The information the participants received during the workshops is considered a part of the fundamental training that MARC trainees receive. Before and after the workshops, participants were asked to fill out a questionnaire to assess their confidence levels in graduate school information, as well as their expectations of the effect the workshops would have on their current skill levels. After four workshops, participants had up to one week to respond to the post-survey. Both the pre-questionnaire and post-questionnaire were comprised of 15 questions, which measured responses using a 10-point Likert scale: 1 = (know very little); 10 = (Know a lot about this). Data were analyzed using unpaired t-tests.

Workshops and related activities were all trained prior to joining the team. Training for these teachers used Guskey's framework of teacher change, which relates alterations in teacher attitudes and perceptions through courses.[30] In accordance with this prior discussed model,[30] workshop facilitators had a training history and went through follow-up testing with WSSU instructors. Facilitators were prepared on the differences in WSSU student body population beforehand, and how to work with diverse individuals.[34] This included discussions around intentional mentoring and holistic mentoring to ensure that workshop coordinators understood the unique challenges faced by underrepresented students and strategies to individualize help to ensure they are able to respond in a proactive way.[5]

The first workshop, titled "The Champion's Mindset", focused on informing participants on strategies to implement a champion-oriented mindset to better instill confidence and willingness for growth.[33] A champion-oriented mindset is defined as viewing intelligence as a flexible skillset, resulting in better performance and achievement outcomes than those with a fixed mindset.[35] This workshop offered a general sense of preparing for the next steps professional school, graduate school, and networking opportunities.

The second workshop, titled "The importance of mentors and how to handle more than one", informed participants on the importance of seeking research internship opportunities and multiple mentors prior to applying to graduate school.[32] Early exposure to research internships can be crucial for URMs as they provide students with the chance to build their network, find and connect with mentors, gain research experience, and can receive financial support.[2,36,37] As a part of the workshop, participants were encouraged to find potential opportunities (e.g., research internships) outside of their institutions.

Table 2. MARC and *Project Strengthen* similarities and differences

Similarities	Differences
Aim to support underrepresented minority (URM) students in science, technology, engineering, math, and medicine (STEMM) fields.	MARC is limited to a select number of undergraduate institutions that meet specific criteria and receive funding from the National Institutes of Health (NIH); *Project Strengthen* can be hosted by various facilitators at an institution, both domestic and international.
Prioritize preparing students for advanced studies in graduate or professional school through skills in research and professional development.	MARC programs have specific eligibility criteria, including a minimum GPA (3.0) and class standing requirements, while having limited slot numbers, while *Project Strengthen* workshops were open to all interested STEMM undergraduate students at WSSU.
Involves workshops for students to provide career development opportunities and essential skills training.	MARC workshops and programming span multiple years, providing ongoing support and resources to participants, while *Project Strengthen* workshops were conducted over a 10-week period, offering a more condensed and expedited training experience.
Highlights the importance of mentorship and encourages students to utilize mentors to can guide and support their academic and career endeavors.	MARC involves research component and typically a matched mentor, while *Project Strengthen* can aid in networking but does not provide funding to work in a laboratory. However, *Project Strengthen* offers more trainings specifically for mentors than are required by MARC programs, which may have inter-institutional variability.
Focuses on practicing hands-on skills necessary for graduate school including writing personal statements, choosing recommenders, networking, and seeking internships.	MARC programs are more comprehensive, also providing, resources and support systems, such as financial stipends, tuition assistance, travel funds, and academic support.

The third workshop highlighted the importance of supportive mentors and establishing a reciprocal relationship and how mentors are able to help participants learn and grow as future STEMM professionals.[32] It is important to underscore that the mentorship style of each mentor was intentional and holistic, which complemented the participants' background and career aspirations.[5,6,38]

The fourth workshop guided participants on how to distinguish themselves when applying to graduate school by finding effective mentors[31] and resources on applying to graduate school, creating a professional curriculum vitae and resume, asking the right people for letters of recommendation, incorporating mentors to write an engaging personal statement, and identifying the extracurricular or volunteer activities that will help them stand out to admission officers. The fourth workshop required students to complete multiple personality tests (including Big Five Personality Test, Myers-Briggs Type Indicator, Five Love Languages) to help them contextualize their needs for themselves and from mentors before the upcoming semester and how to prepare for any future challenges.

The fifth workshop (Data S1) worked on the "Power of Saying No", which focused on the importance of knowing one's own limits when taking on additional work.[39] Importantly, the power of saying "no" can increase mental health among undergraduates.[40] This workshop focused on the importance of building this skill, as well as discussing scenarios that are useful to say no, especially when it comes to unreasonable expectations by mentors.

The sixth workshop (Data S2) "Building Diverse Mentoring Networks through Holistic Mentoring" focused on using conferences, social media, and scholarship to build primary and secondary mentoring networks.[41] This workshop offered resources to increase allyship and create multifaceted mentoring support networks through seminars and other available opportunities.

The seventh workshop (Data S3) focused on "Time Management and the Nuances of Professionalism," as well as maximizing one's time and effort.[42] Through a variety of techniques, including individual development plans and using productivity apps and artificial intelligence, one can focus on more important tasks and effectively use their time. Given that time management skills are weaker among younger students,[43] this workshop prioritized practical and clear skills for students. It also discussed strategies to improve professionalism and combat aggressive spaces for underrepresented individuals, such as through professional pettiness.

The eighth workshop (Data S4) focused on "Avoiding Microaggressions and Responding to Them to Avoid Burnout." Microaggressions are commonly faced by minority students and can include small or subtle cues that are intended to dissuade minority students.[4] This workshop focused on identifying micro- and macroaggressions, as well as techniques to stand up to them, both against oneself and through allyship. This workshop also discusses toxic stress, burnout, and John Henryism.[44] Critically, John Henryism, which is a form of hypertension associated with toxic stress, burnout, and overwork, commonly found among African Americans.[45] Beyond elucidation of these topics, this workshop also delivered strategies on how to cope with burnout.

The ninth workshop (Data S5) was entitled "Finding an Identity Through Writing Accountability Groups and Team Building." While multi-focused, in general, this workshop gave a brief explanation of what writing accountability groups are, as well as the numerous positive benefits they offer for early career faculty and students, especially URMs.[46,47] These tools were highlighted by journal clubs to discuss papers during this workshop, which can serve as an avenue for students to foster teamwork. It also discusses team working in a broader sense, including finding a niche or passion.
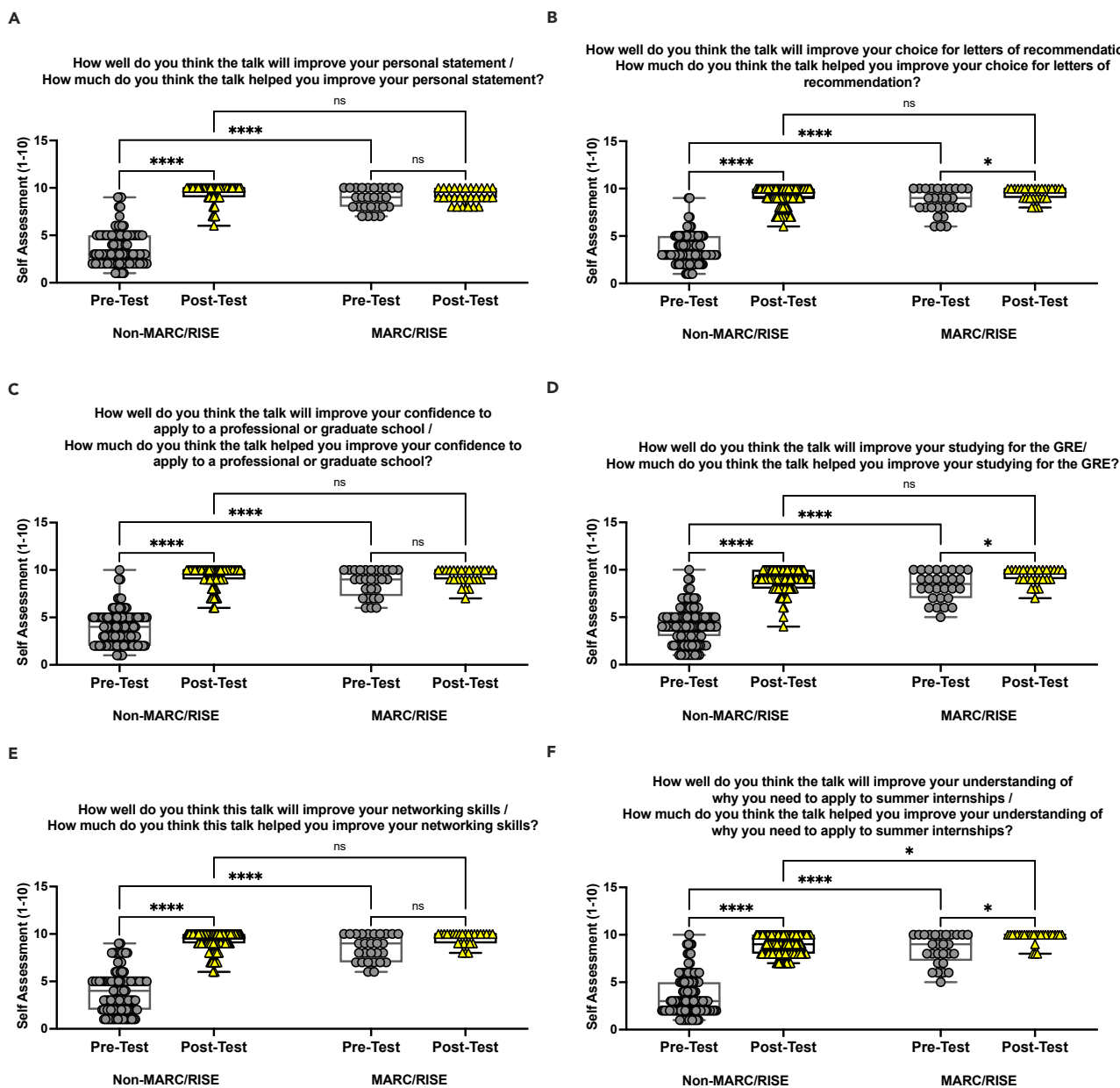
Figure 1. *Project Strengthen* helps non-MARC students prepare for graduate school

Non-MARC participants saw significant score increases in improving their understanding of personal statements (A), selecting recommendation writers (B), applying for professional/graduate school (C), studying for the GRE (D), networking skills (E), and applying to summer research internships (F), as compared with MARC participants. MARC participants also saw an increased score in selecting recommendation writers, studying for the GRE, and applying for summer internships. Ns represents no significance, * represents $p < 0.05$, and **** represents $p < 0.0001$.

The tenth and final workshop (Data S6) focused on "Cultural Competency and Cultural Humility Requires Strong Leadership".[48,49] In this workshop, general concepts and styles of leadership were discussed. Beyond this, the concept of cultural competency and humility, recognizing the need for understanding other cultures, especially in a laboratory setting, were further explained.[50]

The first phase of *Project Strengthen* involved attending seminars on career development, which laid the foundation for the subsequent activities. To further reinforce learning, additional activities were incorporated into the program to offer more holistic training that focused on teamwork.

The goals were to give back, to stay teachable, and stay humble always. – Dr. Morris Clarke, Professor and Assistant Chair WSSU.
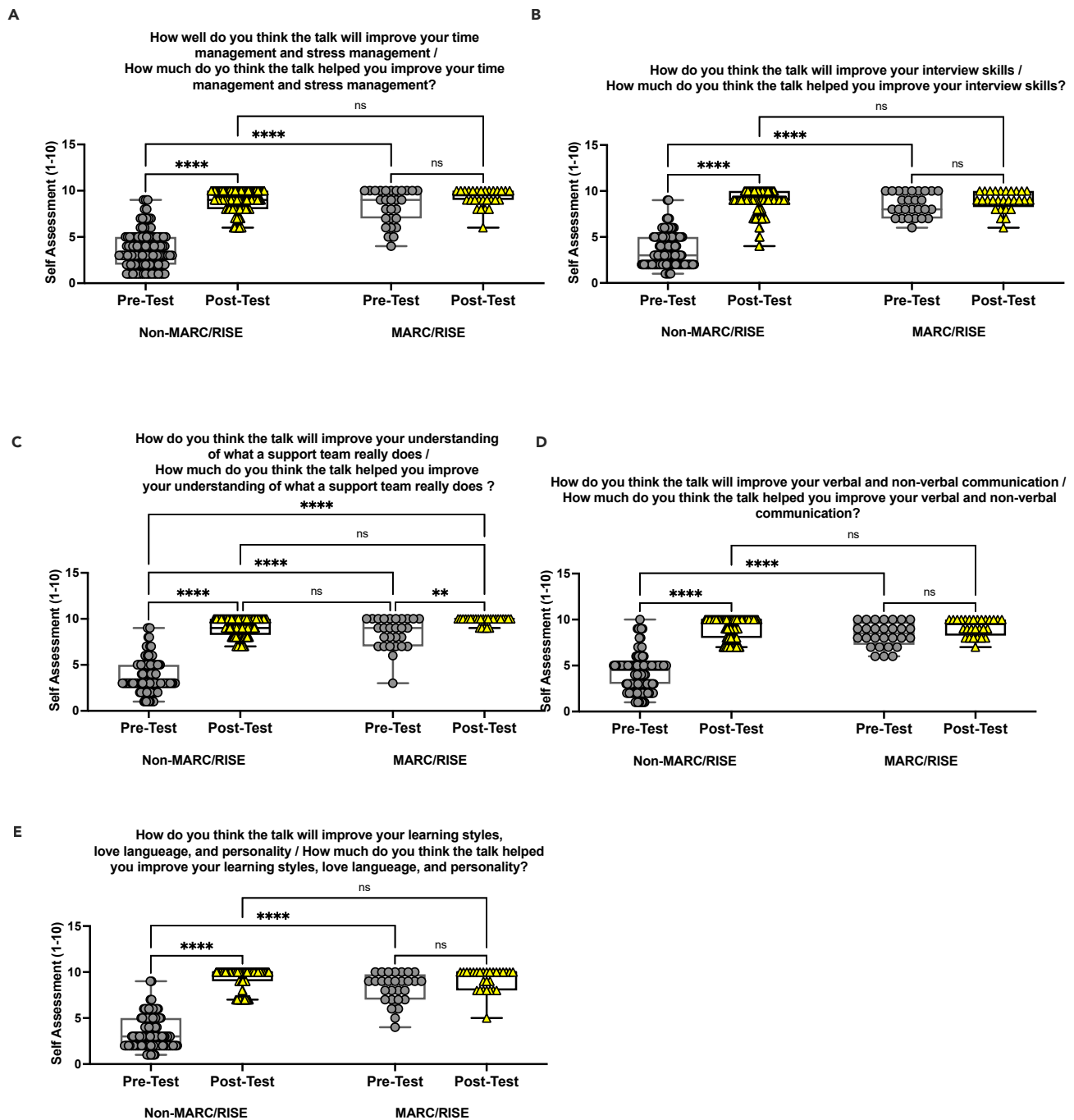
Figure 2. *Project Strengthen* helps non-MARC students gain skills necessary for graduate school
Non-MARC participants saw significant score increases in their understanding of time and stress management (A), interviewing skills (B), role of a support team (C), verbal and non-verbal communication (D), and learning styles, love language, and personality (E), as compared with MARC participants. MARC participants also saw an increased score in their understanding of the role of a support team. Ns represents no significance, ** represents $p < 0.01$, and **** represents $p < 0.0001$.

This included weekly practical pieces of training and covered various aspects of individual development plans (IDPs) (Data S7),[51] providing insights on how to effectively manage goals and deadlines. Beyond this, discussions were held on improving letters of recommendation and how to ask teachers for good letters of recommendation, per previously written sources.[52,53] To further enhance practical skills, practice interviews and networking sessions were also conducted, which aimed to simulate real world scenarios. Furthermore, students were encouraged to network within their groups through weekend outings that focused on fine dining, how to use silverware, tennis, and golf to help

Figure 3. Improvement in graduate school preparedness following *Project Strengthen*

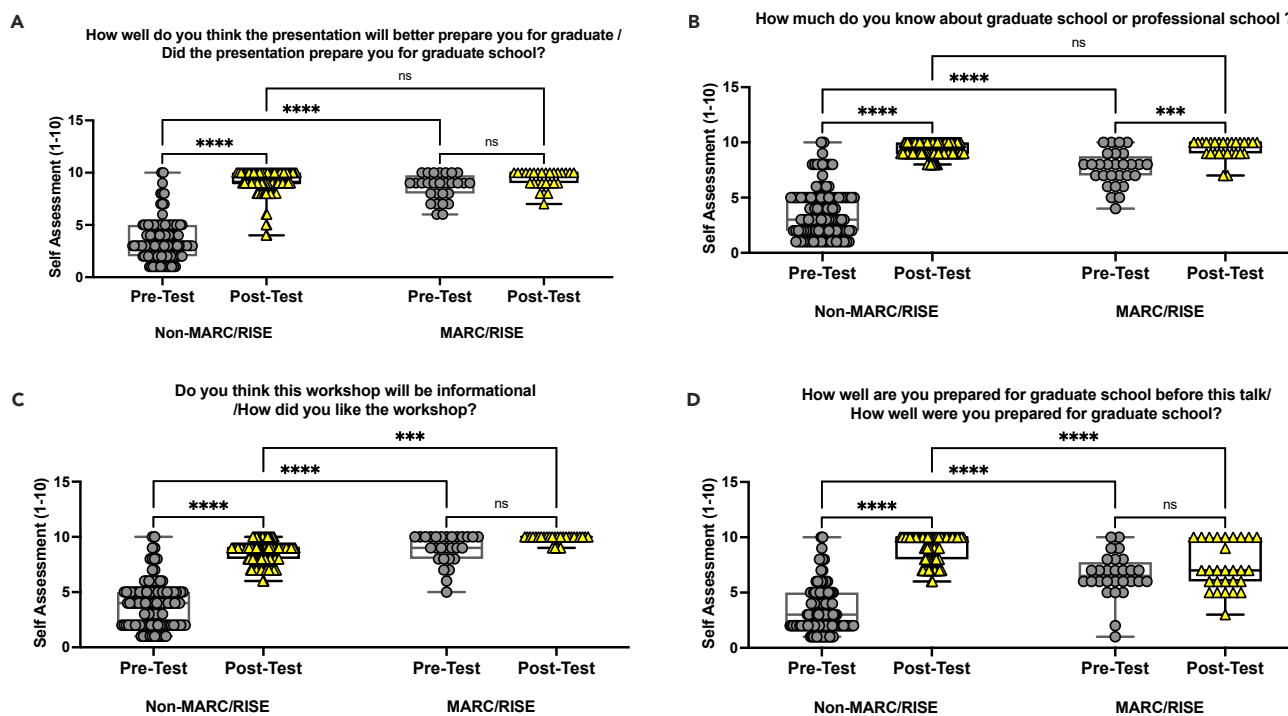Non-MARC participants saw significant score increases in improving their preparation for (A) and learning about graduate school (B). In general, while MARC students have high pre-workshop expectations, these expectations were much lower for Non-MARC participants. Non-MARC participants also saw an increase in percived importance of the information presented (C) and how it can help them prepare for graduate school (D) following the workshop. Ns represents no significance, *** represents p < 0.001, and **** represents p < 0.0001.

network in business arenas. To further facilitate connections, the program organizer also selected participants to accompany research speakers on outings. This allowed participants to engage in discussions about research and explore avenues for career growth. By connecting with experienced professionals in their respective fields, individuals could gain valuable insights and more easily meet with potential laboratory mentors.

In addition to the educational components, the program emphasized community engagement and volunteerism. *Project Strengthen* participants adopted a street for regular clean-up activities, volunteered at soup kitchens, and dedicated time to teaching high school students science. This was part of the goal of finding a passion for students and staying humble through ways to give back to the community. Together, with these seminars and supplemental sessions to community engagement and networking initiatives, we aimed for participants to have the necessary skills and experiences to both achieve personal growth, as well as advance their careers.

The first 4 workshops have previously been published and are available from Pathogens and Disease in Marshall et al., 2022 (See ref. [7,25–27]). The rest of the workshops are based on existing literature as referenced appropriately in the framework section and available as supplemental files (Data S1, S2, S3, S4, S5, and S6). All PowerPoint presentations are made utilizing Canva or PowerPoint with publicly available photos that the authors claim no ownership over.

RESULTS

Assessment of the pre-workshop questionnaire items (Figure 1) for MARC participants (n = 30) revealed that MARC students approached the workshops with confidence in their abilities. In comparison, the pre-workshop questionnaire responses from non-MARC participants suggested an overall uncertainty about their own abilities to prepare for advanced studies in STEMM. Non-MARC students felt unprepared to write a personal statement, but they felt much more prepared following the workshops (Figure 1A). In contrast, MARC students reported high confidence in writing personal statements prior to the series of workshops; therefore, there was no increase in confidence following workshops, causing post-test values for both groups to be similar (Figure 1A). This was a similar trend seen in non-MARC students from pre- and post-workshops, where non-MARC students felt like they better understood choosing recommenders for letters of recommendation, applying to graduate school, studying for the GRE, networking, and the importance of seeking summer internships (Figures 1B–1F). While MARC students reported non-significance for many skills taught in the workshop series (Figures 1A, 1C, and 1E), some information taught in the series of workshops was deemed helpful (Figures 1B, 1D, and 1F).

Table 3. Feedback from students who participated in the MARC program

Positive Feedback Regarding Speakers	Enjoyable/Fun/Motivational	Learned/Resource
The seminar speakers were great.	The program was a lot of fun.	PS was very hard to focus sometimes because I would not know everything about the speaker's talks. However, it helped me learn what I didn't know.
The presentations were relevant and focused. I found myself in the speakers. It is so nice to see Black and brown speakers. It makes me believe. The work is worth it.	I enjoyed it. I would do it again.	I learned how to network.
I hate having to think outside the box because I am not good at it. However, [the workshop coordinator] really pushed us to give it our all even when we had bad attitudes. She is so resilient.	I enjoyed my experience but I do wish there was more mentorship of all the students in the program. I think some faculty really committed their time and others were not as invested as they could have been. I am proud of the mentors that helped run the program.	I found my people in these seminars and outside activities.
The seminar series speakers were [dynamic] and full of knowledge.	The seminars were really interesting and valuable for me.	I learned how to dress and I learned how to make sure I was somebody.
Most of the seminar speakers had action plans of attack.	The perspectives from the seminars was fire.	The PS program was very resourceful and knowledgeable.
The speakers provided so many opportunities around career development.	Very honest and moving [seminars].	The seminars were a great resource.
I really enjoyed learning from the speakers.	The seminar series was very important to my motivation.	I hope WSSU keeps this program in the future. It provided me with all of my career development opportunities. Not everyone is a MARC or RISE scholar. We need more programs like this for the 2.5 [GPA] girl or 2.5 guy.
The presenters were always willing to help us understand the content and never gave up on us.		

For other skills that are considered helpful for graduate school, including time management, interview, building a support team, non-verbal and verbal communication, and learning styles, this trend continued as non-MARC students significantly improved their understanding of these following the workshop series (Figures 2A–2E). In comparison, for MARC students, there was already a high level of understanding of these topics, except for understanding of support teams, which showed a significant increase for MARC students following the workshop series (Figure 2C).

Non-MARC students also felt the presentations helped them become more prepared and knowledgeable about graduate schools following the workshops, reaching a high level comparable to MARC students (Figures 3A and 3B). Even for already knowledgeable MARC students, this workshop series increased their knowledge about graduate school (Figure 3B). Prior to the start of the workshop, non-MARC students had lower expectations for this workshop (Figure 3C), yet they were satisfied with the content of the workshop. Beyond this, non-MARC students felt more prepared for graduate school following these workshops, even in comparison to their MARC counterparts (Figure 3D). For all of these skills, while non-MARC students lacked expertise in the topics prior to the workshops, after participating in the workshop they were able to improve their understanding to a comparable level to MARC students, who were more knowledgeable at the beginning of the workshop.

Overall, as seen in Figures 1, 2, and 3, non-MARC participants felt they did not have the confidence or knowledge based on their current skill levels prior to the workshops, but their confidence or knowledge increased after the workshops. As for MARC participants, they came to the workshop already possessing a level of confidence or knowledge, and after the workshop either had the same or a higher level of confidence and/or knowledge.

We also gave *Project Strengthen* (non-MARC) students the option to provide feedback on the program (Table 3). As seen in the tabulated and summarized responses (Figure 4; Table 3), the feedback was positive, focusing on the speakers and liking that they had a shared identity, the enjoyability of the seminars, and the program as a resource to both learn new skills and network. Some students remarked the program was challenging, but worth it in the end. One of the only drawbacks to the program mentioned by the students was one student mentioning they wished "there was more mentorship of all the students in the program. I think some faculty really committed their time and others were

Figure 4. Most frequently used words in students' responses to *Project Strengthen*

not as invested as they could have been." This suggests that future renditions of the program can better ensure that all faculty partaking in it have the time to offer intentional mentoring.

MARC programs have tremendous inter-institutional variability and full outcomes from WSSU are not reported, but generally national studies show that around 30% of MARC students go on to earn a Ph.D., 12% earn an M.D., and 25% pursue other advanced degrees.[14] This represents a total of around 70% of MARC STAR-U participants going on to earn an advanced degree.[14] In comparison, we found around 60% of *Project Strengthen* students (n = 124) went on to earn advanced degrees (Table 4). While fewer students earn PhDs, more earn other types of professional degrees, including M.D.s (Tables 4 and 5). Furthermore, we see high variability in the degrees obtained by *Project Strengthen* participants, with many becoming nurses, entering industry, or other professional or master's degrees (Table 5). This demonstrates that *Project Strengthen* may encourage students to pursue a range of academic and career pursuits with similar effectiveness as MARC programs.

DISCUSSION

To understand where the difference in skills for graduate school and confidence levels lie for non-MARC students compared to their counterparts (MARC students), we sought to measure the confidence levels and understanding of the following three key concepts to support STEMM graduate success: familiarity with graduate school and/or professional programs, the application processes, and tools for graduate school success. Overall, this data suggests that MARC participants arrived with a higher level of confidence and self-assessed knowledge of the workshop topics, while non-MARC participants gained competence and confidence in skills related to graduate school and applying to graduate schools through the series of workshops. When comparing pre- and post-test scores, non-MARC participants made larger gains than MARC participants, with MARC students showing an increase in terms of knowledge (Figures 1, 2, and 3). There was relatively little change for MARC students based on their pre- and post-questionnaire, thereby suggesting that MARC programs are effective in delivering important skills and knowledge regarding success for graduate school to students enrolled in MARC programs. This highlights that, above all, MARC programs have been and continue to be effective and their continous funding, where possible, is necessary. For areas that cannot offer MARC programs, our results also suggest that *Project Strengthen* may be helpful for non-MARC students.

Interestingly, one of the lowest average pre-survey scores for non-MARC students concerned their own assessment of their preparedness for graduate school (Figure 3D). One of the questions on the survey asked participants how much they felt the workshop might help improve their preparedness for graduate school. Many non-MARC participants initially gave themselves lower scores pre-workshop and high scores post-workshop, suggesting participants felt they were more prepared following this workshop. This trend may stem from a lack of exposure to information regarding graduate school and a lack of real-world application opportunities to develop skills used to prepare for graduate school (e.g., networking, writing clear personal statements, etc.) prior to the workshop. This may include students being unclear about what skills may help them prepare for graduate school. This pattern reflects the importance of the informal laboratory learning environment where students are exposed to skills outside of the classroom. In contrast, non-MARC students felt more prepared for graduate school after the workshops than MARC students. At the same time, while in many metrics these results show MARC programs are effective in training MARC students in many areas, by adding practical components to the MARC program, students could become more familiar with professional skills; therefore, gaining confidence in being prepared for graduate schools. However, our program slightly differed from MARC programs as MARC programs have a specific aim to produce Ph.D.-attaining students (see https://nigms.nih.gov/training/MARC/Pages/USTARAwards.aspx); in

Table 4. Outcome following participation in *Project Strengthen*

Highest Degree Obtained	Count	Percentage
BS Degree (or equivalent)	50	40.3
Master's Degree of Equivalent (PA, MPH, MBA)	34	27.4
Professional Degree (DDS, PharmD, MD, ND, OD, etc.)	21	16.9
Doctoral Degree (PhD, PhD Candidate)	15	12.1
Other	4	3.2
Total:	124	100.0

contrast, *Project Strengthen* encouraged individuals to find a passion, regardless of professional or graduate school, leading to more individuals pursuing alternative, but equally important pathways to careers in STEMM, including nursing, industry, and MBAs (Table 5).

Furthermore, for students who are not enrolled in MARC programs, these results suggest that the workshop series may bridge the gap in several non-traditional skills needed apply for graduate school and pursue a career in STEMM. We would recommend that institutions consider using a workshop format to share important information as part of their undergraduate STEMM training programs. MARC students already possess a familiarity with the information presented in the workshop, therefore, workshop-based interventions are unnecessary for them. Similarly, MARC participants also were more expectant prior to the workshop (Figure 3C), suggesting MARC programs have been effective in creating students excited about STEMM. In contrast, there exist disparities in the resources and knowledgebase between non-MARC and MARC students. By offering these workshops where MARC programs are not available, this gap may be bridged in a cost-effective way.

The exact reasoning behind students to attend undergraduate and their motivational factors vary, and different theoretical frameworks posit alternative hypotheses that inform techniques to improve retention. Past studies have employed the human capital theory framework, which posits that students ultimately aim to earn a return in undergraduate with rationale toward the effort put in, which is a framework that may be far-better suited for non-traditional students or community college students.[54] MARC programs are most readily explained by Walberg's theory of educational productivity, which posits that psychological environments – including motivation, quality and quantity of education, and classroom quality – influence educational outcomes, yet such a framework negates the role of underrepresentation in dictating educational barriers.[55,56] MARC satisfies many of these psychological environmental factors, including offering higher quality advisors, resources, and oftentimes motivations, yet all of these factors typically require a large cost and time requirement, limiting the applicability of MARC programs. Therefore, drawing on prior literature that lays out frameworks for student retention on the basis of professional development training[57] and building student-authority interactions in a collaborative environment,[13] we focused on the development of shortened and high-yield workshops.

With regards to the implementation of programs, such as MARC, requires a self-sustaining scaffolding that institutions can integrate the program into their pre-existing structures, including providing institutional resources to maintain this program.[14] Institutions that experience difficulty attaining a T34 grant may still have the capacity to run workshops, such as these, and may already have some of the resources to do so. To address overall resource needs, institutions can use pre-existing diversity, equity, and inclusion (DEI) educators to serve as graduate success educators or workshop leaders to intervene in URM student communities. These educators can then use pre-existing materials and present them to students so that information is equally distributed across a multitude of institutions. Not only would this tackle the issue of finding dedicated educators, but it would also increase the need for DEI educators and the implementation of DEI strategies in other programs. Other considerations for institutions planning to implement *Project Strengthen* or similar, in a physical or non-physical space, include providing a designated space for support teams to interact, access to platforms to share resources with a group of students, and a team of mentors with research projects.

Conclusion

Although MARC programs have consistently demonstrated success since their inception in 1982,[14] MARC programs have faced challenges such as limited availability, eligibility requirements, and funding limitations. In relation to the availability, MARC programs on average can accommodate roughly 20–30 students at a time, as opposed to similar programs that could reach approximately 120 students per cohort. Also, the MARC criteria for accepting trainees exclude students at a disadvantage, especially if they do not meet the MARC criteria for acceptance. As opposed to our workshop series alone, MARCs offer numerous benefits, including travel grants and research experience. Thus, there is still a clear role for MARC programs and their continous funding, wheras *Project Strengthen* is more applicable where MARC programs are limited. While *Project Strengthen* does not include these benefits, it offers a cheaper alternative for low-resource institutions that may offer improvements in certain key areas for students to prepare for graduate school. This can greatly benefit more URMs by preparing them for graduate school through *Project Strengthen*-like programs, which have no eligibility requirements, and could allow for a wider spectrum of participants who are not as limited by entry factors, such as GPA.

The pre- and post-survey revealed that most non-MARC STEMM students do not receive such information, as compared with MARC students. While the MARC program is effective, there is limited access in reach due to the additional functions it serves. It is important to expand the workshops used in *Project Strengthen* to broaden the reach of pieces of training beyond MARC programs to institutions that may not have these sorts of programs. *Project Strengthen* allows for a wider base of students to be benefitted from the delivery of this information. With these suggestions in mind, expanding to other portions of the community, making the eligibility process simpler, and including more practical

Table 5. Specific outcome following participation in *Project Strengthen*

	Count	Percent
BS (Clinical/Academia)	3	2.4
BS (Industry)	10	8.1
BS (Nursing)	7	5.6
BS (Unspecified)	25	20.2
BSN	5	4
DDS	4	3.2
Deceased	2	1.6
Masters in Physicians Assistant	4	3.2
Masters	16	12.9
MBA	7	5.6
MD	11	8.9
MPH	2	1.6
MS	3	2.4
MSN	1	0.8
Naturopathic doctor	1	0.8
OD	1	0.8
PA	1	0.8
PharmD	4	3.2
PhD	13	10.5
PhD Candidate	2	1.6
Switched Majors	2	1.6
Total	124	100

Outcomes of Project Strengthen (n = 124) participants following several years after their participation in Project Strengthen. (BS: Bachelor's of Science; DDS: Doctor of Dental Surgery; Masters: Mixed degrees including divinity; MBA: Master's of Business Administration; MD: Medical Degree; MPH: Master's of Public Health; MS: Master's of Science; MSN: Master's of Science in Nursing; OD: Doctor of Optometry; Ph.D.: Doctor of Philosophy).

applications of the presented information, future *Project Strengthen* workshops may be more capable of bridging the path to STEMM success and reach more students who are not able to participate in MARC programs.

Limitations of the study

These workshops could be expanded to include interactive exercises to help students practice applying skills (e.g., how to network and interview) in the real world. Here, we did not consider how class standing, race, gender, ethnicity, GPA, or other factors affect overall change in attitude. In consideration of students' outcomes, although all students came from a similar pool at WSSU, non-random assignments may affect students' outcomes based on their prior knowledge levels. However, any applications of correcting for such differences may skew the data as we aimed to simply understand baseline knowledge, which may be inherently different between MARC and Project *Strengthen*. Thus, viewing the study in this context is important. While we had a dominantly underrepresented sample, we did not measure how many were first generation. Future studies may consider how these workshop series benefit non-MARC and MARC students across different demographics. In addition, this study specifically looked at effectiveness of MARC programs in a range of topics, compared to students with no prior experience. Future studies may broaden this to also consider the comparative efficacy of other programs, such as research experiences for undergraduates, institutional-funded peer-mentoring, or minority-serving institutions programs. For example, alternative research programs, such as UROP, are less reliant on professional development and are more focused on research engagement, so it may be possible that *Project Strengthen* is more effective in conjunction with such programs (Table 2). Additionally, while MARC programs are not available at community colleges, *Project Strengthen* may be effective for engaging community college students.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

- KEY RESOURCES TABLE
- RESOURCE AVAILABILITY

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.isci.2023.107766.

AUTHOR CONTRIBUTIONS

T.B., K.N., and B.S. contributed equally to this work and should be considered co-first authors.

Z.V., H.S., and A.H.J. both coordinated this work and should be considered co-senior authors.

T.B., K.N., B.S., H.S., Z.V., and A.H.J.: Conceptualization, Formal analysis, Investigation, Methodology, Writing - original draft.

T.B., K.N., B.S.: N.V., E.C.S., K.K., Z.C., L.V., M.V., N.V., A.C., S.A., A.D., H.K.B., A.G.M., M.K., D.S., C.B.P-M., F.J., J.D., S.D., C.N.M., S.A.M., C.V., D.J.M., H.S., Z.V., and A.H.J.: Data curation, Investigation, Writing – review and editing.

DECLARATION OF INTERESTS

Authors declare that they have no competing interests.

INCLUSION AND DIVERSITY

We worked to ensure gender balance in the recruitment of human subjects. We worked to ensure ethnic or other types of diversity in the recruitment of human subjects. We worked to ensure that the study questionnaires were prepared in an inclusive way. One or more of the authors of this paper self-identifies as an underrepresented ethnic minority in their field of research or within their geographical location. One or more of the authors of this paper self-identifies as a gender minority in their field of research. One or more of the authors of this paper self-identifies as a member of the LGBTQIA+ community. One or more of the authors of this paper self-identifies as living with a disability. One or more of the authors of this paper received support from a program designed to increase minority representation in their field of research. While citing references scientifically relevant for this work, we also actively worked to promote gender balance in our reference list.

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STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Software and algorithms		
GraphPad	GraphPad Software, San Diego, California USA	www.graphpad.com
Other		
Workshop 1	Marshall et al.[31]	https://doi.org/10.1093/femspd/ftac022.
Workshop 2	Marshall et al.[32]	https://doi.org/10.1093/femspd/ftac011
Workshop 3	Marshall et al.[33]	https://doi.org/10.1093/femspd/ftac024
Workshop 4	Data S1	
Workshop 5	Data S2	
Workshop 6	Data S3	
Workshop 7	Data S4	
Workshop 8	Data S5	
Workshop 9	Data S6	
Individual Development Plan Templates	Data S7	

RESOURCE AVAILABILITY

Lead contact

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Materials availability

All workshops are available as supplemental files in this publication or previous publications.[31–33]

Data and code availability

- All data reported in this paper will be shared by the lead contact upon request.
- This paper does not report original code.
- Any additional information required to reanalyze the data reported in this paper is available from the lead contact upon request.

METHOD DETAILS

Participants

From 2016-2020, we provided workshops to student participants on various career topics related to STEMM. The participants of the *Project Strengthen* study were students from WSSU, a historically black college, and university primarily serving the African American community. Students at WSSU are mostly Black/African American with a smaller White population. 84% of students are minorities or people of color. Participants were all STEMM majors with at least a 3.0 GPA and third-year class standing. The participants self-reported their gender information and no other demographic data was collected. The demographics of the participants at the talk are similar to the demographics of the student population at WSSU, in which WSSU is vastly made up of URM students. As of 2023, the WSSU has 24.4% women compared to 76.6% men undergraduate population, while 80.5% of the undergraduate population were Black. Of relevance, WSSU has consistently maintained a 4-year graduation rate lower than 30% across at least the past 5 years (as per https://www.wssu.edu/about/assessment-and-research/student-data.html, accessed March 25th 2023). A total of 150 participated in *Project Strengthen* were surveyed. Of the 150, 120 students had not participated, were not involved, and/or not supported in the MARC program and were referred to as ''non-MARC'' students in this article. The remaining 30 students were enrolled in the MARC program and are herein referred to as "MARC" students. These two cohorts were independently given two identical sets of workshops. During the time when this data was collected, WSSU had a MARC program. As of 2018, the MARC program was dissolved. Data was collected consecutively from *Project Strengthen* participants from 2016-2020 so that responses from MARC students (Control) could be compared to non-MARC students.

At WSSU at the time of this study, MARC students were paired with a mentor in a lab setting and learned basic lab techniques, how to dress and behave in the lab, and how to create a project to present at a national conference. In addition to research experience, MARC students had access to a support team consisting of MARC directors who mediate the general workflow, mentors in their labs along with secondary mentors and shadow mentors, career and professional development educators, past MARC alumni who provided students with career development

presentations, other current MARC students, and counselors. To provide more in-depth interaction, there were also 1-on-1 meals or coffee meetings to plan future endeavors and increase networking skills, open door policy to professors, food events and social events, as well as volunteer activities to teach service. In this particular cohort used within the study, MARC students also engaged with Research Training Initiative for Student Enhancement (RISE) Scholars and met with them for weekly presentations from WSSU faculty/staff members or a faculty/staff member from another institution.

EXPERIMENTAL MODEL AND STUDY PARTICIPANT DETAILS

The project entitled "Promoting engagement in science for underrepresented ethnic and racial minorities (P.E.E.R)" was duly evaluated by the Kaiser Research Institute's Office of Research and Scholarship and determined not to be human subjects research and thus did not require IRB approval (Proposal tracking number: 21-MortonD-HSR-SOM-01).The IRB for the Protection of Human Participants in Research at Winston-Salem State University (WSSU) has approved the exemption of IRB for this project.

Upon completion of surveys, all student data was anonymized and separated from demographics to avoid potential identification. Dei-dentified data were limited to researchers using a secure file transfer protocol to ensure the safety and security of the data. Participants were informed of the potential risks and benefits of participating in the study, as well as the risks and benefits of sharing de-identified data, and had the option to opt-out at any time.

Project Title: Promoting Engagement in science for underrepresented Ethnic and Racial minorities (P.E.E.R), 21-MortonD-HSR-SOM-01, Kaiser Foundation Research Institute FWA: FWA00002344.

Project Title: Promoting Engagement in science for underrepresented Ethnic and Racial minorities (P.E.E.R), 015-2022 Chia Vang, New Mexico Highlands University.

Ethics Approval and consent to participate: Yes.

Consent for publication: Yes.

QUANTIFICATION AND STATISTICAL ANALYSIS

Figures 1, 2, and 3 had all statistical analysis conducted via GraphPad Prism (La Jolla, USA). An unpaired t-test was used for comparisons among groups, or a non-parametric equivalent if appropriate. Variable sample numbers are shown by symbols on graphs. Ns, *, **, ***, and **** indicates non-significant, $p < 0.05$, $p < 0.01$, $p < 0.001$, and $p < 0.0001$, respectively.