

## Science Identity and Career Intentions: A Matched-Control Study of MARCOS Scholars

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High-quality mentorship plays a pivotal role in shaping students' persistence in STEM. Studies show that faculty mentorship correlated with stronger science self-efficacy, science identity, and commitment to a science career. Notably, students with stronger science identities were more likely to commit to entering a science career. This suggests that faculty-student mentorship is important to cultivate student wellbeing and persistence in STEM. The Mentoring to Accelerate Retention and Change Outcomes in Science (MARCOS) Program supported academically talented biology students with scholarships, faculty mentorship, proactive advising, and professional development opportunities to improve retention and graduation rates, as well as foster students' identity in science. This study draws on a conceptual framework that positions faculty mentorship in multiple areas (e.g., academic, career, and personal) as a key driver of students' wellbeing and post-graduate pursuits. We employed a matched-control design to examine the impact of dedicated faculty mentorship on career trajectories, development of science identity, and belonging. Fifteen MARCOS scholars who had participated in the program for two to four years were compared to 15 biology students who were individually matched based on cumulative GPA, total credits earned, and participation in previous research experiences. All students completed a survey assessing their sense of belonging to the science community, scientific identity prominence, frequency of seeking faculty mentorship for academic, career, and personal support, and post-graduate plans. MARCOS Scholars were significantly more likely to seek faculty mentorship for academic, career, and personal support compared to control students. Statistical moderations revealed that scholars who sought less career mentorship showed lower sense of belonging to the science community, while those with more career mentorship showed the highest scientific identity. High scientific identity positively correlated with plans to pursue STEM work or graduate school. The MARCOS program provided access to quality mentorship that influenced students' belonging and career plans.

*Keywords:* Faculty-student mentoring, scientific identity, sense of belonging, career intentions

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### Introduction

Mentorship has been widely recognized as a crucial factor in promoting student persistence and success in science, technology, engineering, and mathematics (STEM) fields, particularly among underrepresented groups (Byars-Winston & Dahlberg, 2019; Estrada et al., 2018). High-quality faculty mentorship has been linked to stronger science self-efficacy, the development of a science identity, and increased commitment to science careers—factors that improve students' academic trajectories and long-term career outcomes (Hanauer et al., 2016; Robnett et al., 2018; Stets et al., 2017). Fostering scientific identity and

sense of belonging are particularly important in STEM, where student attrition remains a persistent concern, especially for students from historically marginalized backgrounds (Hausmann et al., 2007; S-STEM REC, 2023; Whitcomb & Singh, 2021). Successfully transitioning students, especially those from underrepresented backgrounds, into STEM graduate programs or professional schools builds a highly skilled workforce and increases access to high-paying, high-impact jobs.

The Mentoring to Accelerate Retention and Change Outcomes in Science (MARCOS) Program was established to address these challenges by providing academically talented biology students with financial support, structured

faculty mentorship, proactive advising, and professional development opportunities. Drawing on a conceptual framework that positions faculty mentorship as a driver of student wellbeing and persistence, this study uses a matched-control design to evaluate the impact of the MARCOS program on students' sense of belonging in the scientific community, scientific identity, and post-graduate intentions.

### Literature Review

The most effective mentoring relationships are formed with intentionality, build interpersonal trust, and have shared experiences (Byars-Winston & Dahlberg, 2019). For example, Nora and Crisp (2007) propose four key constructs for an effective faculty-student mentorship, including the formation of a role model, providing emotional support, being an academic subject knowledge expert, and supporting students with setting academic/career paths. Faculty role models can encourage scholars to adopt healthy study habits and foster belief in their ability to be successful in college. Furthermore, these role models can provide vicarious learning and positive encouragement to help students navigate college, overcome academic obstacles, and establish a mentoring network (Dahlberg & Byars-Winston, 2019).

Furthermore, faculty mentorship is particularly important for supporting the academic and personal success of underrepresented minority students. Minority students entering into STEM fields may face stereotype threat and lack a sense of belonging, which can adversely impact persistence (Hausmann et al., 2007). In one study, students who reported more social support, including peer-group interactions, faculty, and parental support, had a higher sense of belonging and improved academic integration in college (Chen et al., 2023). This effect was especially strong among Black students (Hausmann et al., 2007). Other studies have shown that women and minority students who reported having a quality mentor in their junior and senior years had improved scientific identity and efficacy (Estrada et al., 2018) and were twice as likely to persist and have higher GPAs (Nora & Crisp, 2007).

In addition to supporting retention and graduation, faculty mentorship can also promote positive psychological outcomes such as an increased sense of belonging and seeing oneself as a scientist. Faculty mentorship can increase students' sense of belonging through the creation of a space that supports honest and authentic communication. This means students feel comfortable seeking support for both academic and career reasons, as well as for more private or personal issues. Feeling like you are part of the scientific community is central to student persistence in STEM (S-STEM REC, 2023). Participating in research with faculty is another pivotal opportunity for students to receive mentorship that has a profound impact

on the development of scientific identity and interest in pursuing a STEM PhD (Estrada et al., 2018). For example, students learn from their advisor, who has a mutual passion for science and exposes them to what a career in science looks like. These experiences not only deepen students' understanding of scientific work but also help them envision themselves as future scientists, strengthening their commitment to pursuing advanced degrees and careers in STEM. Despite the many benefits of faculty mentorship, students often hesitate to seek out these relationships on their own, highlighting the need for structured programs that actively facilitate and encourage meaningful mentor-mentee connections

### MARCOS Scholars Program Description

The Mentoring to Accelerate Retention and Change Outcomes in Science (MARCOS) Program, a National Science Foundation-funded program, provided scholarships, mentorship, wellness checks, blocked scheduling, and professional development to low-income biology students in order to improve retention, graduation, and students' self-efficacy to thrive in science. First, the MARCOS Scholar Program used a cohort model where incoming scholars participated in a pre-freshman year orientation to begin to foster identity as a science scholar and introduce students to STEM faculty for their fall courses. The main goal was to break down barriers and the sense of isolation by immediately creating a cohort of friendly learners present in all of their freshman classes and establishing the program director as a dedicated faculty mentor (Guzzardo, 2020). Next, to bolster cohort cohesion, the scholars participated in team-building activities and social icebreakers to create space for scholars to develop interpersonal relationships. Past research found that when Black students in a freshman computer science program were asked to identify just two friends, they exhibited greater resilience to adversity, a stronger sense of belonging, and higher academic performance, highlighting the importance of peer mentorship in STEM (Walton & Cohen, 2007). Therefore, the MARCOS program provided weekly professional development and social activities (i.e., holiday parties, movie night, field trips) to create space for inclusion and connection. Finally, the MARCOS program aimed to build students' sense of belonging and self-efficacy through both formal and informal mentoring and support networks. To support student success, interventions that foster self-efficacy must be implemented "early—before struggles erode students' motivation to persist" (Tinto, 2016).

Beginning in freshman year, the program director (first author) scheduled optional study sessions before exams in challenging STEM courses (chemistry, mathematics, and general biology). This intervention reduced the social threshold to self-assembly, created infrastructure

and an expectation for scholars to study, as well as a space for students to share their understanding, and build a peer support network. The program director also hosted weekly professional development meetings addressing career topics like how to identify a graduate mentor, identifying funding for graduate programs, and components of an effective personal statement. In addition, some of the events were intentionally left as an open session for scholars to share their struggles, reflect on their courses, and pressure points in their lives to provide psychosocial support. During COVID, scholars were starved for socialization, so the director hosted Netflix streaming parties, Jackbox game nights, and safe-distance outdoor hiking and picnic meetups. The program director was very intentional with providing “just in time” mentoring and was flexible with the schedule to meet scholars where they are. Sometimes meetings were cancelled because scholars were stressed about an upcoming exam, and occasionally additional meetings were added as workshops to help students with writing accountability. Collectively, these components of the MARCOS program provided early access to a dedicated faculty connection, research experiences, academic support, and career planning. In qualitative feedback, students frequently mentioned the value added by forming meaningful connections with peers and faculty. For example one student said that “I have made more friends which has increased my confidence in asking for help, especially from my peers and overall increased my success.” Another student mentioned, “The MARCOS Scholar Program has helped tremendously, [sic] If I was not a part of this program I am fairly sure I would have had to take a semester off. Last semester took a toll on my mental health and without the social and financial support from this program I probably would have given up.” Students frequently make comments about being “connected” with other students, professors, and their school and reference how critical a support system is for their success.

## Method

S-STEM Scholarship Selection Criteria. The MARCOS Scholar Program interviewed and enrolled freshman biology students from 2018 - 2020. The National Science Foundation S-STEM scholarship at the time of this program required that students be federal aid eligible, have remaining unmet financial need, enroll full-time, and be academically talented (we defined academic talent as maintaining a minimum 3.0 GPA). Any students who met these criteria were enrolled in the program and S-STEM scholarship amounts varied based on the individual unmet financial need of each student as determined by our Office of Financial Aid. The focus of this work was to examine the effect of dedicated mentoring on the development of science identity among MARCOS Scholars in comparison to matched Biology student controls.

## Participants

MARCOS scholars. In spring 2022, 15 MARCOS Scholars completed a post-test survey from three cohorts, 2018 cohort (n = 4), 2019 cohort (n = 4), and 2020 cohort (n = 7). There were 13 female and 2 male MARCOS students, with an ethnic composition of 60% Hispanic, 20% Asian American and Native American Pacific Islander (AANAPI), 13.3% White, and 6.7% Black. The biology students recruited into the MARCOS Scholars Program reflect the campus in both gender and ethnicity, since our university holds both Hispanic Serving Institution (HSI) and Asian American and Native American Pacific Islander (AANAPISI) Serving Institution designations.

## Biology Controls

106 Biology majors recruited from cohort-matched STEM courses completed a control version of the post-test survey at the end of the spring 2022 semester. Each MARCOS Scholar was matched with a member of the control group based on having research experience (or not), having a similar cumulative GPA, and completed units. In the matched control group, all but one student had conducted research aligning with a matched MARCOS Scholar. There were twelve female students and three male students in the matched biology control group and of those 53.3% Hispanic, 33.3% White, and 13.3% Black, resulting in a similar, but not exact demographic match.

## Procedure

All participants completed a post-test survey at the end of Spring 2022. The post-test survey included a variety of variables, but mentoring type and frequency, sense of belonging in science, scientific identity prominence, and post-graduate plans are the focal point of this article.

## Measures

### *Types of Faculty Mentoring*

Participants completed 13 items related to types of faculty mentoring (e.g., for academic advising, career advising, or personal issues). The scale uses a 5-point Likert scale to examine frequency of use, ranging from 1 (never) to 5 (very often). To reduce the 13 items into meaningful categories, a principal component analysis (PCA) was conducted using a varimax rotation with Kaiser normalization. The rotated factor matrix revealed that items loaded strongly onto respective factors, then examined the internal consistency of the items loading on each component using Cronbach's alpha and excluded items that improved the alpha reliability. This resulted in three subscales assessing academic advising (3 items;  $\alpha = 0.74$ ; e.g., “ask questions about course materials or assignments”), career advising (4 items;  $\alpha = 0.87$ ; e.g., “prepare application materials for careers or graduate school”), and personal issues (4 items;  $\alpha = 0.91$ ; e.g., “seek emotional support”).

### **Scientific Identity Prominence**

Participants completed five items selected from the Scientific Identity Prominence scale (Stets et al., 2017). The scale uses a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating that the individual thinks of themselves as a scientist and it is an important part of their self-image. Sample items included, "In general, being a scientist is an important part of my self-image" and "Being a scientist is an important reflection of who I am." A composite score was created for each participant by averaging across all scores,  $\alpha = 0.93$ .

### **Sense of Belonging in Science**

Participants completed two items selected from the College Student Persistence in the Sciences scale (PITS; Hanauer et al., 2016). The scale uses a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating a feeling of belonging in the field of science. Sample items included "I have a strong sense of belonging to the community of scientists" and "I feel like I belong in the field of science." A composite score was created for each participant by averaging the two scores,  $\alpha = 0.88$ .

### **Post-graduate Plans**

Participants responded to a categorical question, "What are your plans after you finish your bachelor's degree?" Response options included (1) work in a STEM field, (2) work in a non-STEM field, (3) Master's in a STEM field, (4) PhD in a STEM field, (5) Professional Degree (e.g., Dental, Medical, Physical Therapy), (5) Certification Program, (6) Undecided, (7) Other. Using these categories, a new dummy-coded variable was created where plans to attend graduate school or workforce in STEM were 1, undecided was coded 0, and plans to attend professional school were coded -1.

## **Results**

### **Matched-Control Comparisons**

A series of paired samples t-tests were conducted to examine mean differences between MARCOS Scholars and their matched controls for all variables measured. The descriptive statistics, Cohen's  $d$  effect size, and inferential statistics are shown in Table 1. MARCOS Scholars reported seeking mentoring for academic, career, and personal reasons more frequently than the matched controls (all  $ps < .05$ ). However, there were no differences in sense of belonging in science nor scientific identity prominence between MARCOS Scholars and their matched controls (all  $ps > .05$ ). Finally, MARCOS scholars who received more career preparation and exploration as part of the program were more likely to indicate their desire to pursue a STEM job or graduate program after graduating compared to matched controls who were more likely to indicate a desire to pursue a professional degree ( $p = .03$ ).

### **Table 1 (Not Submitted with Paper)**

#### *Mean Differences in Primary Variables Between MARCOS Participants and Matched Controls*

Note.  $N = 30$ . Greater than ( $>$ ) or less than ( $<$ ) signs indicate a significant difference at the  $p < .05$  threshold. STEM Post-Graduate Pathway = 1, Professional Degree = -1.

### **Correlations with Mentoring Types**

Next, the zero-order correlations between all variables were examined within each group ( $n = 15$  per group) as shown in Table 2. Among MARCOS Scholars (below the diagonal in the left half of the table), academic mentoring frequency was positively correlated with career mentoring frequency,  $r(13) = .63$ ,  $p < .05$ , and personal mentoring frequency,  $r(13) = .70$ ,  $p < .01$ . MARCOS Scholars who sought more career mentoring also reported more sense of belonging in science,  $r(13) = .72$ ,  $p < .01$ , and stronger scientific identity,  $r(13) = .60$ ,  $p < .05$ . Scientific identity prominence positively correlated with sense of belonging in science,  $r(13) = .78$ ,  $p < .01$ , and planning to enter a STEM pathway after graduation,  $r(13) = .55$ ,  $p < .05$ . Among matched controls (above the diagonal, in the right upper half of the table), all mentoring types positively correlated with each other, all  $rs > .60$ ; however, there were no other significant relations among the other variables.

### **Table 2 (Not Submitted with Paper)**

#### *Correlations Between All Variables for MARCOS Scholars (Below Diagonal)*

#### *and Matched Controls (Above Diagonal)*

Note. Correlations for MARCOS Scholars appear below the diagonal; correlations for matched controls appear above the diagonal.  $df = 13$ . STEM Post-Graduate Pathway = 1, Professional Degree = -1. \*  $p < .05$ , \*\*  $p < .01$ .

## **Discussion**

The current study sought to examine the mentoring experiences and science-related identity development of MARCOS Scholars in comparison to matched controls. MARCOS Scholars reported seeking faculty mentorship more frequently for academic, career, and personal reasons compared to the matched student controls, highlighting the program's emphasis on early exposure to faculty who were willing to provide multi-dimensional support. The MARCOS Scholar program fostered a culture of seeking faculty support through a pre-college orientation to campus, a practice shown to mitigate higher freshman attrition rates in biology majors (Hausmann et al., 2007). Although the MARCOS program facilitated seeking faculty more frequently for support and mentorship, there were no significant differences in sense of belonging in science or scientific identity between the scholars and the matched controls. Research experience has been shown to improve students' feelings of

belonging to science and the formation of scientific identity (Estrada et al., 2018). In our study, 14 out of 15 students in the matched-pair groups had prior research experience, which may obscure the impact of dedicated mentoring. Future analyses will also evaluate the program's outcomes relative to the broader population of biology students on our campus—most of whom have not participated in research outside the classroom and do not regularly seek faculty support. As evidence of the programs impact, MARCOS Scholars achieved a four-year graduation rate of 71.1%, compared to just 23.3% among GPA matched biology students who did not receive these support services.

Further analyses revealed that not all mentorship experiences contribute equally to students' development, particularly when it comes to fostering a strong science identity and sense of belonging. Most notably, only career-related mentoring correlated with a stronger scientific identity and a greater sense of belonging in science among MARCOS scholars, but not among the matched controls. MARCOS Scholars participated in intentionally designed career support workshops led by the project director, while control students likely received occasional career mentoring through faculty advisors or research mentors. This data suggests that the quality and focus of mentorship, not just its frequency or availability, are crucial. To improve scientific identity and belonging for all students, educators need to build more opportunities for career-related support, such as exposing students to different career paths and options (academia, industry, government, non-profits), discussing what makes students competitive for graduate school, and providing feedback on application materials.

There were other associations experienced only among MARCOS scholars that were not mirrored in the matched control group. Specifically, scientific identity prominence was positively correlated with students' intentions to pursue a STEM-related career path, reinforcing prior research that underscores identity as a key predictor of post-graduate trajectories in STEM (Estrada et al., 2018). In contrast, these associations were not found among matched controls with research experience.

The career path divergence toward higher STEM degrees rather than professional programs may reflect the MARCOS program's emphasis on substantive faculty mentorship that supports gaining research experience and exploring graduate programs in STEM. For example, scholars who actively engaged with the program received weekly professional development meetings where scholars explored careers outside of medicine, developed job or graduate school application materials, and participated in conversations about how to overcome imposter syndrome. MARCOS Scholars participated in bi-monthly professional development workshops that regularly explored career opportunities beyond medicine which may have contributed to their broader interest in non-

clinical STEM careers. In one workshop, scholars were asked to identify three professions that they would feel fulfilled in and map out exactly what was needed to achieve each. Finally, the program connected scholars to paid research opportunities and internships. Impressively, 93.3% of MARCOS Scholars surveyed completed intensive paid research experiences which is not typical of all biology students, therefore control students were matched based on research experience. These research opportunities also broadened students' mentoring networks, creating critical connections needed to thrive in science and close equity gaps in graduation rates (Haeger et al., 2024). Future research should explore factors that predict students' interest in pursuing professional schools compared to graduate programs. Students who have not been exposed to mentorship or programming that highlights STEM pathways may be opting for more traditionally visible and socially validated professional pathways because they seem like the obvious, more prestigious, and financially lucrative postgraduate path.

While there were positive outcomes of the MARCOS programming and mentorship, there are several limitations to consider. Because the NSF award supported a limited number of scholarships, the current study relied on a relatively small sample size that limits the generalizability of the results and reduces statistical power to detect smaller effects. However, a key strength of this work is the use of a coursework and research experience matched-control group of similar peers majoring in Biology who did not participate in the MARCOS program. The matched-control design uses a repeated-measures analysis that increases the statistical power of the study. Another limitation is the inability to examine the impact of specific mentoring relationships because students did not identify who they thought of when completing the survey items. Anecdotally, MARCOS students had considerable interactions with the program director (first author) and may have engaged less or differently with their faculty research supervisors.

Future research should evaluate the quality and focus of each unique mentoring relationship. This would elucidate which relationships are most likely to influence the development of their scientific identity and research self-efficacy.

## Conclusion

This project contributes to a growing body of evidence that quality holistic mentoring can improve outcomes of freshman high-achieving, low-income, traditional (18 - 26-year-old) university students pursuing a biology degree at a minority-serving institution. This was achieved by providing a pre-college two-day orientation, weekly professional development, proactive advising, social integration, intensive career mentoring, and access to funded research opportunities. Students who reported a higher

frequency of career mentoring correlated with an increased sense of belonging and scientific identity, and these students were open to pursuing a STEM graduate degree over professional school. Further studies need to delve into the nuance of intentional career mentorship as a controlling variable and determine what level of intervention is needed to achieve similar success metrics.

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