Engineering Student Success: Implications of combined Scholarship, Academic, and Community Support Interventions

Seyedehsareh Hashemikamangar, The University of Memphis
Dr. Stephanie S Ivey, The University of Memphis

Dr. Stephanie Ivey is a Professor with the Department of Civil Engineering in the Herff College of Engineering at the University of Memphis. She directs the Southeast Transportation Workforce Center and the West TN STEM Hub.

Craig O. Stewart, The University of Memphis

Dr. Craig O. Stewart is a professor of Communication at the University of Memphis.

Dr. Aaron Robinson, The University of Memphis

Dr. Aaron L. Robinson is an Associate Professor in the Department of Electrical and Computer Engineering at the University of Memphis. He is also a member of the CAESAR DTL and DRONES Research Cluster. His research foci include signal processing, sensor system analysis and design (with a focus on infrared wavelengths), turbulence mitigation, light propagation, and incorporation of electrical engineering concepts to transportation issues such as intelligent transportation system development, freight logistics, pre-emptive malfunction detection, workforce development, and student retention. He serves as faculty advisor for the University of Memphis student chapters of National Society of Black Engineers and the Institute of Electrical and Electronics Engineers.

Engineering Student Success: Implications of Combined Scholarship, Academic, and Community Support Interventions

Abstract

STEM fields play an important role in providing job opportunities and improving economic growth. The United States suffers from a shortage of and lack of diversity in STEM workers, particularly in engineering. One way to alleviate these challenges is to encourage students to choose engineering disciplines and support them as they progress through their engineering programs so that they develop a strong identity and sense of belonging in their chosen discipline. The University of Memphis (UofM) has been collaborating with the University of Colorado Denver (UCD) and Indiana University Purdue University Indianapolis (IUPUI) in the Urban STEM Collaboratory project since 2018. This NSF-funded project supports academically talented students with demonstrated financial need from the colleges/schools of engineering at the three institutions. The main goals of this project are increasing the recruitment, retention, success, and graduation rates of students and implementing strategies contributing to student academic success, development of STEM identity, and workforce readiness.

In this project, the UofM has supported more than 50 engineering and mathematics students since the academic year 2019-2020. This paper presents participation data, outcomes, and impacts of this five-year experience for UofM scholars. For both scholars and other eligible students, demographic data including gender, race and ethnicity, and first-generation status and academic performance data including overall GPA, GPA in math courses, GPA in major courses, credits received, retention rates, and graduation status are presented. Also, academic performance of scholars and non-scholars (S-STEM eligible students) are compared. The data is also analyzed to report gender and underrepresented/represented demographics.

The UofM scholars showed better academic performance across all measured categories and higher retention rates than S-STEM eligible students. To gain better insight into the impacts of the Urban STEM project on personal and academic life of the scholars, focus groups and interviews were used to allow scholars who have participated in the project to share more detail regarding their experiences, the benefits they gained, and the obstacles they faced. These findings and insights can support implementation or improvement of similar engineering student success initiatives at other institutions.

1. Introduction

The expansion of STEM graduates is crucial to cultivate economic progress as its increasing share has a positive impact on employment and economic growth [1]. According to U.S. Bureau of Labor Statistics, employment in STEM occupations is growing at 10.8% [2]. However, graduation rates in STEM majors are not very high. Nationwide, fewer than 40% of students entering college to major in a STEM field graduate with a STEM degree [3]. A U.S. Department of Education study showed that 48 percent of bachelor's degree students and 69 percent of associate's degree students who entered a STEM program between 2003 and 2009 either switched to a non-STEM field or left the college before earning a degree [4]. These low rates are especially more noticeable among women and underrepresented minority (URM) students. They leave STEM majors at higher rates than non-URM male students [3]

In this regard, family income and socioeconomic status (SES) are very impactful. A study using data from the NCES High School Longitudinal Study of 2009 indicated that 78 percent of the highest SES ninth-grader students were enrolled in postsecondary education in 2016 which was 50 percentage points larger than for the lowest SES students (28 percent) [5]. Since a school and/or family obligation requires low-income students to work, they cannot engage well in school and afford engagement activities like football games. The underrepresentation of low-SES graduates means that those graduates are missing out on the financial and professional benefits of job opportunities available through STEM. This underrepresentation also impacts the overall numbers of STEM professionals in the U.S [6]. The Scholarships in Science, Technology, Engineering, and Mathematics (S STEM) Program is an NSF-funded program that supports institutions of higher education to fund scholarships for academically talented students with financial need who are pursuing associate, baccalaureate, or graduate degrees in STEM. It also helps the institutions develop and implement activities that support their recruitment, retention and graduation in STEM [7]. Many institutions have applied funds from this program either exclusively or along with other financial resources to support academically talented low-income students.

Although research supports the positive impact of financial support on recruitment, academic performance, retention, and graduation rates of STEM students [6], [8]–[14], financial support alone is not enough for student success and retention. In one S-STEM program, scholars ranked the program components in terms of importance to them remaining in a STEM major. Although it is unclear whether students would be willing to participate in the program without financial gain, most scholars did not mention the financial award as the most important aspect to their retention [14].

Another way to help STEM students' success and retention is to support them academically. Workshops, seminars, meetings, and conferences [12], [15]–[19], faculty, scholar, or peer mentoring [10], [12], [16]–[20], research opportunities [12], [15]–[19], study and discussion groups [12], [15], professional development seminars [13], [16], [21], peer tutoring [21], faculty advising [13], [20], [22], Journaling, and VIP-based learning [12] are some activities that have been implemented to support STEM students academically.

Community building activities are very beneficial for STEM students as well. To retain their major and complete their degree, STEM students need a strong sense of community (SOC). It is shown that place and intentional interaction among community members are key factors in creating and sustaining SOC [23]. A strong community provides a trustworthy environment in which members learn from one another, share their experiences, help one another through academic or personal struggles, and expand their perspectives. Building a sense of STEM community not only supports current STEM students, but also encourages new students to join the community [24]. Many institutions [9], [18], [25], [26] have created a Living-Learning Community (LLC) to provide students with a strong social support system. LLCs are created by group events and activities such as annual retreat, peer mentoring, group studying, and Boot Camp in which students, peers, and faculties interact actively and meaningfully. It is shown that LLC has a positive impact on retention rate and academic success of STEM students [26]. Peer relationships and peer mentoring are of great importance in building a STEM community. A study focused on STEM identity among a group of S-STEM engineering scholars who were 'at risk' for dropping out of STEM due to unmet financial need showed that peer mentoring relationships and informal peer relationships plays an important role in scholars' journeys into becoming engineers. Peer mentoring relationships led them to feel connected to and recognized by other STEM students and motivated them to participate in STEM activities. Through informal peer relationships, scholars could see how others share the same interests in STEM fields and the same issues with STEM courses. These relationships were seen as the primary means for building community and getting help with courses [27].

The University of Memphis (UofM) has been collaborating with University of Colorado Denver and Indiana University Purdue University Indianapolis in the Urban STEM Collaboratory project since 2018. This NSF-funded project supports academically talented students with demonstrated financial need from the colleges/schools of engineering at the three institutions, and interventions are designed to support students in development of STEM identity and sense of belonging to facilitate academic success. In this project, the UofM has supported more than 50 engineering students since the academic year 2019-2020. Several components have been developed and implemented to provide students with academic and community support. This paper presents participation data, outcomes, and impacts of this five-year experience for UofM scholars.

2. Overview of the Program

The overall theme of the program is to support scholars to develop a STEM identity and sense of belonging so that they are retained and graduate from their engineering major. A main goal of the project is to apply, research, assess, refine, and improve a sustainable and flexible model to recruit and retain academically talented STEM students with financial need and help them to succeed in studies and careers within an urban setting. To achieve this goal, the collaborators have built on research, best practices, and evidence-based findings from other projects including several collaborators' NSF/DUE S-STEM and STEP projects.

2-1. Goals

There are six overarching goals of the Urban STEM Collaboratory project. All project activities, evaluation, and research efforts were designed with these goals in mind. The six goals include:

Goal 1. Increase the recruitment, retention, student success, and graduation rates of academically talented undergraduate mathematical sciences and engineering majors with financial need.

Goal 2. Implement strategies and activities that contribute to student academic success, development of student STEM identity, and workforce preparation.

Goal 3. Implement mechanisms to ensure student participation in the program's activities, including a special Urban STEM Collaboratory Badge system.

Goal 4. Implement special strategies and activities for mathematics classes that contribute to high probability of success in precalculus and calculus 1 and 2.

Goal 5. Conduct a research study for the program's goals.

Goal 6. Conduct project evaluation to investigate the extent to which each goal is being met.

2-2. Project strategies and activities

Considering findings and lessons learned from previous projects at each institution and incorporating best practices from research and other projects, several components were developed and implemented to provide students with academic, and community support. These components are explained in this section. While it was noted in Goal 4 that special strategies for mathematics classes were a priority, this proved very difficult because of the varied levels of readiness with which students entered the majors. Thus, the research team shifted focus to other activities rather than mathematics course interventions after the first year of the project.

Table 2: Academic and community support of program components

Component	Academic Support	Community Support
Course Networking (CN) Model	• Provides scholars with a platform for showcasing academic achievements • A place to find academic support	• A communication tool. • Boosts intercampus activities (fosters STEM identity and sense of belonging) • Promotes mentoring interactions
Summer Bridge Program	• Getting familiar with current academic technologies and resources (such as free tutoring services)	• A starting point to develop STEM community among scholars and faculty
Academic Year Workshops	• Ensures students are connected to academic support resources	• Maintains connections among scholars and project faculty • Provides access to free resources such as for mental health and career preparation • Connects students with alumni who share about their career journeys
Mentoring Program	• Academic Support through Faculty, Peer, and Career/Research mentoring	• Boosts communication skills, leadership skills, and self-efficacy (fosters STEM identity)
STEM Ambassadors Model	• Essential professionalism • Strengthens STEM content knowledge	• Boosts communication skills, leadership skills, and self-efficacy (fosters STEM identity) • Builds community among Ambassadors (fostering STEM identity and sense of belonging)
S-STEM Scholar Participation		• Encourage scholars to be an active member of STEM community

2-2-1. Course Networking (CN)

CourseNetworking (CN), provided by CourseNetworking, LLC is a key component of the project by which students can communicate and collaborate via the online academic networking platform. CN facilitates intercampus activities to lead to cultivation of the scholars' STEM identity. The ePortfolio feature of CN allows scholars to showcase their accomplishments, academic work and micro-certification badges that verify their project participation, knowledge, behaviors, and skill sets. Student self-reflection and student-student and student-faculty interactions are improved by CN posting and reflection tools.

'Seeds' and 'badges,' are features of the CN that are used as incentives for scholars to engage in project activities. They help incentivize, monitor, reward, and celebrate participation and achievements of scholars in the program. Accumulation of seeds provides a measurement for the scholar and project investigators to monitor participation in various activities. Low participation in activities reveals a focus for improvement, for both the project and the student, including identifying obstacles a scholar may be facing. Representative incentive focus areas for activities and events for the accumulation of seeds leading to badges include: i) academic success; ii) professional society leadership; iii) mentoring; iv) peer-led team leadership; v) career exploration and development; vi) research; vii) innovation and entrepreneurship; and viii) community service. Scholars have the opportunity to earn recognition through one of 17 badges offered, including a student-defined badge that requires review and approval by the project's faculty team. Examples of badge offerings are provided in Figure 1.

	Badge	Criteria
	STEM Collaboratory Bridge Scholar	Successfully complete the summer bridge STEM Collaboratory program as a student or a mentor, including building an initial e-Portfolio within CN.
	STEM Collaboratory Participant – *Semester*	Earn 250 seeds for posting to the STEM Collaboratory Network or one of the affiliated group networks (networks on CN).
	STEM Collaboratory Influencer - *Year*	Members selected for Post of the Week receive an additional 25 seeds. Students selected for 3 Posts of the Week in the STEM Collaboratory Network for any academic year receive the STEM Collaboratory Influencer badge.
	STEM Professional Member - *Year*	Join a professional organization related to major field of study. One badge will be awarded for active participation in each membership per year. Active participation requires attending at least 2 organization events each semester. Examples include, but are not limited to: ACM, ASCE, ASEE, ASME, BMES, IEEE, MAA, SHPE, SIAM, SWE, etc.

Figure 1. Example badge opportunities for Urban STEM Scholars.

2-2-2. Off to a Good Start – Summer Bridge Program

The Summer Bridge Program (SBP) is designed collaboratively by students and faculty each year and offered to each new cohort as well as continuing students across partner institutions. It serves as a starting point for students to develop STEM community. Students get familiar with CN during the SBP, which helps them start the process for becoming part of a local STEM community and engages them in a larger community across the Collaboratory. Students also take part in various activities designed to help them get to know one another and program faculty and to learn about the various support services available to them on campus, including tutoring, mental health services, and career preparatory support. The SBP was offered in person in the summer of 2019, virtually in 2020 due to COVID-19, and then in person each subsequent summer. Figure 2 shows examples of some of the activities students engage in during the SBP.

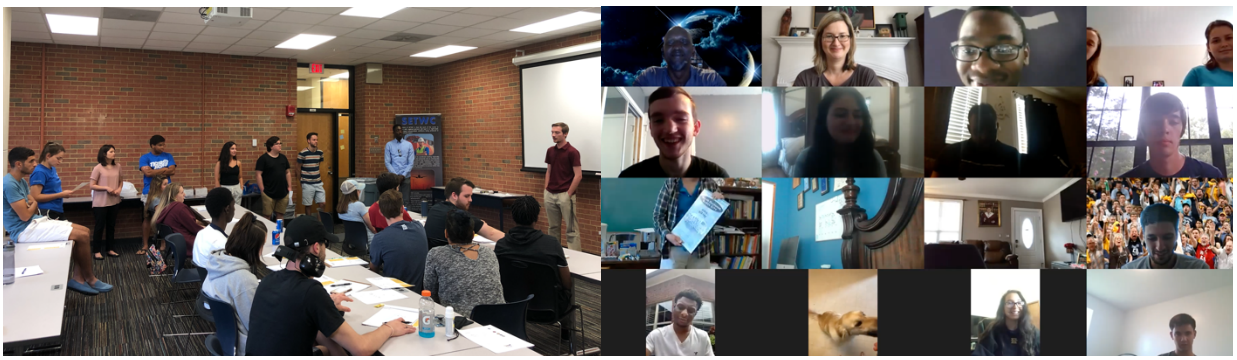

Figure 2. SBP participants learn about STEM student organizations (L) and participate in a virtual scavenger hunt (R).

2-2-3. Academic Year Workshops

The academic year workshops serve both a networking function as well as resource to ensure students are aware and taking advantage of support services on campus. Workshops are typically hosted around lunches or other meals and include time for students and faculty to network with one another in addition to the workshop program. Workshops focus on topics such as time management, stress management, student organization involvement, and campus career services. The sessions also include panels of recent graduates or industry leaders sharing insights into their career pathways and answering scholars' questions. Figure 3 shows an example of typical semester activities.

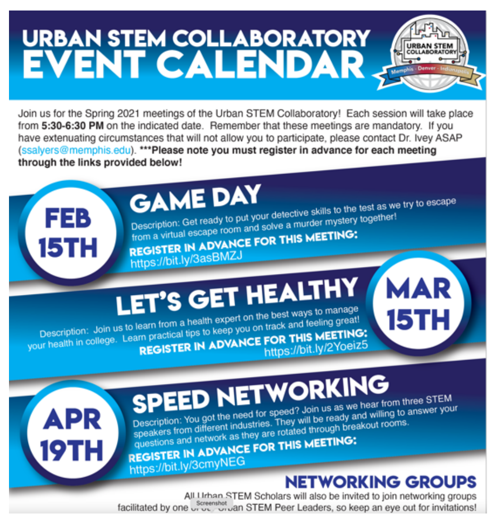

Figure 3. Example semester event calendar.

2-2-4. Mentoring Program and Structure

The mentoring program has evolved over the course of the project. Initially, scholars were connected to a faculty mentor during the summer Bootcamp. They met with their faculty mentors monthly in small groups. Based on feedback from the students, the mentoring program evolved in the second year to being conducted by upper division scholars. The current peer mentoring model also provides opportunities for scholars to develop leadership skills as part of STEM identity development.

2-2-5. UofM STEM Ambassador Program

The University of Memphis included its STEM Ambassador model as a core strategy for increasing scholars' STEM identity and success. The STEM Ambassador program engages undergraduate STEM majors in a paid work experience providing on-site support for teachers, community agencies, or companies that wish to engage K-12 students in STEM learning activities, benefiting both K-12 students and Ambassadors. K-12 students are provided with tutoring, STEM competition coaching, and other support while Ambassadors learn essential professionalism, communication, and leadership skills. A pilot-scale study with ten schools within the Shelby County Schools district during the 2015-16 academic year showed that students working with Ambassadors achieved math performance goals at rates of 12% (middle school) and 30% (elementary) higher than that of their peers [27]. It also revealed increased confidence in communication and leadership abilities and STEM self-efficacy ratings from the Ambassadors. Urban STEM scholars were offered the opportunity to join the STEM Ambassador program but were not required to participate.

2-3. Cohorts and Scholarships

The numbers of cohorts and numbers of years students receive S-STEM scholarships vary at each partner institution. The annual undergraduate tuition and fees for UofM are $8,619 and the estimated annual costs to attend to live at home or live on campus are UofM $15,214/$24,190. The UofM has awarded $1M for S-STEM scholarships over the 5-year duration of the grant to three scholar cohorts. The UofM team recruited from high schools and first-year UofM students for Cohorts 1 (2019) and 2 (2020) and first-year students for Cohort 3 (2021). In 2022 and 2023, upper division students were added to the cohorts if a spot became available due to a scholar leaving the program. This approach ensured that each scholar would have the potential to receive funding through their fourth year of college, and that all available funds would be awarded to eligible students.

2-4. Recruiting and Selection Process

Although each partner institution recruits and selects from its own pool of applicants, the process is coordinated across the Collaboratory. Working closely with financial aid offices and university recruiters, team members determine unmet financial need of qualified students and maximize quality, quantity, and diversity of applicants with demonstrated financial need. The partnering institutions take advantage of their urban settings with many students living nearby and make school visits to garner a strong pool of applicants from first generation students and students from underrepresented groups. UofM recruits from high schools as well as from a pool of committed in-coming freshmen and eligible students who are in their first year of college. First year college student applicants are recruited primarily from regular and honors calculus classes as well as from a first year "Introduction to Engineering" course. The PI also works directly with the financial aid office to obtain a list of eligible entering and continuing students so that an email regarding the opportunity can be shared with all students who qualify. Selection is determined by factors including GPA (3.0 high school GPA), ACT or equivalent scores (25), discipline, unmet financial need, potential to eliminate a 'working' barrier, willingness to participate in project activities, letters of recommendation, and student application letter. However, in almost all cases, all students who met the academic and financial eligibility criteria who applied were awarded scholarships as enough funds were available in the program to do so.

The UofM has recruited 56 Scholars since the beginning of the program in 2019. 17 scholars in 2019, 21 scholars in 2020, 12 scholars in 2021, 5 scholars in 2022, and 1 scholar in 2023 have joined the program. A total of 50 scholarships were intended to be awarded across the primary cohort years (2019-2021). However, due to scholars leaving the program or to a decrease in unmet need (and thus scholarship amount) for some scholars, six additional students were able to be added to the program in 2022 and 2023. Table 1 shows the scholars' gender distribution. Women make up 45% of the overall scholar cohort at UofM.

Table 1: Scholar's gender distribution

Gender	**2019**	**2020**	**2021**	**2022**	**2023**
Female	8	9	3	5	0
Male	9	12	9	0	1

Students of different majors and races have been recruited. Figure 4 and Figure 5 show scholar's major distribution Scholar's race/ethnicity distribution respectively. The overall cohort at the UofM is quite diverse. It is comprised of 41% biomedical engineering, 21% civil engineering, 16% mechanical engineering, 13% computer engineering, 5% engineering technology, 2% electrical engineering, and 2% mathematical sciences students. URM students make up 48% of the overall cohort.

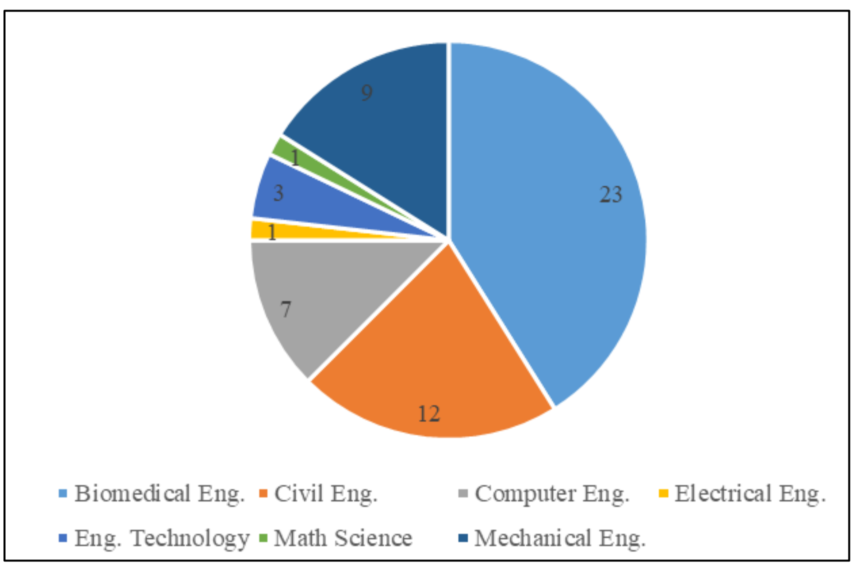

Figure 4: Scholar's major distribution.

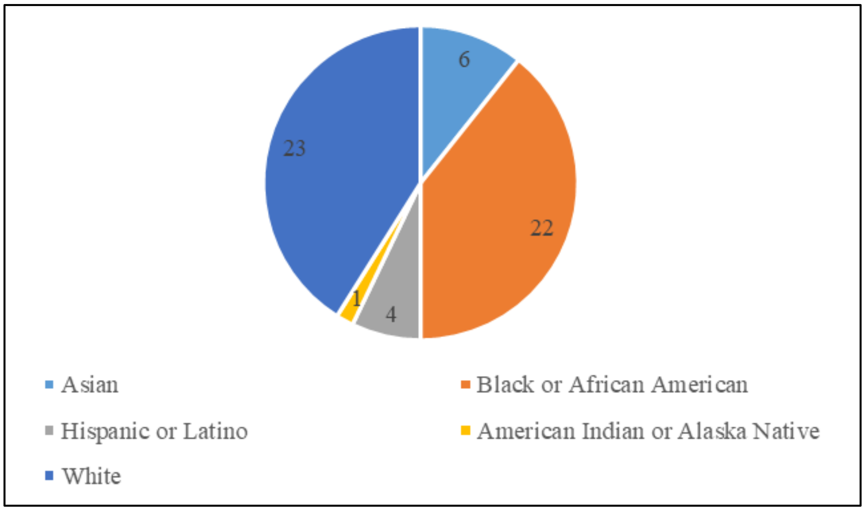

Figure 5: Scholar's race/ethnicity distribution.

3. Results and Discussion

Over the course of the project, a total of 56 scholars have been selected for the program. Of 56 scholars, 9 scholars have left the program at some point. Seven of these scholars changed their major and 2 scholars left the UofM (one in good standing due to family issues and one due to academic probation). More detailed results are presented in the following four sections. The first section is a demographic comparison of scholars and non-scholars which includes breakdown by gender, underrepresented, and first-generation statuses. The second section provides academic performance comparisons of scholars and non-scholars, including GPAs and retention rates. The non-scholars comparison group includes all students who were eligible to apply for the program but chose not to do so. Thus, these students met the same GPA and financial criteria as the scholars who did apply and did not have significantly different average GPA or financial need than the scholars group upon entry. The primary difference between scholars and non-scholars is in participation in Urban STEM program activities and receipt of scholarship awards. Only the scholars were included in the project interventions and received scholarships from the grant program. In the third section, academic performance of STEM Ambassador and Non-STEM Ambassador scholars are compared. The last section presents the impacts of the Urban STEM project on personal and academic life of the scholars.

3-1. Demographic comparison of Scholars and Non-scholars

Overall, the project has been successful in attracting a diverse group of scholars in terms of gender, first-generation, and URM statuses. Figure 6 compares representation of female students among scholars in the Urban STEM Collaboratory project and non-scholar (but with the same academic and financial eligibility) students. In all years, female representation is significantly higher among scholars than non-scholars. In years 2019 and 2020 almost half of the scholars were women, while women counted only for 22% of non-scholar students.

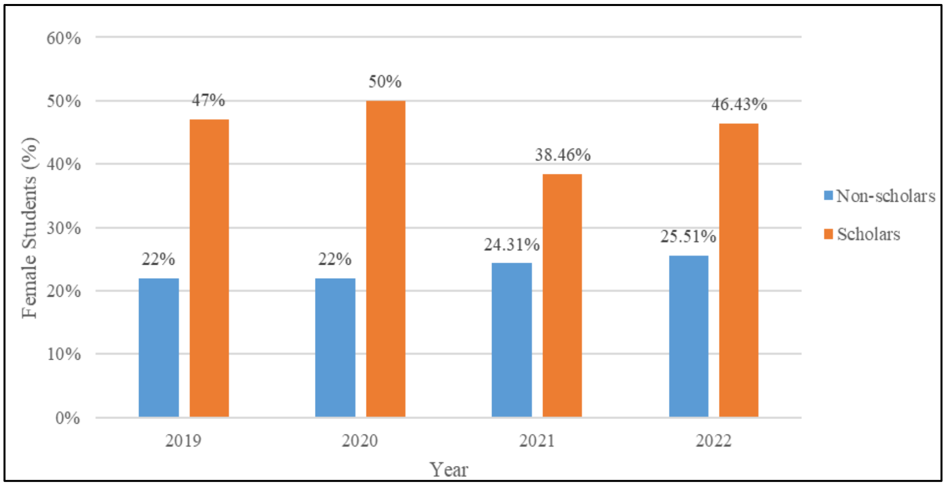

Figure 6: Percentage of female students among scholars and non-scholars.

Figure 7 shows the comparison between scholars and non-scholars regarding first-generation status. In all years, the representation of first-generation students is higher among scholars than non-scholars.

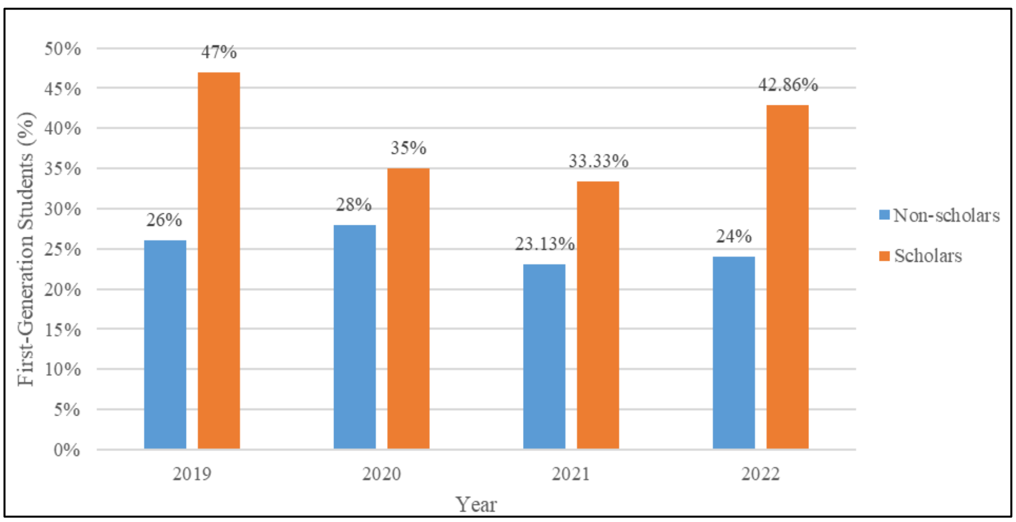

Figure 7: Percentage of first-generation students among scholars and non-scholars.

Figure 8 compares the percentage of underrepresented (African American, Hispanic, Two or More Races) students among scholars and non-scholars. In the years 2021 and 2022, underrepresented students' share is higher among scholars than non-scholars. Although this is not true for the years 2019 and 2020, underrepresented students' share among scholars shows a growing trend from 2019 (29%) to 2022 (64.29%), indicating the project became more successful in attracting underrepresented applicants over time.

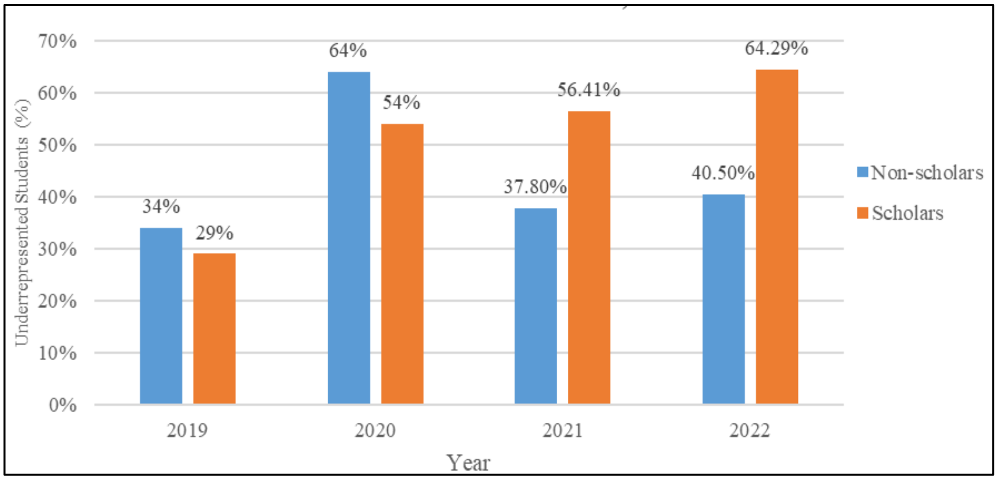

Figure 8: Percentage of underrepresented students among scholars and non-scholars.

The fact that the scholar cohorts are especially diverse in terms of gender, race and ethnicity, and first-generation status is important not only because it indicates the project was successful in attracting a diverse pool of qualified applicants, but also because it will allow further research on the impact of project interventions on these demographic groups. As female, URM, and first-generation students are underrepresented in engineering programs, and particularly in engineering graduates, understanding which strategies prove to be successful in increasing academic success and graduation broadly is very important.

3-2. Academic performance of Scholars and Non-scholars

To compare academic performance of scholars and non-scholars, GPAs and retention rates are presented. Table 2 shows overall GPA, GPA in Math Courses, Major GPA / GPA in Major Courses, and Calculus 1 GPA. To participate in the scholarship program, students had to demonstrate academic talent (GPA of 3.0 for high school students, 2.75 for college students) as well as unmet financial need. All students who met these criteria were invited to apply. In almost all cases, all students who applied were awarded a scholarship as enough funds were available through the program. Except for Major GPA in 2019 and Calculus 1 GPA in 2022, scholars earned higher GPAs in all cases. This enhanced performance is especially noticeable in 2021 when scholars' GPAs were 0.5 to 1 point higher than non-scholars. Additionally, data for overall GPA is also available for all engineering students. Both non-scholars (same academic and financial need as scholars) and scholars achieved higher overall GPAs in all cases than the average for all engineering students.

Table 2: GPAs of Scholars and Non-scholars.

Year	Overall GPA (excludes grades from transfer courses)			GPA in Math Courses (CALC 1 or higher)		Major GPA / GPA in Major Courses		Calculus 1 GPA	
	All Engineer. Students	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars	Scholars
2019	2.67	2.90	3.09	2.06	2.52	2.18	1.93	2.61	2.81
2020	2.71	2.95	3.35	2.48	2.92	2.74	3.16	2.34	3.55
2021	2.77	2.98	3.48	2.09	3.01	2.63	3.25	2.21	3.00

2022	2.81	3.02	3.27	2.29	2.83	2.63	3.05	2.13	1.67

Table 3 presents the retention rates for progression from Freshman to Sophomore and Sophomore to Junior in both the students' initial majors and in STEM. Retention rates of scholars were higher in all cases than for non-scholars. In the year 2020, 100% of Sophomore scholars remained in their major. Also, in the year 2022, all of Freshman and Sophomore scholars remained in STEM. Retention rates for freshman to sophomore in major is reported for all engineering students in Table 3 as well. Interestingly, non-scholars are retained at lower rates than for engineering students as a whole, indicating financial need may be causing a significant barrier for these students. The non-scholars demonstrated academic talent like the scholars group but did not have the scholarship to alleviate unmet financial need.

Table 3: Retention Rates of Scholars and Non-scholars.

Year	Retention Rates Freshman to Sophomore in Major			Retention Rates Freshman to Sophomore in STEM		Retention Rates Sophomore to Junior in Major		Retention Rates Sophomore to Junior in STEM	
	All Engineer. Students	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars	Scholars	Non-scholars	Scholars
2020	73.6%	61%	86%	70%	86%	74%	100%	78%	100%
2021	64.2%	49%	80%	59%	80%	71%	67%	76%	78%
2022	56.6%	63%	75%	71%	100%	80%	86%	86%	100%

Scholars are with the program for different numbers of years, depending on whether they were selected for the program at the freshman or sophomore level. As shown in Figure 9, we also see an increasing trend in GPA for scholars with number of years in the Urban STEM Collaboratory program. GPAs presented in the figure are mean values for all scholars in the cohort in a given year. While more detailed analysis is required, we know that interventions that build community, sense of belonging, and STEM identity positively impact students' academic success. As the math intervention was discontinued after the initial year of the project, the only remaining interventions were the scholarship component and the project activities designed to address community building and connection to campus resources. Further investigation is needed to better understand how the these individual component impacted the positive outcomes for our scholars, and to better understand implications across demographic groups.

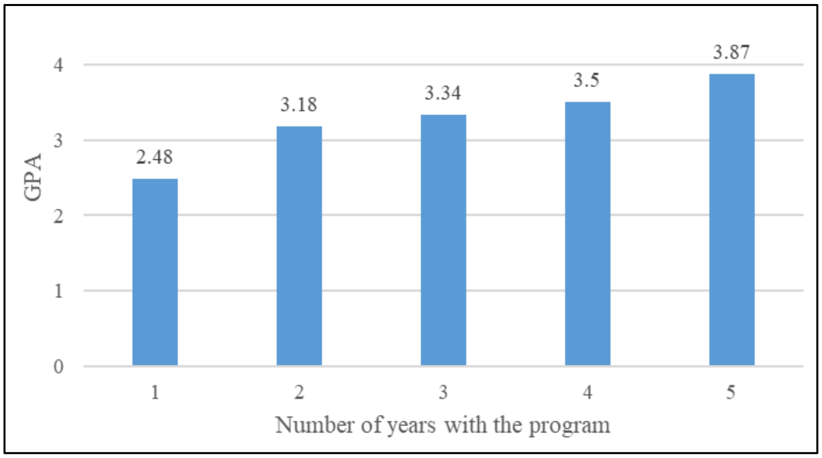

Figure 9: GPA vs numbers of years with the program for scholars.

3-3. Academic performance of STEM Ambassador and Non- STEM Ambassador

In this program, 21 scholars have served as STEM Ambassadors while the remaining 35 have not. The average GPA for the STEM Ambassador scholars is 3.5, which is higher than that of non-ambassador scholars, with a mean GPA of 3.0. Differences are also seen in terms of academic progress. 85% of Ambassadors are currently on track to a four-year graduation or have graduated in four years. For non-ambassador scholars, 53% are on track for graduation in four years. Figure 10 highlights the differences between these two groups of scholars.

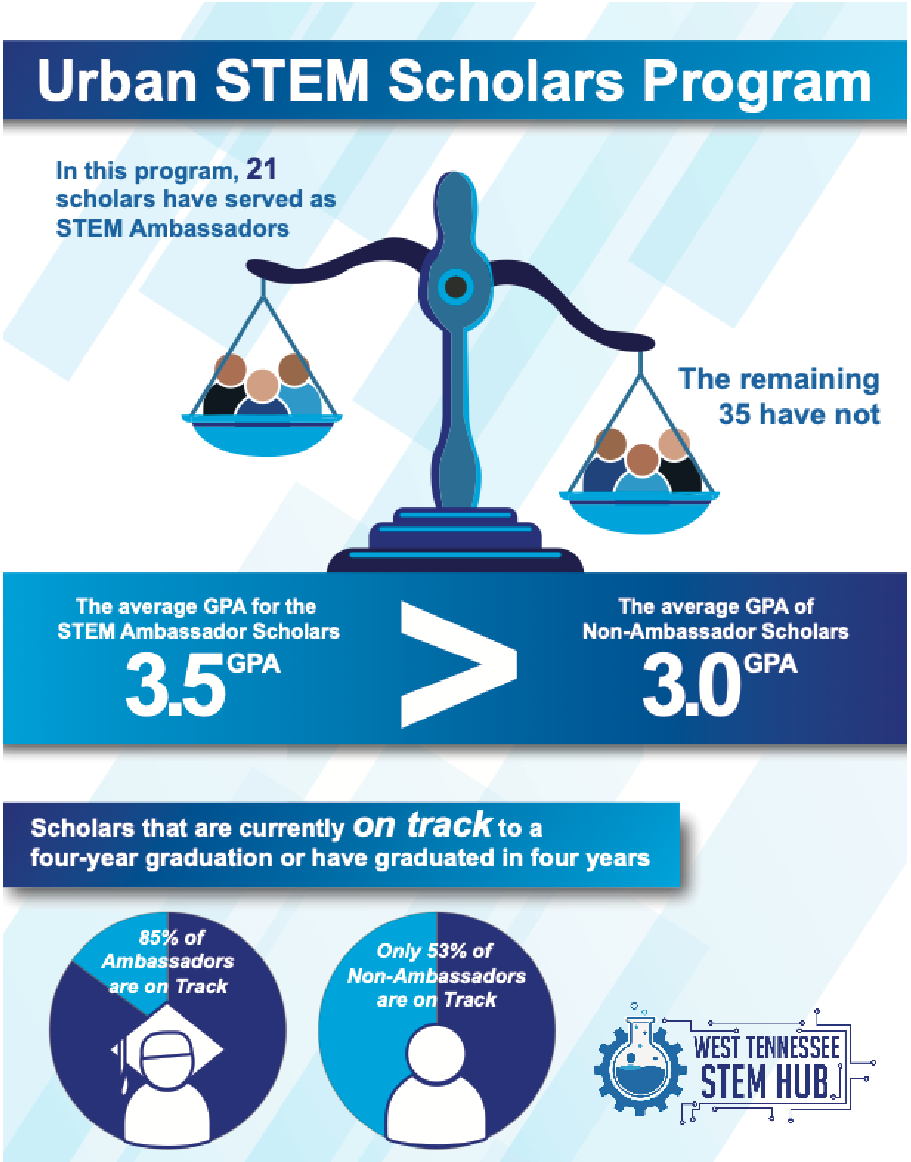

Figure 10. Comparison of academic success of STEM Ambassador scholars vs. non-Ambassador scholars

The findings related to scholars' participation in our STEM Ambassador program are quite promising. Future research will also examine the entire STEM Ambassador population as compared to the scholar Ambassadors to try to isolate the impact of the scholarship versus the STEM Ambassador program itself.

3-4. Impacts of the Urban STEM project on personal and academic life of the scholars

Urban STEM Scholars at the UofM reported positive impacts of the program on their personal and academic lives. These impacts were realized primarily through formal and informal peer and faculty mentoring they received through the program. The following quotation illustrates the benefit of being connected to a community of engineering peers who understand the challenges associated with their major and can help support one another with those challenges:

> I definitely like being in a community that understands engineering because there's a lot of people in my life that, when I'm spending hours and hours doing engineering work, that don't get it, that don't understand how much time needs to be put into engineering. We always say, for every hour in class, it's three hours outside of class for engineering. It's different for each major, but for engineering, that's the case, and so it's difficult for other people who don't understand engineering, that aren't in the engineering field, to understand that. But it's definitely comforting when I actually am connected with people that do understand that, as like, "You get me," or "You know how much time it takes."

Another scholar credited the Urban STEM faculty leadership for encouraging students to build connections with one another and communicating this desire for student engagement authentically: “I feel like you guys want it the most. That matters. I can tell that you're just like, ‘I want you to meet each other.’”

Other students discussed benefits of both one-on-one and group mentoring with faculty. One student described how the Urban STEM program facilitated relationships with faculty who they might not otherwise interact with frequently:

> In class, I generally don't interact with [faculty] too much […] so I think being part of the Urban STEM and Dr. [X] being assigned to our group just sort of extended that relationship and helped it be more concrete to the point where even outside of [class], it's fun to talk to him and listen to what he has to say.

Another student described how faculty mentoring helped them to feel part of the Urban STEM community:

> It did make me feel like I was part of a community because I was getting together with my classmates, with Dr. [Y], talking about engineering things, non-engineering things, Dr. [Y] is working on our classes. So, it was nice to get together and feel like I was a part of that group of that community.

In our research on STEM identity, across all three campuses, we found evidence that peer interactions and both formal and informal relationships with STEM peers and faculty were important factors in how Urban STEM scholars experienced their developing STEM identities [28].

4. Conclusion

The University of Memphis has recruited a diverse group of 56 scholars in terms of gender, major, and race/ethnicity since 2019. While results are preliminary and more analysis is needed, findings related to the scholars’ academic performance, retention, and graduation are promising. The demographic comparison of scholars and non-scholars from 2019 to 2022 shows better inclusion of female students, first-generation students, and underrepresented students among scholars than non-scholars. In all years, female students and first-generation students are represented at higher rates among scholars than non-scholars and the representation of URM scholars shows a growing trend from 2019 (29%) to 2022 (64.29%). The GPA and retention rate comparison of scholars and non-scholars from 2019 to 2022 reveals better academic performance of scholars. They achieved higher GPAs (overall GPA, GPA in Math Courses, Major GPA / GPA in Major Courses, Calculus 1 GPA) in almost all cases. Their retention rates (Freshman to Sophomore and Sophomore to Junior each in Major and in STEM) were higher in all cases, as well. Additionally, while non-scholars achieved higher performance in terms of GPA as compared to the average for all engineering students, they were retained at lower rates, indicating that the financial barrier to completing the degree is significant. The data also shows that the length of time a scholar is with the Urban STEM program positively correlates with GPA earned. Moreover, data reveals better academic performance (GPA and being on track to four-year graduation) of STEM Ambassadors scholars than non-ambassador scholars.

The findings, while preliminary, point to the success of the Urban STEM project. Additional research is needed to ascertain the extent to which the financial support and program interventions impacted student outcomes. Examination of the program's impact on various demographic groups is also underway. The increased success of the STEM Ambassador scholars provides further evidence of the value of supporting engineering students' development of STEM identity and sense of belonging. Future research will include the final cohort of scholars in the analysis and deeper examination of the impact of specific project interventions as well as implications for female, URM, and first-generation students and intersectionality of these demographics.

Acknowledgements

This work is supported by National Science Foundation S-STEM Grants #1833987 (UofM), #1833983 (UCD), #1833817 (IUPUI).

References

[1] M. Bacovic, Z. Andrijasevic, and B. Pejovic, "STEM Education and Growth in Europe," *J. Knowl. Econ.*, vol. 13, no. 3, pp. 2348–2371, 2022, doi: 10.1007/s13132-021-00817-7.

[2] "Employment in STEM occupations : U.S. Bureau of Labor Statistics." https://www.bls.gov/emp/tables/stem-employment.htm (accessed Dec. 16, 2023).

[3] S. Olson and D. G. Riordan, "Engage to excel: producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Report to the president.," *Exec. Off. Pres.*, 2012.

[4] S. A. Report, "STEM Attrition: College Students' Paths Into and Out of STEM Fields," 2014.

[5] Massachusetts. Executive Office of Education., "The condition of education," p. v., 1994, [Online]. Available: https://nces.ed.gov/pubs2017/2017144.pdf.

[6] D. G. de la Rosa-Pohl and C. Horn, "The Endeavour S-STEM Program: A Multi-College Collaboration to Increase Engagement and Retention in STEM," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[7] "NSF Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM) | NSF - National Science Foundation." https://new.nsf.gov/funding/opportunities/nsf-

scholarships-science-technology-engineering (accessed Dec. 19, 2023).

[8] B. Wright, S. Lee, K. Zaromatidis, and O. Huk, “Invited Contributions to STEM Education NON-REFEREED ARTICLE Increasing Retention of STEM Students with Financial Need via the NSF S-STEM DESIRE Scholarship Program,” no. December, pp. 24–38, 2021.

[9] M. Kalevitch, C. Maurer, P. Badger, and G. Holdan, “Building a Community of Scholars : One University ’ s Story of Students Engaged in Learning Science , Mathematics , and Engineering Through a NSF S-STEM Grant – Part II,” vol. 16, no. 2, pp. 40–45, 2015.

[10] T. Dallas, “Recruiting and Retaining a Diverse S-STEM Program Recruiting and Retaining a Diverse S-STEM Program.”

[11] L. Sci-, “SETS : Lessons Learned and Best Practices of Implementing S-STEM project in the Engineering Technology Department of a Large Urban Minority Serving Public Research Intensive University,” 2020.

[12] C. W. Ferguson, “Scholarship Program Initiative via Recruitment , Innovation , and Transformation (SPIRIT): SSTEM Program Initiatives and Early Results Scholarship Program Initiative via Recruitment , Innovation , and Transformation (SPIRIT): S-STEM Program Initiati.”

[13] M. L. Morris, “Board 109 : Retention-Focused , S-STEM Supported Program,” 2019.

[14] R. Tashakkori, C. Norris, and M. E. Searcy, “The components of a successful S-STEM program: What works at Appalachian State University,” *SIGCSE 2018 - Proc. 49th ACM Tech. Symp. Comput. Sci. Educ.*, vol. 2018-Janua, pp. 362–367, 2018, doi: 10.1145/3159450.3159600.

[15] A. G. Enriquez, C. B. Lipe, and B. Price, “Enhancing the success of minority STEM students by providing financial, academic, social, and cultural capital,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2014, doi: 10.18260/1-2--20421.

[16] E. A. Adams, C. Haden, C. L. A. Dancz, Y. Ahn, and K. Willis, “Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Engineering Scholars Program at a Two-Year College: Preliminary Interventions and Outcomes,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[17] I. Chatterjee, K. Scalaro, A. M. Vollstedt, J. M. Williams, and A. Kirn, “S-STEM: Creating Retention and Engagement for Academically Talented Engineers-Lessons Learned,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2023.

[18] T. Utschig, V. Sooklal, M. L. Lowder, C. Ham, and R. Butler, “Using Motivational Theory to Implement S-STEM Activities Supporting Student Success,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[19] D. Hartenstine, “CS / M Scholars Program - an NSF S-STEM Project Preparing Students for Careers in Computer Science and Math - a Report on a Current S-STEM Project The CS / M Scholars Program , funded by an NSF S-STEM grant , supports students to computer science through ,” 2020.

[20] E. Y. Kang and M. Jackson, “Impact of Three Years of Intervention in Culturally Adaptive Pathway to Success on S-STEM Scholars,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2022.

[21] A. Miguel, "ECE scholars: NSF S-STEM grant," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2018-June, 2018.

[22] J. R. Gurganus, B. County, B. County, and B. County, "Board 103 : Work in Progress : NSF S-STEM Program : Recruitment , En- gagement , and Retention : Energizing and Supporting Students with Diverse Backgrounds in Mechanical Engineering NSF S-STEM Program : Recruitment , Engagement , and Retention : Energizi," 1995.

[23] M. White, E. Legg, B. Foroughi, and J. Rose, "Constructing past, present, and future communities: Exploring the experiences of community among last-dollar scholarship students," *J. Community Psychol.*, vol. 47, no. 4, pp. 805–818, 2019.

[24] "Building a Sense of Community." https://serc.carleton.edu/lsamp/community.html (accessed Dec. 24, 2023).

[25] E. Sayre, "An official website of the United States government Here ' s how you know Awards STEM Community Building to Support Academic Success and Retention of Low-Income Students Feedback," 2023.

[26] M. Kalevitch *et al.*, "Living-Learning Community in Support of Stem Education: a Quantitative and Qualitative Study of the Nsf Stem Scholar Cohort (2009-2013) At Robert Morris University," *J. Teach. Educ.*, no. January, 2015, [Online]. Available: https://www.researchgate.net/publication/290107179.

[27] West Tennessee STEM Hub, "Annual Impact Statement 2020-2021," 2023 [Online]. Available: https://static1.squarespace.com/static/5e6fa4827373c97a3f66bdc6/t/63360c5fe77b23374bb63fed/1664486503660/Hub+Impact+Statement+2020-21.pdf

[28] C. O. Stewart *et al.*, "Communicating identity in the Urban STEM Collaboratory: toward a communication theory of STEM identities," *Int. J. Sci. Educ. Part B Commun. Public Engagem.*, vol. 13, no. 4, pp. 345–361, 2023, doi: 10.1080/21548455.2023.2179380.