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Beyond Scholarships: A Comparative Analysis of Institutional Approaches to Student Retention and Academic Achievement

Ms. Mary J Combs, Quality Measures, LLC

Mary J. Combs has over 20 years of experience in higher education and healthcare working with faculty as an instructional designer to create student-focused curricula using assessment data and program evaluation. She also has experience working with community-based organizations advancing health equity through data-driven strategies and providing performance feedback to improve clinical education. Combs excels in qualitative and quantitative analysis, project management, and delivering impactful training programs. She holds a Master's degree in Occupational and Technical Studies. As a Senior Evaluator at Quality Measures, LLC, Combs is committed to fostering continuous improvement and ensuring that programs achieve their intended outcomes. Her expertise in stakeholder engagement and communication ensures that evaluation findings are disseminated and utilized for maximum impact.

Dr. Codjo AC Akpovo, Quality Measures, LLC

Dr. Codjo AC Akpovo is a physicist with expertise in laser-produced plasmas, utilizing fast and ultra-fast high-power laser beams. From 2006 to 2024, he conducted and coordinated research activities for numerous scientific grants at Florida A&M University (FAMU). While coordinating research and program services for the NSF HBCU-UP Science Community for Active Learners to Enhance Achievement and Retention (SCALAR II) STEM research education grant at FAMU from 2019 to 2021, Dr. Akpovo continued conducting scientific research part-time. His experience with this grant sparked a strong interest in program evaluation, which led to an opportunity to step into the field as an independent contractor with Quality Measures LLC (QM) from 2019 to 2024. In 2024, Dr. Akpovo joined the Quality Measures, LLC team as a Program and Project Evaluator.

Dr. Gwen Lee-Thomas, Quality Measures LLC

Dr. Gwen Lee-Thomas is the founder and CEO of Quality Measures, LLC—a Virginia-based consulting firm specializing in program and project evaluation and training in evaluation capacity building. She has been an external consultant for nearly 30 years serving businesses, government organizations, community-based organizations, and colleges and universities across the nation. In addition, Gwen has worked in executive leadership capacities as state board chair of the Indiana Minority Health Coalition (IMHC), Executive Assistant to two college/university presidents (Rose-Hulman Institute of Technology (RHIT) and Old Dominion University (ODU)), and commissioner on the Indiana Commission for Higher Education (ICHE). As the Director of Assessment at RHIT, she has worked with faculty in developing and creating rubrics for student learning outcomes (SLOs) as well as consulting with other universities on the creation and alignment of SLOs for regional accreditation. She has worked collaboratively with her board members, senior administrators, and legislative caucuses in navigating state budget cuts, developing a revenue-generating subsidiary, designing, and implementing an affiliation/de-affiliation agreement with local coalitions, and developing their 5-Year strategic plan. As the Executive Assistant to the President of RHIT, Gwen worked closely with the president in the restructuring of the organization's administrative team—including retirements, reassignments, and promotions, provided the logistical work for the 5-Year strategic plan with the College's 52-member board of directors, and supported the College in reducing their budget by 6% across all functional areas. In addition to these experiences, Gwen has conducted over 130 grant-funded education and research-based evaluations, collectively throughout the United States. Gwen received her bachelor's degree from Southeastern Louisiana University in 1984, a master's degree in Curriculum and Instruction in 1996, and a PhD in Education Administration in 1999, both from Indiana State University.

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Abstract

The National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program supports low-income, high-achieving STEM students through scholarships and tailored support services. This paper compares the implementation and impact of three different S-STEM projects across three diverse institutions—Rowan University, Albany State University, and Tennessee University, highlighting their distinct approaches and outcomes for diverse student populations.

At Rowan University (RU), a public R2 university in the northeastern United States, the 5-year S-STEM project — *Engineering Persistence: Support System for Low-Income Students to Catalyze Diversity and Success* — targets undergraduate engineering students, offering scholarships and a robust support system that includes Diversity, Equity, and Inclusion (DEI) leadership training. These efforts foster academic success and retention among underrepresented students. Evaluation findings showed a pre-to-post increase (3.1 to 3.7/4.0) in scholars' intent to complete undergraduate engineering degrees but highlighted the need to improve peer engagement in DEI discussions, as evidenced by a decline (3.2 to 2.9/4.0) in DEI engagement.

At Albany State University (ASU), a public Historically Black College and University (HBCU) in the southeastern United States, the 6-year S-STEM project — *It Takes a Village: Communities Leveraged to Advance Scholars' Success* (CLASS) — served undergraduate biology, chemistry, and forensic science majors. Student services included peer mentoring, career development, and a science communication learning community. The project emphasized community engagement through first-year courses and faculty and alumni mentoring. Evaluation findings indicated that self-reported survey data showed that 75% of the initial program participants stayed with the program the second year. Additionally, scholars demonstrated a strong commitment to completing undergraduate and graduate STEM degrees, with likelihood ratings ranging from 3.0 to 3.5/4.0.

At Tennessee State University (TSU), a public R2 land-grant HBCU in the southern United States, the 5-year S-STEM project — *Scholars to Attract and Retain Students (STARS) in Graduate Engineering and Computer Science* — supported graduate engineering and computer science students through financial assistance, mentorship, and professional development. A key project goal was to establish a graduate student association to sustain the student community post-funding. As of Fall 2022, retention for Cohort 3 (Fall 2021 entrants) reached 83%. Graduation rates by the fourth year were 100% for Cohort 1 (Fall 2019 entrants) and 86% for Cohort 2 (Fall 2020 entrants). These outcomes are comparable to the institutionally reported fall-to-fall retention rate of 86% for master's students, excluding those who had already completed the program. Despite recruitment challenges, pandemic impacts, and post-grant sustainability concerns, the project successfully cultivated a supportive community, enhancing student success.

Using a quasi-experimental evaluation design, the paper evaluated retention, academic performance, and post-graduation outcomes. The findings indicated that tailored services, such as mentoring, early intervention, and professional development, enhanced the persistence and success of underrepresented and low-income STEM students. The findings underscored the importance of inclusive, evidence-based strategies in fostering a diverse STEM workforce and highlighted the need for institutional structures to sustain project benefits beyond the funding period.

This paper focuses on the diversity of S-STEM project implementation and outcomes, emphasizing how tailored support services contributed to the long-term success of underrepresented and low-income students in STEM fields and advocating for strategies to promote inclusivity and sustainability.

Introduction

The NSF S-STEM program aims to enable academically talented, low-income students to pursue successful careers in promising STEM fields. The program seeks to increase the number of low-income students graduating with STEM degrees and contributing to the American innovation economy [1]. While efforts to enhance representation in STEM has led to nearly a 74% increase in STEM degrees awarded from 2010 to 2020, representation gaps remain, particularly for low-income students, first-generation college students, and underrepresented racial and ethnic minorities [2]. These disparities are concerning because the nation's demographics are shifting, and projections indicate that by 2045, no single racial or ethnic group would constitute a majority [3].

These inequities pose a challenge to fostering a STEM workforce that reflect the diversity of the U.S., which is essential for bringing the unique perspectives and experiences critical for innovation and global competitiveness [3]. Addressing these issues is not just a matter of social justice but a strategic imperative for sustaining the nation’s leadership in scientific and technological advancements. Marginalized students face systemic barriers in accessing, persisting, and succeeding in STEM fields, which necessitate the implementation of targeted projects like S-STEM [4].

This paper examines distinct implementations of S-STEM projects to demonstrate how their goals aligned with the broader mission of diversifying the STEM pipeline. It highlights the role of support services in fostering student retention and academic success, while also offering insights into the broader implications for advancing STEM education across various institutional contexts. Furthermore, the paper explores how these projects integrate with larger institutional models, shedding light on their potential for long-term impact. By addressing persistent challenges such as recruitment barriers, pandemic-related disruptions, and the need for sustainability beyond grant funding, this work contributes to the growing evidence supporting inclusive, data-driven strategies that promote academic success and workforce diversity in STEM.

The following analysis provides insight into project elements that promote long-term student success across different institutional settings and examines how these projects align with broader institutional models to better understand their potential for sustained impact. The paper examines key institutional factors — funding structures, leadership support, and faculty involvement — that drive the success and sustainability of S-STEM projects. Overall, it contributes to the growing body of evidence supporting inclusive, data-driven strategies that advance academic success and workforce diversity in STEM. To guide this analysis, the paper addresses the following research questions:

1. How do tailored support services contribute to the long-term success of underrepresented and low-income students in STEM fields?
2. How do S-STEM projects align with broader institutional models to promote inclusivity and sustainability in STEM education?

Theoretical Framework and Methodology

The overall project evaluation employed a comprehensive and robust data-gathering strategy, with outcomes operationalized to reflect Tinto's Model of student retention [5]. The model was used to assess persistence among graduate and undergraduate students, with a particular focus on those from underrepresented and low-income backgrounds. Tinto's framework provided a lens for understanding the factors that influence student retention, with specific attention to both social and academic integration.

To guide the analysis presented in this paper, two primary constructs from Tinto's Model were used to examine how each project's evaluation reflected student persistence outcomes: (1) Pre-Entry Factors, referring to students' baseline characteristics at the time of program entry, and (2) Institutional Commitments, which include two sub-constructs. The first, *Social Integration*, was reflected in the RU's Engineering Learning Community (ELC) structure, modified to support its Engineering Persistence project-related initiatives; Peer-to-Peer, Faculty and Alumni Mentoring through the CLASS project at ASU; and graduate student engagement opportunities, such as the Graduate Student Organization component of the TSU STARS project. The second sub-construct, *Academic Integration*, encompassed experiences involving faculty interaction with students, faculty, alumni and peer-to-peer mentoring, professional development, and research opportunities. Using Tinto's Model in this way allowed the paper to examine how each project's design and implementation supported students' persistence in STEM.

The evaluation plan for the S-STEM projects at participating institutions employed a quasi-experimental design [6] involving two groups: an experimental group consisting of project participants and a comparison group of non-participants. Students in the experimental group were enrolled in the S-STEM project and required to engage in key project activities, while those in the comparison group had access to these activities but were not mandated to participate. By ensuring comparable student profiles across groups, this design offered valuable insights into the impact of the required activities on student success. This methodology was particularly appropriate in educational settings where random assignment to groups was not feasible.

The evaluation model for the project employed both outcome-based and process evaluations [7] to provide a comprehensive understanding of the mechanisms driving its success. Outcome-based evaluations measured the project's impact on student success by examining factors such as retention, academic performance, and post-graduation outcomes. Process evaluations complemented this by exploring the relationships among various components of the project and their influence on achieving the project's overall goals and objectives. Together, these approaches not only assessed the extent of the project's impact but also explained how and why it succeeded.

To support this dual approach, the evaluation incorporated a mixed-methods data collection strategies, combining both quantitative and qualitative data. Surveys and other assessment tools captured key metrics, including project outcomes and students' perceptions of the project contribution to their academic and professional growth.

Evaluation of Key Findings Based on Tinto's Model

Vincent Tinto's Model of institutional departure [8] provides a comprehensive framework for understanding student retention and success by examining pre-entry factors, academic integration, and social integration. These constructs offer insights into how students' backgrounds, initial commitments, academic engagement, and social interactions influence their persistence in higher education. By applying Tinto's Model, this paper analyzes key findings from the evaluations of three S-STEM projects, each implemented to support students in STEM fields. The analysis highlights the unique approaches taken by each institution, while also demonstrating the synergy between their strategies in addressing barriers to student success. Below is a brief examination of the projects' outcomes based on Tinto's core constructs.

Pre-Entry Factors

The three institutions collectively addressed critical pre-entry factors to support students in STEM. RU's Engineering Persistence project aims to support 24 full-time engineering students over the five-year project period, with each eligible to receive up to $10,000 per academic year in scholarship funding. These scholarships will be awarded to three cohorts of eight students each, who demonstrate financial need and an equity mindset. A second-year participant emphasized the importance of this support, stating, "The scholarship in itself helps a lot with the financial burden of college, and that's not something that I have to be stressing about while I'm in school." In addition to financial relief, DEI initiatives fostered a sense of belonging, particularly for underrepresented students. One scholar reflected, "Just me personally being a Black woman in STEM, that's definitely something about diversity inclusion itself... I feel like that's definitely something I see on a daily basis."

At ASU, the CLASS project focused on supporting 24 full-time students in biology, chemistry, and forensic science over the six-year project period, with each eligible to receive up to $10,000 per academic year in scholarship funding. This initiative provided foundational support for college success, including mentorship from faculty and alumni, which reinforced career goals and strengthened students' attachment to the institution. One participant stated, "Although [the

program] is a small part or fraction of what the university has to offer, it does play a big part in feeling connected to something that's really close to the career that I want to pursue later on."

In contrast, the STARS project at TSU was designed to support graduate students already accepted into the master's program in the TSU College of Engineering. The project aimed to support 30 students over the five-year project period, with each eligible to receive up to $10,000 per academic year in scholarship funding. Upon acceptance into the project, STARS scholars participated in an orientation event — the STARS Summer Bridge program —which introduced students to graduate school resources, time management strategies, and career development opportunities. In the later years, the bridge program incorporated components such as alumni panels further enhanced students' understanding of potential career paths One leader remarked, "I was amazed by the alumni; it was multi-year, spanning quite a wide swath of students or alumni."

Despite differences in approach, all three institutions addressed socio-economic and demographic challenges while fostering students' initial commitments through financial aid, mentorship, and structured transitional projects. These efforts collectively established a strong foundation for persistence and success.

Academic Integration

The three institutions demonstrated a shared commitment to academic integration, employing unique strategies to connect students to their academic environments. The Engineering Persistence project at RU developed a multi-faceted support system that included the S-STEM ELC, First-Year Engineering Clinic (FEC) I & II, and Calculus I, faculty and student mentors. The FEC, which had a positive impact on students' academic progress and professional career development. However, while the clinics received a high pre-survey rating (3.6/4.0) for academic impact (n=16) and (3.4/4.0) for impact on job/internship (n=14), the post-survey revealed a decline to (3.3/4.0) for academic impact (n=16) and (2.8/4.0) for impact on job/internship (n=16), highlighting the need for sustained engagement. Hands-on learning experiences such as the algae research project further supported academic integration by bridging theoretical knowledge with practical applications. A scholar described the impact of these activities, stating, "We're doing this algae project where we find actual real-world problems to solve with that [those] algae."

At ASU, the CLASS project included mentoring and research opportunities as key components. Faculty mentors provided opportunities and support including internships, conferences and other available programs. Students participated in professional conferences to gain exposure to the STEM community and develop career readiness skills. One participant described the internship opportunity as "pivotal" and indicated they were encouraged by the experience. Another called a faculty mentor "the reason" why they attended conferences and received travel awards. However, variability in outcomes indicated, as some scholars excelled while others struggled to "balance" other activities with academic expectations. A project leader noted, "We have some students who could probably do all of the skills, and we have some students who cannot." TSU STARS strengthened academic integration by embedding professional development into its cohort model.

Workshops on technical writing, time management, and library resources provided graduate students with tools to navigate the demands of academia.

Together, these efforts illustrated how academic integration was tailored to meet students' unique needs, reinforcing their intellectual development and connection to their fields.

Social Integration

Social integration emerged as a key focus across the three institutions, with projects designed to create a sense of belonging and community. The Engineering Persistence project at RU employed an ELC to promote peer and faculty interactions, fostering a strong sense of connection among students. Post-surveys indicated that 94% of S-STEM scholars[1] (n=17) showed a strong sense of belonging, compared to 81% of ELC-only students (n=91) and 85% of the comparison group (n=150). DEI initiatives further strengthened students' social ties, with one participant noting, "The discussions we've had... made me feel like I was included and that I could actually do it." One student shared, "I feel like [participating in the ELC S-STEM program] provided me the opportunity to make connections with other students in my majors and stuff like that." While another student stated, "Definitely with those connections that I've made in the ELC, it's helped me a lot with understanding a lot of the engineering material and the schoolwork and stuff, so that's been really good to have."

The CLASS project at ASU facilitated social integration through monthly cohort meetings and conference attendance, which encouraged community building and resource sharing. The survey asked the participants to share their level of engagement in mentoring. The survey data indicated gaps in participation in alumni mentoring and peer-to-peer mentoring, with engagement rates of 25% (n=1) and 50% (n=2) respectively, revealed areas for improvement in fostering stronger connections. One Alumni shared, "I think the overall experience has been a great experience. However, I think that some of the challenges are aligning the mentor and mentee's schedules, so you can make sure that you are guiding them and providing mentorship as well as you can is a bit of a challenge."

The social integration journey for STARS scholars began with an orientation event known as the STARS Bridge program, which served as the initial step into the cohort model and laid the foundation for a supportive academic community. This orientation marked the scholars' first exposure to structured peer interaction and institutional engagement. At TSU, participation in the STARS Graduate Student Association, along with other program experiences such as interactions with faculty, mentorship, professional development, and research opportunities, were among the key variables of social integration for STARS scholars. The project relied heavily on its cohort model, mentorship programs (faculty and professional), and professional development workshops and seminars to build a cohesive and inclusive environment. These strategies aimed to alleviate isolation, foster a sense of belonging, and integrate students both academically and socially to support their retention and success. The STARS Graduate Student Association represented the culmination of these efforts, providing a formal platform for sustained peer

[1]Engineering Persistence scholars who received scholarship and are in the ELC

support and community engagement. Across institutions, social integration initiatives fostered collaborative and inclusive environments that enabled students to build meaningful relationships and networks, thereby supporting their academic and personal growth.

In summary, the institutions showcased a unified commitment to improving persistence and success in STEM by addressing pre-entry factors, academic integration, and social integration. Through financial aid, mentorship, transitional programing, and community-building initiatives, they created supportive environments tailored to students' diverse needs. These synergistic strategies, rooted in Tinto's Model, demonstrated how comprehensive, inclusive approaches could enhance student outcomes across academic levels and disciplines.

Comparative Analysis of Project Strategies

The comparative analysis of S-STEM projects strategies at Rowan, Albany State, and Tennessee State Universities was conducted through the lens of Tinto's Model, which emphasizes pre-entry factors, academic integration, and social integration. This framework provided a comprehensive understanding of the strategies employed at each institution to enhance retention, academic success, and diversity in STEM. Moreover, this comparative analysis was expanded with examples of illustrating how administrative support, faculty engagement, and external partnerships shaped the long-term sustainability of these projects.

Pre-Entry Factors

Each project addressed pre-entry factors to varying degrees, preparing students for the rigors of STEM education.

- The Engineering Persistence project leveraged RU's Engineering Learning Community to introduce students to a supportive academic and social environment early in their college journey. The ELC provided a cohesive structure that allowed students to establish a sense of purpose and familiarity with STEM-focused resources.
- The CLASS project prioritized the First-Year Experience (FYE), a foundational ASU initiative aimed at helping students transition into college life. This project equipped students with academic and social tools, including peer, alumni and faculty mentoring, to navigate the challenges of STEM majors.
- The STARS project at TSU implemented the STARS Bridge program as a pre-entry strategy. This 2.5-day orientation focused on critical skills such as time management, study strategies, and navigating graduate school resources, laying a solid foundation for success.

Academic Integration

Academic integration, a core element of Tinto's Model, was addressed through tailored support systems and professional development opportunities across all projects.

- The Engineering Persistence project emphasized academic integration through mentorship, faculty interactions, and the First-Year Engineering Clinics. While these efforts fostered students' development of STEM identities, survey data indicated declining engagement with academic support services over time, suggesting a need for sustained intervention.
- The CLASS project integrated academic support by providing opportunities for students to attend professional conferences and participate in faculty-led and alumni mentoring projects. These activities helped students connect classroom knowledge to real-world applications. However, areas such as scientific communication and writing remained underemphasized, indicating opportunities for improvement in academic preparedness.
- The STARS excelled in fostering academic integration through its cohort model, professional development workshops, and mentorship initiatives. These elements helped students navigate their academic projects and equipped them with the skills needed for career and doctoral pursuits. Alumni panels and guest lectures further strengthened the link between academic experiences and professional readiness.

Social Integration

Social integration was central to the success of each project, aligning with Tinto's emphasis on creating a sense of belonging and community.

- The Engineering Persistence project at RU used its ELC to promote teamwork and networking among students. DEI initiatives were integrated into the project to foster an equity mindset, although sustaining peer engagement in DEI discussions proved challenging. To counter the decline in DEI-related engagement, which may have stemmed from scholar's lack of interest and/or engagement strategies, integrating DEI into required curricula is essential to ensuring sustained participation and meaningful incorporation into the academic experience.
- The CLASS project at ASU focused on cultivating a welcoming and inclusive environment through cohort meetings, peer-to-peer interactions, and faculty and alumni mentoring. These activities created a supportive atmosphere where students believed they were empowered to succeed. Despite these efforts, variability in alumni engagement suggested a need for more consistent social integration strategies.
- TSU STARS built through its cohort model a close-knit and supportive graduate student community. This model mitigated feelings of isolation often experienced by graduate students, particularly those from underrepresented groups. Peer mentorship and cross-cohort interactions orchestrated by the STARS bridge program played a pivotal role in fostering a shared sense of purpose and mutual support. The project also addressed students' mental wellness, further enhancing their social integration.

Factors Influencing Sustainability

The ELC was integrated into RU's structure to promote the program's sustainability. Faculty interviews suggested that components like the ELC were so deeply embedded that their removal would have required active intervention, indicating that the program's core elements were likely

to persist beyond the grant cycle. The ELC contributed by creating a sense of belonging, which was particularly important for students from low-income backgrounds, and by establishing a strong community, as evidenced by peer support. The ELC fostered inclusion through discussions that created a supportive environment, particularly for students from diverse backgrounds. Furthermore, it eased peer and mentor relationships, provided hands-on activities and practical workshops—such as Excel seminars—and enhanced communication and leadership skills. Mentors in the ELC program provided personal support and encouragement, helping peers overcome challenges.

The CLASS project at ASU faced challenges concerning social integration and alumni engagement that could affect its long-term sustainability. While most scholars indicated having a strong sense of belonging, some expressed uncertainty and there was a desire for more personal understanding from the university community regarding scheduling, involvement of campus activities and academic commitments. The project leveraged its faculty and alumni network to mentor students, provide career guidance, and serve as role models, helping students navigate career pathways with firsthand insights. Mentoring programs, particularly alumni mentoring had low participation rates and inconsistent communication. To address these issues, the program should focus on consistently monitoring students' sense of belonging, enhancing mentor training and communication, and making cohort meetings more engaging on a monthly basis. By strengthening social integration and continuing alumni involvement, the program could create a more supportive environment, potentially leading to improved student outcomes and greater program sustainability.

Sustainability beyond the grant period was a concern for the TSU STARS project leaders. While professional development seminars and the graduate student association were expected to continue, the future of faculty mentorship was uncertain. Leveraging Title III funds to support the research aspect of the STARS project was considered. Project leaders highlighted the need for dedicated administrative support to manage the program without overloading faculty. Limited funding at TSU, especially for master's students, could affect recruitment and retention, which the STARS project aimed to address by providing funding to domestic master's students to create a stronger pipeline to the Ph.D. program. Understanding and navigating institutional processes, particularly in managing sub-awards and contracts, are important for replicability, and a post-award orientation for new principal investigators could improve replicability and facilitate the implementation of similar projects in other institutions.

Impact on Retention and Academic Success

Mentorship and community building emerged as critical components across all projects, contributing to both academic and social integration. Early intervention strategies, such as bridge projects and freshman-year initiatives, addressed pre-entry factors and laid the groundwork for student success. However, challenges such as sustaining engagement, addressing variability in outcomes, and ensuring long-term project sustainability highlighted areas for further improvement.

Rowan University's Engineering Persistence multi-faceted support system and leadership development opportunities demonstrated the potential of integrating DEI initiatives into academic and social frameworks, although maintaining engagement remained a challenge. ASU's CLASS combined academic and social support, fostering career aspirations and confidence, but needed to strengthen specific academic skills and mentoring participation. TSU's STARS excelled in building community cohesion and professional development but faced challenges related to recruitment and project sustainability.

By aligning these project strategies with Tinto's Model, this analysis emphasized the importance of addressing pre-entry factors, fostering academic integration through targeted support systems, and enhancing social integration to create a supportive and inclusive environment for STEM students.

Challenges and Lessons Learned

The implementation of S-STEM programs at Rowan, Albany State, and Tennessee State Universities revealed both common challenges and institution-specific responses. By analyzing these experiences through Tinto's Model of Student Retention — which emphasizes pre-entry factors, academic integration, and social integration — this section examines key obstacles and the strategic approaches adopted to address them. The findings offer insights into institutional sustainability, faculty engagement, student support, and program resilience.

Challenges in Recruitment and Diversity Engagement

A challenge across institutions was recruiting underrepresented and low-income students, a critical factor for fostering diversity in STEM fields.

- The Engineering Persistence project, benefiting from established institutional support, was able to overcome early recruitment barriers by embedding its initiatives within university structures.
- The CLASS and STARS projects, however, encountered, at the onset, limited project visibility and external competition, leading to inconsistencies in recruitment outcomes.
- All three institutions identified high-school partnerships and personalized outreach as strategies for increasing engagement and improving recruitment pipelines.
- Despite the challenges encountered, the TSU STARS project was completed and had supported three cohorts of an average of six (6) students each, totaling 19 students. The Engineering Persistence and CLASS S-STEM projects are each in their second year and have supported, thus far, 20 and 12 students, respectively.

Despite the emphasis on Diversity, Equity, and Inclusion (DEI) efforts, sustaining student participation remained a challenge.

- The Engineering Persistence project aligned its programming with broader DEI initiatives, integrating identity-based projects to create meaningful academic connections.

- The CLASS project emphasized community-building activities but struggled with maintaining student engagement over time.
- STARS, though less focused on explicit DEI programming, fostered inclusivity through its cohort model, which provided a structured peer support system.

These variations highlight a key lesson: While DEI engagement can take multiple forms, maintaining long-term participation requires ongoing innovation and institutional commitment.

The Role of Mentorship in Student Retention

Mentorship played a pivotal role in both academic and social integration across the institutions. Faculty and peer, and alumni mentoring were essential for fostering a sense of belonging, professional development, and retention. However, institutions experienced differing levels of success in sustaining mentorship engagement:

- The Engineering Persistence project (at RU) and CLASS project (at ASU) struggled with inconsistent alumni and peer mentoring participation, highlighting the challenge of maintaining engagement beyond the initial implementation phase.
- TSU STARS, by contrast, developed a structured mentorship framework that incorporated faculty, administrators, and peer mentors. This proactive model contributed to student retention and professional growth.

A key takeaway is that mentorship programs must be both structured and scalable, ensuring continuity even in the face of institutional or funding changes. Institutions seeking to replicate these models should prioritize faculty buy-in, clear mentorship roles, and ongoing support mechanisms.

Implications for Practice and Policy

The implementation of S-STEM projects at Rowan, Abany State, and Tennessee State Universities offered insights into improving STEM education practices and policies. These lessons emphasized the need for evidence-based strategies to enhance project success, institutional structures for sustainability beyond grant periods, and broader efforts to foster diversity and equity in STEM fields. The following synthesis provides actionable recommendations for decision-makers and practitioners, focusing on comprehensive support systems, sustainable frameworks, and inclusive practices that drive workforce diversity and student success.

Evidence-Based Strategies for Future S-STEM Implementations

Comprehensive support systems addressing financial, academic, professional, and social needs emerged as critical pillars for successful S-STEM projects. Academic support initiatives, such as the First-Year Engineering Clinics by Engineering Persistence project, the CLASS project First Year Experience and STARS Summer Bridge program (TSU), provided tailored interventions to help students build strong foundations. These efforts were complemented by study groups, peer

mentoring, and workshops on essential skills like time management and test preparation. These strategies fostered collaborative learning and equipped students with tools to excel academically.

Professional development components were equally vital, preparing students for STEM careers by offering resume-building workshops, career counseling, and real-world experiences through internships or co-ops. The CLASS project's inclusion of conference attendance exposed students to the broader STEM community, enhancing their career readiness and professional networks. Community-building efforts played a crucial role in student success. STARS's cohort model fostered camaraderie and mutual support, while the Engineering Persistence's ELC created spaces for collaboration. These approaches highlighted the importance of designing environments where students believed they were supported academically and socially. To maximize impact, targeted recruitment efforts focusing on underrepresented populations ensured that S-STEM projects reached diverse, academically talented students. Strategies included partnerships with high schools and community organizations, workshops, and campus visits designed to showcase the accessibility and benefits of STEM careers.

The Case of Rowan University's integration of the Engineering Learning Community

Rowan University's integration of the ELC into its core structures serves as a powerful example of how initiatives can extend beyond their initial grant periods, ensuring long-term sustainability and impact. Originally part of the Engineering Persistence S-STEM program, the ELC was strategically embedded into the university's framework to support low-income students in STEM fields by fostering a sense of belonging, STEM identity development, and leadership skills through a DEI-focused curriculum.

A key takeaway from this integration is that many of the program's interventions — excluding scholarships — are now permanent fixtures within the university. Rather than operating as short-term, grant-funded efforts, these initiatives have been woven into the institution's fabric in a way that would require active removal to discontinue, demonstrating a strong commitment to their long-term viability. Key aspects of the ELC and its lasting impact include:

- **Multi-faceted Support System**: Students benefit from an academic and co-curricular support structure designed to remove obstacles and increase graduation rates.
- **Engineering Learning Community (ELC)**: By fostering a shared learning experience, students develop a stronger STEM identity and build peer networks that contribute to their success.
- **Leadership and DEI Training**: Students gain valuable leadership skills and a DEI focused perspective, which enhances their personal and professional development.
- **Faculty and Peer Mentorship**: The First Year Engineering Clinics and mentorship programs provide critical academic and career guidance, with students citing these elements as having the most positive impact on their success.
- **Hands-on Experiences**: Through engineering clinics and active-learning courses, students build essential STEM skills while strengthening their sense of belonging.

- **Cohort Model**: The cohort experience enhances community-building, which is particularly important for low-income students who may otherwise feel isolated in STEM fields.

Rowan University's approach illustrates how integrating key elements of a grant-funded initiative into institutional structures can ensure long-term success. By embedding the ELC within the university's broader support system, Rowan has made it an essential part of its STEM education strategy, ensuring that future students continue to benefit long after the original funding period has ended.

Curricular Innovation and Inclusivity

Curricular innovations were instrumental in fostering inclusivity and sustained engagement in STEM projects. Integrating (DEI) principles into course content and assignments ensured that students saw themselves and their communities reflected in STEM disciplines. Faculty development workshops on culturally responsive teaching further equipped educators to create inclusive classrooms. Hands-on learning experiences, such as the Engineering Persistence project's First Year Engineering Clinics bridged theoretical knowledge and real-world applications, enhancing student engagement and confidence.

Identity-based projects further deepened student engagement by allowing them to connect academic concepts to personal interests and societal challenges. These projects emphasized the relevance of STEM to diverse cultural and social contexts, fostering a sense of belonging and purpose.

Data-Driven Project Evaluation

A commitment to data-driven evaluation ensured the ongoing progress of S-STEM projects. By collecting and analyzing both quantitative and qualitative data, institutions identified trends and areas for improvement. Stakeholder feedback, including input from students, faculty, and mentors, informed project refinements. Continuous improvement processes allowed projects to remain dynamic and responsive to evolving student and workforce needs.

Institutional Structures for Sustainability

Sustaining student support programs requires strategic use of existing resources, such as Title III funds and cross-departmental partnerships. These resources provide financial stability, institutional support, and collaborative opportunities that enhance program effectiveness. By integrating available funding and fostering interdisciplinary cooperation, universities can create sustainable models that support student success long-term. Three institutions—Rowan University, Albany State University, and Tennessee State University—offer compelling examples of how leveraging these resources can strengthen and sustain student support initiatives.

The Engineering Persistence project at RU prioritized cross-departmental collaboration to enhance DEI efforts. By bringing together multiple departments, the university fostered an

environment where different perspectives and expertise contributed to student success. Institutional support played a crucial role in ensuring the program's longevity, reinforcing the merit of internal cooperation in sustaining impactful student programs.

The ASU's CLASS demonstrated the power of engaging faculty, alumni, and industry partnerships to support student development. The university leveraged its alumni network to mentor students, provide career guidance, and serve as role models, helping students navigate career pathways with firsthand insights. Additionally, by integrating internship experiences, students gained practical exposure that enhanced their job readiness. ASU CLASS recognized the importance of expanding institutional and industry partnerships to broaden opportunities, ensuring scholars had access to diverse and impactful experiences.

The TSU STARS leveraged Title III funds to enhance the research component of its SSTEM program, strategically utilizing these resources to increase student engagement in research while ensuring sustainability without relying on new funding sources. In addition to financial strategies, the university prioritized professional development by opening seminars to all graduate students, reinforcing critical skills essential for career success. To further strengthen student support, TSU STARS established a graduate association, fostering lasting connections among students, faculty, and administrators. Another key lesson from the program was the importance of understanding institutional processes, particularly in managing sub-awards and contracts. By navigating these administrative elements, the university facilitated smoother program implementation and long-term sustainability.

Here is why it is important to leverage existing research

1. **Financial Sustainability:** Utilizing Title III funds or other grants supports key program components without requiring new financial sources.
2. **Institutional Collaboration:** Cross-departmental and external partnerships create a robust support system for students.
3. **Alumni and Industry Involvement:** Engaging alumni and industry partners enhances career readiness and professional exposure.
4. **Administrative Efficiency:** Understanding institutional processes allows for better resource management, especially in handling research funding and sub-awards.
5. **Long-Term Impact:** Initiatives such as graduate associations and professional development programs ensure the lasting success of student support efforts.

By strategically leveraging available resources, universities can enhance the impact, reach, and sustainability of their student support programs. The experiences of Rowan, Albany State, and Tennessee State Universities with their respective S-STEM projects demonstrate that with careful planning, collaboration, and financial strategy, institutions can ensure the long-term success of programs that empower students and support their academic and career goals.

Broader Implications for STEM Diversity and Equity

S-STEM projects played a pivotal role in addressing systemic barriers and promoting equity in STEM education. Inclusive learning environments, cultural awareness workshops, and equity focused discussions fostered collaboration and belonging. Mentorship opportunities, research experiences, and professional development activities helped students develop strong STEM identities and envision future career paths.

By recruiting and supporting underrepresented groups, S-STEM projects contributed to workforce diversity and innovation. Sharing best practices across institutions expanded these benefits, enabling broader replication of successful strategies. For instance, TSU STARS's emphasis on mentorship and collaboration served as a model for fostering resilience and inclusion.

The Need for Dedicated Administrative Support and Faculty Engagement

Dedicated administrative support and faculty engagement are essential to strengthening institutional commitment to STEM programs for low-income students. At Rowan University, faculty involvement was a driving force behind the success of the S-STEM project, with many faculty members viewing it as an opportunity for collaborative leadership and skill development. Their dedication to fostering diversity, equity, and inclusion enriched the program and deepened students' understanding of these concepts. However, faculty also faced challenges in maintaining student engagement outside the classroom, prompting them to explore innovative strategies, such as centralized online communication platforms. Additionally, mentorship programs and structured academic advising influenced students' academic progress and professional development.

At Albany State University, mentoring emerged from the CLASS project as the preferred form of faculty support. On the post-survey, the scholars were asked to select the mentoring programs in which they have participated. Specifically, 75% of students (n=4) stated that they actively participated in faculty mentoring. Project leaders expressed confidence in the program's ability to recruit and retain low-income students, highlighting its transformative impact. Retention efforts received positive ratings, with an average rating of 4.2/5.0, underscoring the importance of monitoring and engagement strategies such as midterm and final reviews. The institution also identified a need for additional support mechanisms, such as workshops and targeted interventions, to better prepare students for STEM careers.

TSU STARS highlighted the importance of dedicated administrative support in managing the program and alleviating excessive burdens on faculty. Faculty turnover and increased responsibilities, particularly during the pandemic, posed challenges in maintaining a consistent pool of mentors. To address this, dedicated administrative staff provided stability in program operations, ensuring continuity and productivity. One-on-one mentorship emerged as a particularly impactful component, fostering close relationships between students and faculty. The cohort model further strengthened institutional commitment by creating a supportive network where students could rely on peers, faculty, and staff for both academic and personal guidance.

The leadership team's extensive experience in academic and administrative roles ensured the program remained well-organized and adaptable, reinforcing its success.

Across these institutions, the integration of structured administrative support and sustained faculty engagement has been fundamental to enhancing institutional commitment. By facilitating mentorship, fostering collaboration, and ensuring program management, these efforts collectively contribute to the long-term success of STEM initiatives aimed at supporting low-income students.

The Need for Institutional Structures Beyond the Grant Period

Long-term sustainability of S-STEM projects requires embedding successful interventions into the core structures of institutions. This ensures these initiatives become permanent components of the university's commitment to supporting STEM students, rather than temporary projects. For example, TSU STARS embedded professional development seminars into its curriculum, guaranteeing their continuation post-grant. Similarly, mentorship training for faculty and students or regular DEI workshops within academic departments can solidify such projects within the institution. Aligning S-STEM activities with institutional goals further integrates these initiatives into university operations, enhancing resilience against funding changes.

- *Leveraging existing resources is another critical strategy for sustainability.* Financial diversification, such as utilizing Title III funds or repurposing departmental budgets, can maintain key project components without reliance on single funding streams. Collaborative efforts across departments or partnerships with career services and writing centers also minimize redundancy while maximizing impact. For example, S-STEM projects could share resources for career counseling or scientific communication, extending their reach and efficiency.
- *Effective management of these projects requires dedicated administrative support.* Institutions should consider hiring project coordinators, advisors, or mentors to oversee daily operations. When hiring is not feasible, providing faculty with release time to manage S-STEM activities ensures smooth implementation. Streamlining administrative processes through centralized online platforms enhances communication ensuring these projects run well.
- *Faculty engagement plays a pivotal role in sustaining S-STEM initiatives.* Offering professional development opportunities focused on DEI equips faculty to create inclusive environments. Workshops on culturally responsive teaching and mentoring strengthen their ability to support diverse students. Institutions should also develop mentorship training projects to prepare faculty for guiding underrepresented students. Recognizing and incentivizing faculty contributions, such as through teaching awards or professional development funding, further encourages participation in these initiatives.
- *External partnerships and ongoing funding are essential for sustainability.* Community and industry collaborations provided students with internships, co-ops, and research opportunities, extending project benefits beyond graduation. Alumni engagement adds another layer of support, as alumni can serve as mentors, guest

speakers, or networking contacts. Together, these strategies create a robust foundation for sustaining S-STEM projects long-term.

Beyond sustainability, S-STEM projects address systemic barriers that disproportionately affect low-income students in STEM fields. Inclusive learning environments foster collaboration, understanding, and a shared sense of belonging among students from diverse economic and cultural backgrounds. Initiatives like cultural awareness workshops, student affinity groups, and diverse representation in curricula promote equity. Equally important are discussions on the societal impacts of STEM solutions and equity-focused projects that encourage broader perspectives.

A key outcome of these S-STEM projects is fostering a strong STEM identity among students. Mentorship, research opportunities, and professional development activities helped students see themselves as capable professionals. Facilitating mentoring relationships with faculty, alumni, and industry professionals, as well as offering opportunities to present research at conferences, enhanced students' confidence and professional growth. Workshops on public speaking, networking, and leadership further empowered students to articulate their ideas and excel in STEM environments. Career exploration events, job shadowing, and guest lectures also helped students visualize their future in STEM fields.

S-STEM projects also contributed to workforce diversity by increasing representation of underrepresented groups in STEM fields. A diverse workforce fosters innovation and ensures solutions address the needs of broader populations. Institutions can actively recruit and support these students while collaborating with industry to create inclusive workplaces. The success of S-STEM projects provides a model for replication at other institutions, as data highlights their positive effects on retention, graduation rates, and career readiness. For instance, TSU STARS exemplifies how mentorship, early access to resources, and collaboration support underrepresented students. Adapting such strategies enables other institutions to expand opportunities for diverse populations.

By embedding sustainability planning, inclusive practices, and robust mentorship into institutional structures, S-STEM projects can address systemic barriers, promote diversity, and prepare students to thrive in STEM fields. These strategies not only benefit individuals but also contribute to a more equitable and innovative STEM workforce, ultimately advancing societal progress.

Key Lessons and Strategic Takeaways

A comparative analysis of the S-STEM projects at Rowan, Albany State, and Tennessee State Universities offers important insights for institutions aiming to develop sustainable and scalable student support initiatives. See Table 1.

Table 1. Common factors from the Comparative analysis of the S-STEM projects programming

	RU Engineering Persistence	**ASU CLASS**	**TSU STARS**

Factors			
Program Sustainability	Embed initiatives into the institutional structure. Focus on consistent support, career preparation, and financial management resources.	Continuously assess and adjust the program to meet students' evolving needs and institutional changes. Strengthen high school preparation to ensure students are ready for STEM rigor.	Address sustainability concerns by securing diverse funding. Ensure dedicated administrative support to manage the program.
Faculty Engagement	Prioritize faculty mentorship, as it impacts academic progress and career development. Promote cross departmental collaboration and DEI training for faculty.	Encourage faculty mentoring. Increase faculty-student interaction on DEI topics.	Ensure faculty mentorship and support student retention and success.
Financial Strategy	Provide renewable scholarships to reduce financial barriers. Ensure students are well informed about scholarship programs and support services.	Target low-income students and offer dual enrollment credits to ease the transition to advanced coursework.	Alleviate financial burdens to increase diversity in STEM.
Community Building	Foster a sense of belonging through Learning Communities and peer support networks. Encourage discussions to promote inclusivity.	Implement Freshman Year Experience and monthly cohort meetings to provide regular support and motivation. Focus on addressing students' sense of belonging.	Build a strong cohort model for peer support and mentorship. Facilitate connections between cohorts to provide guidance and create networks.
Use of Technology	Establish a centralized online communication hub to keep students informed and engaged.	Develop a dedicated STEM website to serve as a resource and entry point for interested students.	Implement virtual programs to replicate in-person interactions and expand program reach.
Curriculum Integration	Integrate hands-on experiences, identity-based projects, and diverse perspectives into the curriculum. The First Year	Value Freshman Year Experience but improve scientific communication and writing training.	Implement bridge programs providing early access to resources, time management skills, and mental health support.

	Engineering Clinic had a positive impact.		

The following are key insights for future institutions:

- **Holistic Support Systems**: Combine financial aid with comprehensive academic, professional, and social support to address diverse student needs.
- **Faculty Engagement**: Cultivate strong faculty-student relationships through mentorship and DEI initiatives to foster an inclusive environment.
- **Community Building**: Create learning communities and peer support networks to promote a sense of belonging and encourage collaboration.
- **Curriculum Enhancement**: Incorporate hands-on experiences, real-world applications, and identity-based projects into the curriculum to enhance student engagement and career readiness.
- **Adaptive Strategies**: Continuously assess and adjust program components based on student feedback and institutional changes to ensure relevance.
- **Sustainability Planning**: Secure diverse funding streams and embed successful initiatives into the institutional structure to ensure long-term sustainability.

By integrating these insights, institutions can develop sustainable and scalable S-STEM programs that promote student success and broaden participation in STEM fields.

Overall, the experiences of Rowan, Albany State, and Tennessee State Universities with the S-STEM projects illustrate that while institutions face common challenges—including recruitment barriers, mentorship sustainability, and funding limitations—tailored, institutionally embedded approaches lead to greater program sustainability and student success. In addition, programs that prioritize faculty engagement, integrate mentorship into institutional structures, and develop hybrid program delivery models are better equipped to adapt to external disruptions and funding uncertainties. Finally, these findings provide a roadmap for institutions and policymakers seeking to enhance STEM student support programs. Future research should explore longitudinal outcomes of embedded vs. grant dependent programs and assess how institutions can further integrate technology and hybrid learning models to improve student success.

Conclusion

The comparative analysis of S-STEM projects across Rowan, Albany State, and Tennessee State Universities highlighted the transformative potential of comprehensive, evidence-based support systems in fostering student success. These projects demonstrated that retention, graduation rates, and career readiness in STEM fields could be enhanced by combining financial aid with robust academic, social, and professional development initiatives. Effective mentorship, tailored community-building efforts, and data-driven refinements emerged as pivotal factors for achieving positive outcomes. The findings underscored the importance of holistic project designs

that address the diverse needs of students while equipping them for long-term success in STEM fields.

To build on these successes, institutions and decision-makers must prioritize the scalability and implementation of proven strategies such as cohort-based learning, bridge projects, and professional development workshops. For these strategies to achieve their full potential, institutions need to integrate them into their operational frameworks, ensuring these supports become enduring components of their missions. Additionally, inclusivity must be central to project designs, incorporating diversity, equity, and inclusion (DEI) initiatives that reflect the needs of all students. Institutions must also adopt innovative funding mechanisms to sustain these efforts beyond the initial grant periods.

Embedding comprehensive support systems into institutional structures is essential for ensuring the longevity and impact of S-STEM projects. These systems should extend beyond financial assistance to include academic, social, and professional development opportunities tailored to the multifaceted needs of students. By institutionalizing these supports, universities can create sustainable frameworks that continue to benefit students well after the conclusion of grant funding. A culture of mentorship is equally critical, requiring intentional strategies to provide structured guidance from faculty, industry professionals, and peers. Such mentorship helps students navigate academic challenges, explore career opportunities, and build networks that support their professional growth.

Community building within institutions must also be a priority. Implementing cohort models fosters a sense of belonging and mutual support, which enhances student retention and engagement. Shared learning experiences through cohort-based approaches create collaborative environments that are vital for success in STEM disciplines. Meanwhile, decision-makers must act swiftly to increase and diversify funding for S-STEM projects, ensuring adequate resources for scholarships and the comprehensive services that drive student success.

DEI integration across all aspects of STEM education is another critical area for advancing SSTEM projects. Embedding DEI principles into curricula, project structures, and institutional practices ensures equitable opportunities for all students, regardless of their backgrounds. Decision-makers can further enhance project success by supporting data-driven decision-making. Requiring institutions to collect and analyze data on project outcomes allows for evidence-based improvements that address challenges and adapt to evolving needs.

Collaboration with high schools presents a powerful avenue for preparing students for STEM projects and creating pipelines for underrepresented populations. Strengthened partnerships between educational institutions and high schools can introduce students to STEM concepts and career paths earlier in their academic journeys, ultimately contributing to a more diverse and inclusive STEM workforce.

Future research will play an instrumental role in advancing the success and sustainability of SSTEM initiatives. Longitudinal studies are necessary to assess the long-term efficacy of these projects and to refine frameworks for embedding their components into institutional operations.

Such research will provide critical insights into the academic and career trajectories of participants, guiding future project enhancements. Concurrently, policy efforts must focus on amplifying support for low-income and diverse students in STEM by ensuring sufficient funding, fostering partnerships with community and industry stakeholders, and building institutional capacity for impactful programming.

In conclusion, these S-STEM projects have demonstrated their capacity to not only support individual student success but also address systemic barriers in STEM education and workforce development. By implementing the strategies outlined here and committing to research and policy reforms, institutions and decision-makers can scale the impact of these projects, creating a more equitable, innovative, and resilient STEM workforce. These efforts will not only empower students but also strengthen the nation's ability to meet the technological and scientific challenges of the future.

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