Creative Education, 2026, 17(6), 897-908
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

Multi-Semester Mentoring and GPA Trajectories in SPINS: A Longitudinal Program Evaluation of STEM Scholars

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How to cite this paper: Davenport, L., Mwiinga, B., Kassu, A., Drabo, M. and Egarievwe, S. (2026). Multi-Semester Mentoring and GPA Trajectories in SPINS: A Longitudinal Program Evaluation of STEM Scholars. *Creative Education, 17,* 897-908.
https://doi.org/10.4236/ce.2026.176056

Received: April 5, 2026
Accepted: June 7, 2026
Published: June 10, 2026

Abstract

This exploratory longitudinal program evaluation examined GPA trajectories among 14 STEM scholars participating in the Scholarly Partnership in Nuclear Security (SPINS) mentoring program at an HBCU. Using de-identified administrative data (37 scholar-semester observations), the study compared baseline and latest term GPAs anchored to each scholar's first funded semester. A Wilcoxon signed-rank test was used to assess within-student change. Mean GPA increased modestly from 3.46 (SD = 0.30) at baseline to 3.61 (SD = 0.33) at the latest observed semester, with 12 of 14 scholars (85.7%) showing net improvement (median change = +0.12). The Wilcoxon signed-rank test indicated a statistically significant positive shift (W = 18, $p = 0.030$). However, scholars entered the program with a high baseline GPA, and ceiling effects were evident for several participants. Grounded in Social Cognitive Career Theory, findings suggest that multi-semester participation in SPINS is associated with GPA stability and modest improvement in an already high-performing cohort. Results should be interpreted cautiously given the small sample size and single-group design. The study highlights the value of sustained, culturally responsive mentoring at an HBCU while underscoring the need for larger evaluations with comparison cohorts and broader psychosocial outcomes. An evidence-informed mentoring framework is proposed to strengthen multi-semester support.

Keywords

Mentoring, STEM Persistence, GPA Trajectories, Longitudinal Program Evaluation, HBCU, Social Cognitive Career Theory, Science Identity

1. Introduction

Mentoring is widely recognized as a critical factor in student persistence and success in higher education, particularly in STEM fields (Harris & Nagle, 2023). Effective mentoring integrates psychosocial support, academic guidance, career socialization, and clear expectations (National Academies of Sciences, Engineering, and Medicine, 2019; Crisp & Cruz, 2009). In STEM, mentoring frequently operates alongside undergraduate research experiences, faculty interaction, and near-peer support (Keller & Lindwall, 2020). These combined elements have been linked to increased confidence, skill development, graduate school aspirations, and persistence in STEM pathways (Russell et al., 2007; Estrada et al., 2018).

This study is grounded in **Social Cognitive Career Theory (SCCT)** (Lent et al., 2005), which posits that environmental supports such as structured mentoring can enhance academic self-efficacy, outcome expectations, and goal persistence, especially for students from underrepresented groups. SCCT is particularly relevant at Historically Black Colleges and Universities (HBCUs), where culturally congruent mentoring can help offset contextual barriers and strengthen science identity (Randolph, 2019; Byars-Winston & Rogers, 2018).

Recent studies at HBCUs demonstrate that structured faculty and near-peer mentoring programs support academic success among African American STEM students (Dickens et al., 2025; Hur et al., 2024; Boyd et al., 2024). However, many evaluations rely on cross-sectional designs or short-term outcomes (Eby et al., 2007; Raposa et al., 2019). Longitudinal examinations of GPA trajectories across multiple semesters remain relatively rare.

The present study provides an **exploratory longitudinal program evaluation** of the Scholarly Partnership in Nuclear Security (SPINS) program at Alabama A&M University. Using de-identified administrative data from 14 STEM scholars (37 scholar-semester observations), the study examined GPA patterns from each scholar's first funded semester to their most recent funded semester. The evaluation was guided by two primary descriptive questions: 1) What patterns of GPA change are observed among SPINS scholars over their funded participation periods? and 2) Do scholars with longer funded participation show descriptively different GPA trajectories compared to those with shorter participation?

2. Methods

2.1. Design and Data Source

This study employed a retrospective, single-group longitudinal program evaluation design. De-identified administrative records from the Scholarly Partnership in Nuclear Security (SPINS) program at Alabama A&M University were analyzed. The dataset included 14 unique STEM scholars and 37 scholar-semester observations spanning Spring 2023 through Fall 2025.

The 14 scholars represent the complete set of students who received multi-semester funding and had complete GPA records during the study period. No participants were excluded due to attrition in the analytic sample, which reflects the

program's strong support structure. Researchers removed all identifying information and assigned scholars study IDs (S01 - S14) prior to analysis. The study was determined to be exempt from review by the Alabama A&M University Institutional Review Board as it involved secondary analysis of existing, de-identified program records.

2.2. The SPINS Program at Alabama A&M University

SPINS is Alabama A&M University's (AAMU) flagship undergraduate-to-graduate mentoring and workforce-development initiative in STEM designed with a Vertical Education Enhancement (VEE) approach (Egarievwe, 2015). The VEE model strongly promotes collaborations between universities, industries, and government agencies, community engagement, and adequate funding and research support (Egarievwe, 2021). The VEE model has also been used successfully in faculty development and collaborations among international institutions (Egarievwe, 2015), and in its curriculum development component, it includes active-learning approaches for technical training and skillset development (Egarievwe, 2021).

Launched in 2020, the program recruits full-time STEM majors (especially Mechanical, Electrical, Civil, Nuclear, and Computer Engineering) with junior standing, a minimum 3.0 GPA, and U.S. citizenship. Recruitment operates on three annual cycles (Spring/Summer/Fall) using campus recruiting events, engineering department seminars, outreach at HBCU/MSI conferences, digital campaigns, and targeted K-12 outreach. The 2023 SPINS K-12 Teachers and High School Students Enrichment Program engaged 22 high-school students and 5 K-12 STEM teachers through lectures on fundamentals and emerging topics, hands-on lab training, science/technology movie discussions, and group research projects. This early-exposure initiative builds a sustainable pipeline from K-12 upward.

A dedicated SPINS Selection Committee manages a rigorous, rubric-based process: pre-interview screening and application scoring using the validated SPINS rubric (total 100 points: 40% academic preparedness, 20% qualifications/experience, 20% career goals and future plans, 20% interview). Selected scholars receive immediate faculty/near-peer mentor assignment, an individualized awardee portfolio, and access to an early-alert system. Program activities include U.S. Department of Energy (DOE) national laboratory visits and internships, professional development workshops, and 8-10-week summer co-ops. By 2023, the program had supported more than 100 students, with strong placement rates in nuclear energy, aerospace, and defense-contractor roles.

Mentoring in SPINS is delivered through direct faculty guidance on subject material scholars find challenging. Graduate students serve as near-peer mentors to explain difficult concepts and theories. Faculty and program leaders actively seek feedback from scholars on their research and academic interests and use this information to tailor custom workshops and summer research internships at DOE national laboratories to align with individual student goals.

2.3. Measures and Operational Definitions

The primary outcome was term GPA. To account for scholars entering the program at different academic stages, we anchored time to each scholar's entry into SPINS. **Baseline GPA** was defined as the GPA in the scholar's first funded semester in the dataset. **Latest GPA** was defined as the GPA in the scholar's most recent funded semester. We calculated GPA change as latest GPA minus baseline GPA for each scholar.

We categorized scholars by duration of funded participation (2 terms, 3 terms, or 5 terms). Because the administrative dataset did not contain institutional enrollment records, major persistence data, graduation status, or information on non-SPINS STEM students, "retention" in this study refers specifically to the number of funded semesters of participation in SPINS rather than broader institutional retention or degree completion.

2.4. Statistical Analysis

Descriptive statistics (means, standard deviations, medians, and frequencies) summarized cohort characteristics and GPA patterns. We examined individual scholar trajectories visually. We evaluated within-student change in GPA from baseline to latest semester using both a paired-samples t test and the nonparametric Wilcoxon signed-rank test. We emphasized the Wilcoxon test due to the small sample size, bounded nature of GPA data, and evidence of ceiling effects.

We conducted subgroup analyses by funded participation length for descriptive purposes only. Given the very small subgroup sizes (as low as n = 2), we performed no formal inferential statistical tests on these strata. We performed all analyses using R and/or SPSS. We evaluated statistical significance at $\alpha = 0.05$.

3. Results and Analysis

3.1. Cohort Profile

The analytic sample consisted of 14 STEM scholars (37 scholar-semester observations). Nine scholars participated for two funded terms, three for three terms, and two for five terms. Nine scholars were classified as undergraduates, four as graduate students, and one as an undergraduate-to-graduate transition case. All recorded term GPAs were ≥ 3.05, indicating that the cohort entered the SPINS program with relatively strong academic performance (mean baseline GPA = 3.46, SD = 0.30).

3.2. Overall GPA Change Patterns

Analyses were anchored to each scholar's first funded semester in the SPINS program. Mean GPA increased from 3.46 (SD = 0.30) at baseline to 3.61 (SD = 0.33) at the latest observed semester. The average within-student change was +0.15 GPA (median = +0.12). 12 of the 14 scholars (85.7%) showed a net positive change, while two scholars showed a decline.

A Wilcoxon signed-rank test was conducted to evaluate within-student change.

Twelve scholars had positive ranks and two had negative ranks, yielding W = 18, $p = 0.030$. A paired-samples t-test produced consistent directional results, t (13) = 1.79, $p = 0.096$. The rank-biserial correlation effect size was r_rb = 0.66, indicating a large practical effect despite the small sample size. Given the small sample size and potential ceiling effects, the nonparametric Wilcoxon test provides the more appropriate inferential summary.

3.3. Visualizing Scholar Trajectories

Individual GPA trajectories and baseline-to-latest change scores are presented in Figures 1-3. Figure 1 displays each scholar's GPA change from first to latest funded term. Figure 2 shows full term-by-term trajectories, and Figure 3 provides a summary by funded participation length.

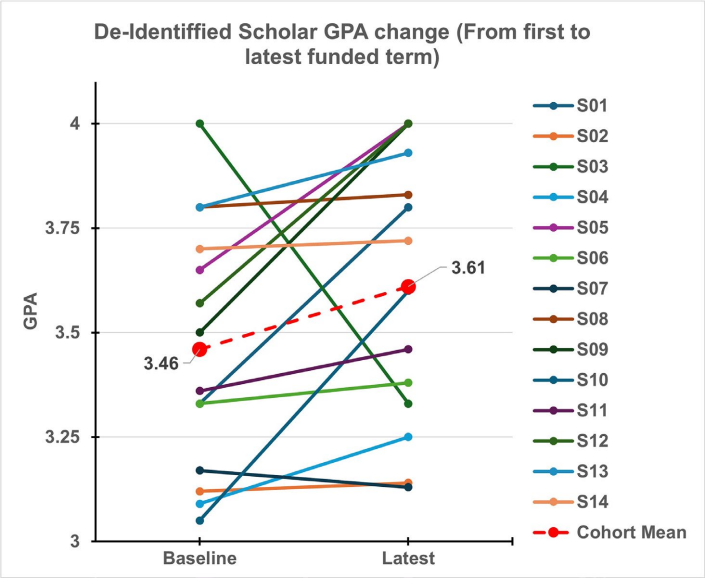

Figure 1. De-identified scholar GPA change from first to latest funded term.

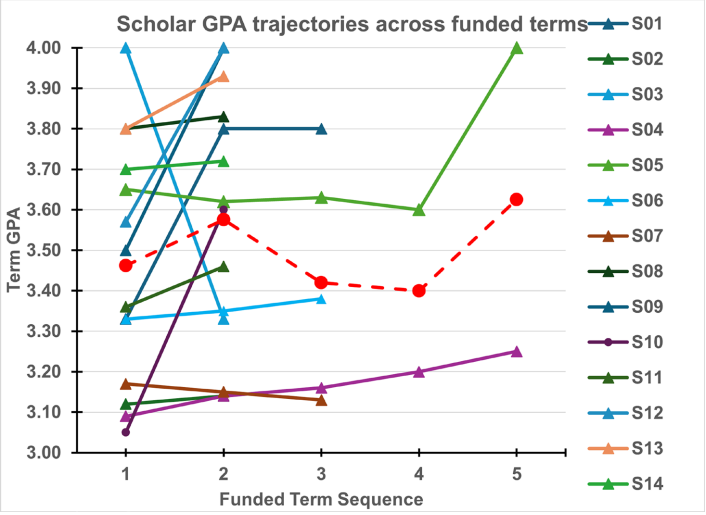

Figure 2. Scholar GPA trajectories across funded terms.

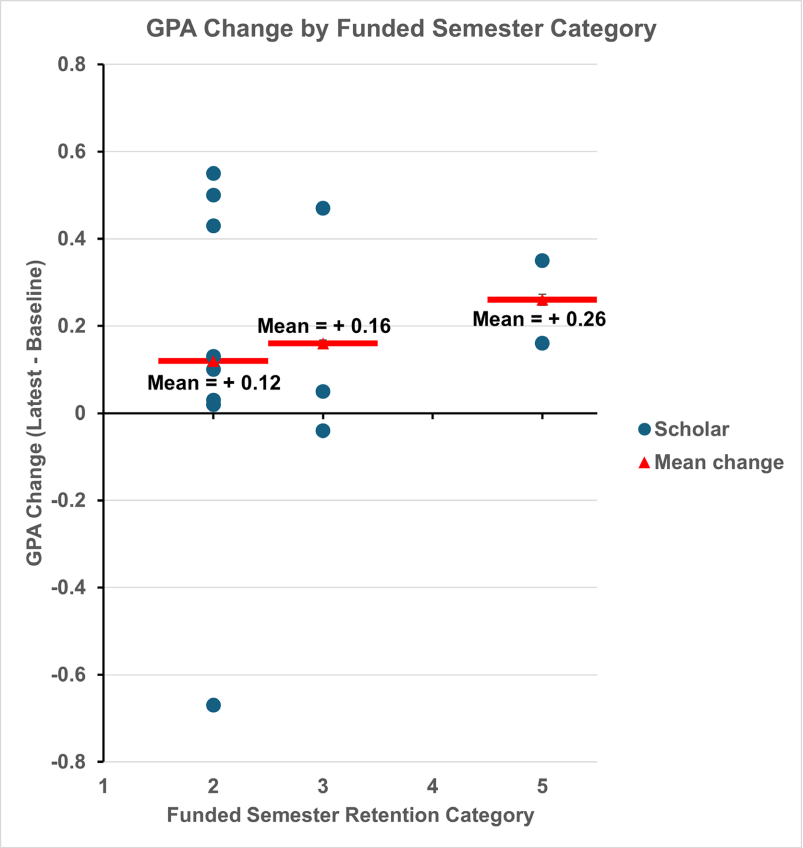

Figure 3. GPA change by funded-semester participation length.

3.4. GPA Patterns by Funded Participation Length

Table 1 presents GPA patterns descriptively by number of funded terms. A gradient in mean GPA change was observed across participation categories: scholars funded for 2 terms showed a mean change of +0.12, those funded for 3 terms +0.16, and the 2 scholars funded for 5 terms showed +0.26. However, because subgroup sizes were very small (particularly the 3-term and 5-term groups), these patterns are presented for descriptive purposes only and should not be interpreted as reliable evidence of differential effects. No formal statistical comparisons were conducted between subgroups due to insufficient sample sizes. Scholar-level baseline and latest GPA outcomes for all 14 participants are presented in Table 2.

Table 1. Baseline-to-latest GPA pattern by funded-semester participation length.

Group	n	Mean Baseline GPA	Mean Latest GPA	Mean Change	Improved n (%)
Overall	14	3.46	3.61	+0.15	12 (85.7%)
2 terms	9	3.54	3.67	+0.12	8 (88.9%)
3 terms	3	3.28	3.44	+0.16	2 (66.7%)
5 terms	2	3.37	3.62	+0.26	2 (100%)

Table 2. Scholar-level baseline and latest GPA outcomes.

Scholar ID	Level	Terms	Base sem.	Latest sem.	Base GPA	Latest GPA	Change	Pattern
S01	Grad	3	Fall 2024	Fall 2025	3.33	3.80	+0.47	improved
S02	UG	2	Fall 2024	Spring 2025	3.12	3.14	+0.02	improved
S03	UG	2	Fall 2024	Spring 2025	4.00	3.33	-0.67	declined
S04	UG	5	Fall 2023	Spring 2025	3.09	3.25	+0.16	improved
S05	UG→Grad	5	Fall 2023	Spring 2025	3.65	4.00	+0.35	up w/fluctuation
S06	UG	3	Spring 2023	Fall 2023	3.33	3.38	+0.05	improved
S07	UG	3	Fall 2024	Fall 2025	3.17	3.13	-0.04	declined
S08	Grad	2	Spring 2025	Fall 2025	3.80	3.83	+0.03	improved
S09	Grad	2	Summer 2025	Fall 2025	3.50	4.00	+0.50	improved
S10	UG	2	Spring 2025	Fall 2025	3.05	3.60	+0.55	improved
S11	Grad	2	Fall 2024	Spring 2025	3.36	3.46	+0.10	improved
S12	UG	2	Fall 2024	Spring 2025	3.57	4.00	+0.43	improved
S13	UG	2	Spring 2025	Fall 2025	3.80	3.93	+0.13	improved
S14	UG	2	Spring 2023	Fall 2023	3.70	3.72	+0.02	improved

4. Discussion

This small-cohort longitudinal evaluation suggests that participation in the SPINS program is associated with GPA stability and modest improvement among an already high-achieving group of STEM scholars at an HBCU. The observed average within-student GPA increase of +0.15 points occurred in a selective cohort that entered the program with a strong mean baseline GPA of 3.46. In this context, maintaining uniformly strong performance (all term GPAs 3.05 or higher) and achieving modest gains for 12 of 14 scholars is a positive outcome, particularly given the presence of ceiling effects for students who entered with GPAs near 4.0.

These findings align with Social Cognitive Career Theory (SCCT), which emphasizes how structured environmental supports can bolster academic self-efficacy and goal persistence (Lent et al., 2005; Randolph, 2019). The multi-layered mentoring approach in SPINS—combining faculty guidance on challenging coursework, near-peer tutoring, and individualized feedback for workshops and internships—likely contributed to these results by reinforcing science identity and a sense of belonging in the scientific community (Byars-Winston & Rogers, 2018; Ghazzawi et al., 2021).

A notable strength of the SPINS program is its location within an HBCU environment, which often provides culturally responsive mentoring practices that resonate strongly with African American students. This context appears to enhance the effectiveness of the program's technical and professional development activities.

While GPA trajectories provide a valuable objective indicator of academic performance and persistence, they do not directly capture psychosocial constructs

such as science identity or sense of belonging. Future iterations of the SPINS evaluation will benefit from incorporating validated instruments, such as the Science Identity Scale (Vincent-Ruz & Schunn, 2018) or the single-item STEM Professional Identity Overlap measure (McDonald et al., 2019), to more fully assess these important mediators of long-term STEM persistence.

However, several limitations must be acknowledged. The small sample size (N = 14) limits statistical power and generalizability. As a single-group design without a matched comparison cohort, the study cannot fully rule out natural academic maturation, course selection effects, or survivorship bias. Reliance on GPA as the sole outcome, while appropriate as an intermediate metric for multi-semester programs (Cappelli et al., 2019), does not capture important psychosocial factors.

Despite these constraints, the use of nonparametric methods (Wilcoxon signed-rank test) along with a large rank-biserial correlation effect size (r_rb = 0.66) provides a robust exploratory signal for a program of this nature (Habig & Gupta, 2021). Program records further show strong alumni placement into national laboratories and industry, suggesting meaningful contributions to the STEM workforce pipeline.

This evaluation reinforces the importance of sustained, high-quality, culturally responsive mentoring over short-term interventions. Future studies should use larger samples, matched comparison groups, and multifaceted outcomes to better examine program impact (Valla & Williams, 2012).

5. Implications for Practice

This exploratory evaluation suggests that multi-semester mentoring programs like SPINS can help maintain strong academic performance and support modest GPA improvement among already high-achieving STEM scholars at HBCUs. The program's combination of faculty-led academic guidance, near-peer mentoring, and individualized customization of workshops and research opportunities appears promising for sustaining academic momentum.

Program leaders should therefore prioritize sustained, responsive, and culturally congruent mentoring structures rather than one-off interventions. Specific recommendations include:

- Implementing formal mentoring agreements and Individual Development Plans (IDPs) for each scholar to clarify expectations and goals (National Academies of Sciences, Engineering, and Medicine, 2019).
- Strengthening early-alert systems tied to academic performance.
- Routinely collecting scholar feedback to tailor professional development and internship placements.
- Explicitly incorporating practices that support science identity and sense of belonging, consistent with culturally responsive approaches common in HBCU settings.
- Expanding program evaluation beyond GPA to include psychosocial outcomes

such as science identity, belonging, STEM major persistence, graduation rates, and post-graduation placement.

Table 3 presents a practical, evidence-informed mentoring framework for future implementation. This proposed framework addresses gaps identified in the current exploratory study by integrating systematic collection of psychosocial data (such as belonging and science identity) alongside traditional academic metrics.

Table 3. Recommended SPINS mentoring plan for one academic-year pilot.

Program component	Action	Cadence	Primary owner	Metric to track
Structured mentor matching	Match each scholar with one primary faculty/staff mentor and one near-peer mentor using discipline, career interests, and availability.	Before each funded term	Program director	100% of scholars matched by week 1
Mentor training	Require a short mentor orientation anchored in communication, expectation-setting, feedback, diversity/inclusion, and career development.	Before term + annual refresh	Program leadership	Mentor completion rate; post-training self-assessment
Mentoring agreement	Use a one-page mentoring compact that defines meeting frequency, expected response time, academic goals, and research/professional goals.	Week 1	Mentor + scholar	Completed compact on file
Individual development plan	Set one academic goal, one research/professional goal, and one well-being/support goal each term.	Weeks 1 - 2	Scholar + mentor	IDP completion and end-of-term review
Regular touchpoints	Hold biweekly check-ins during the semester and one midpoint progress review using GPA, course load, and engagement indicators.	Biweekly + midpoint	Mentor	Meeting logs; midpoint status
Early-alert system	Trigger support when a scholar misses two meetings, reports academic difficulty, or shows a sharp GPA decline risk.	As needed	Program coordinator	Time from alert to follow-up
Research and identity support	Connect scholars to research presentations, lab visits, conference preparation, and scientist identity-building opportunities.	Monthly	Program staff + mentors	Participation counts; reflection prompts
Professional development	Offer workshops on time management, graduate school planning, scholarly writing, and networking.	2 - 3 per term	Program staff	Attendance; workshop feedback
Program evaluation	Collect baseline and end-of-term data on mentoring quality, belonging, science identity, and next-step outcomes in addition to GPA.	Each term	Program evaluator	Survey response rate; longitudinal dashboard

6. Limitations

This study has several important limitations. First, the overall sample size is small (N = 14 scholars, 37 scholar-semester observations), which results in low statistical power and restricts generalizability, even within the specific institutional or HBCU STEM context. Subgroup analyses by duration of participation were especially constrained, with some groups containing as few as two or three scholars. These small strata are too limited to support reliable inferential comparisons and are highly susceptible to individual student variance. Nonparametric approaches such as the Wilcoxon signed-rank test were used to maximize the validity of inferences possible with small samples (Habig & Gupta, 2021).

Second, the study used a single-group, retrospective longitudinal design without a matched comparison cohort of non-SPINS STEM students with similar baseline academic profiles. Scholars entered the program with a relatively high mean baseline GPA of 3.46, and several entered with GPAs near 4.0. This introduces notable ceiling effects, making large GPA increases unlikely. Without a suitable control group, it is not possible to fully determine whether the observed modest GPA increase (+0.15 on average) resulted from SPINS participation or from natural academic maturation, course selection patterns, or survivorship bias.

Third, the study relied exclusively on GPA as the outcome measure. While GPA is an appropriate intermediate indicator for multi-semester programs (Cappelli et al., 2019), it does not capture important psychosocial factors such as science identity, sense of belonging, or mentoring relationship quality. Broader institutional data on STEM major persistence, graduation rates, and long-term workforce outcomes were also unavailable.

Fourth, because scholars entered the SPINS program at different points in their academic careers, baseline and latest GPAs correspond to heterogeneous developmental stages. Although time was anchored to each scholar's first funded semester, this staggered entry still introduces potential confounding.

Despite these constraints, the longitudinal, individual-level trajectory data offer rare insight into multi-semester mentoring patterns among high-achieving STEM scholars at an HBCU. The findings should be interpreted as preliminary and exploratory, intended to inform program improvement and guide the design of larger, more rigorous future studies.

7. Conclusion

SPINS demonstrates encouraging academic patterns in this dataset. Across 14 scholars and 37 scholar-semester observations, GPAs remained uniformly strong and showed a general upward trend over time. The most defensible interpretation is that SPINS participation is associated with maintaining academic excellence while enabling modest but meaningful GPA gains for many students, particularly those with longer periods of engagement.

These results align with Social Cognitive Career Theory, suggesting that structured, multi-layered mentoring can support academic self-efficacy and science identity development even among high-achieving students at an HBCU (Byars-Winston & Rogers, 2018; Lent et al., 2005). The program's culturally responsive approach—combining faculty guidance, near-peer mentoring, and individualized support—appears well-suited to the HBCU context and contributes to sustaining student momentum in STEM.

Table 3 presents a practical, evidence-informed mentoring framework designed to build directly on SPINS' existing strengths. With enhanced mentor training, more comprehensive outcome tracking (including science identity and belonging), and continued longitudinal evaluation, SPINS has significant potential to make valuable contributions to both the STEM mentoring literature and

the development of a diverse, highly skilled national STEM workforce.

Acknowledgements

This study is sponsored by DOE/NNSA MSIPP DE-NA0003980. The authors are thankful to the support of the DOE/NNSA program manager and colleagues at participating universities and national labs.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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