Mathematics as a Common Language in Science: A Scholarship Program for Students in Science, Technology, Engineering and Mathematics at Mississippi State University

Maggie E. L. Herring, Anastasia D. Elder, Seth F. Oppenheimer, Donna M. Pierce, Deb Mlsna
Mississippi State University

Abstract

This study evaluated a scholarship support program, "Mathematics as a Common Language in Science," that was funded by the National Science Foundation (NSF). Running from 2015 to 2020, the scholarship support program assisted 31 students to major in chemistry, physics, or mathematics with the intent of supporting these students to enter graduate school and careers in the physical sciences. In this study, student outcome metrics and survey data were collected to investigate the impact of the program elements on the participants' academic success. Additional program elements, such as access to tutoring support, outreach opportunities, and undergraduate research, were emphasized to support students in their designated major. A 1-credit-hour course, taught first semester for the first-year cohort of students, emphasized study skills and university resources, and engaged students to consider the overarching applicability of math concepts to the science curriculum. The findings of this study offer insight into program elements that supported student success with consideration of aspects that did not function as planned. The authors hope that sharing these insights will aid other programs to structure effective programming for students.

Keywords: undergraduate mentoring, STEM majors, undergraduate research, scholarship program

Even amid increasingly widespread prioritization of diversity in STEM fields, historically underserved racial and ethnic groups, as well as women, continue to be underrepresented in terms of degree attainment in science and engineering (National Science Board & National Science Foundation, 2022). Part of this issue could be attributed to a combination of college enrollment rates and choice of major. In recent years, enrollment rates in the United States were generally lower among People Excluded due to Ethnicity and Race (PEER) students (in this study defined as Black, Hispanic, Pacific Islander, American Indian/Alaska Native, and multiracial students) than among Asian or White students (National Center for Education Statistics, 2022). So, even though PEER students have been found to declare STEM majors at the same rates as White students (Chen, 2009), lower college enrollment proportional to the overall population results in underrepresentation in STEM fields. Meanwhile, recent college enrollment rates in the United States have been higher among women than men (National Center for Education Statistics, 2022), but previous research has suggested that women are far less likely than men to declare a STEM major (Chen, 2009), especially a physical science or engineering major (Riegle-Crumb & King, 2010).

Unfortunately, lower initial representation is only the tip of the iceberg because many students who declare a STEM major never complete the degree. Attrition rates in STEM fields are disproportionately high for PEER students (Riegle-Crumb, King, & Irizarry, 2019; Whitcomb & Singh, 2021), women (Astorne-Figari & Speer, 2018, 2019), first generation college students (Kamer & Ishitani, 2019; Verdín, Godwin, Kirn, Benson, & Potvin, 2018), and low-income students (Chen, 2013; Kamer & Ishitani, 2019). While some of this attrition is explainable as students with lower grades switching majors or dropping out, that isn't always the case (Astorne-Figari & Speer, 2019) and there are many factors that contribute to attrition. Some research suggests that a part of these patterns of attrition comes down to differences in academic preparation, with students unable to fulfill prerequisites and take as many STEM courses early on in their undergraduate career being more likely to switch majors or drop out (Sovero, Buchinsky, & Baird, 2021). Several studies have suggested that a portion of attrition is due to more cultural reasons. One study suggested women switching out of STEM majors were doing so due to a dislike of the male-dominated nature and competitiveness of STEM fields (Astorne-Figari & Speer, 2019). Other studies have linked attrition to students' sense of belonging in a field or course (Fink, Frey, & Solomon, 2020; Fisher, Thompson, & Brookes, 2022; Verdín et al., 2018). Many low income students suffer compounded effects from a lack of sense of belonging (Nguyen & Herron, 2021) and the necessity to work while taking classes, which can affect grades and completion rates (Carnevale & Smith, 2018).

In response to this gap in degree attainment and attrition rates, universities across the country have implemented various support programs. The components of these programs vary, but it has been suggested that programs are most successful when they include "adequate" financial support, committed and well-trained faculty mentors, a combination of academic and social programs including research and mentoring, and a focus on students' sense of belonging, among other components (Louten, 2022; Pearson, Giacumo, Farid, & Sadegh, 2022).

This study was based on a National Science Foundation (NSF) Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program offered from 2015 to 2020. The scholarship support program was designed to provide financial assistance to underserved students with financial need, and to provide mentoring, outreach, and research experiences that would support and engage students majoring in chemistry, physics, or mathematics in their specific STEM discipline. The program was designed to support two cohorts of 8 students each, 16 students total, throughout a four-year academic major. The purpose of this study was to investigate the participants' experiences, as well as assess the impact of the program on individual student outcomes. It was hypothesized that this support program would sufficiently support participants to graduate in a STEM field.

The research questions that guided this study were:

1. Were program recruiting goals regarding underserved student populations achieved?
2. How were the students impacted by their participation in the program?
3. What were the outcomes of the students supported through this program?

Method

Recruitment

Students with financial need who were majoring in the departments of chemistry, mathematics, and physics were eligible for scholarship selection and program participation. Scholarship details were shared with high school guidance counselors throughout the state and advertised through the university online scholarship portal. Additional recruiting occurred through coordination with other programs at the institution that target underserved excluded and first-generation students. As the program developed, all students majoring in the three designated majors were encouraged to submit applications and students were selected based on financial need and demographic information, including ethnicity, first generation status, and gender.

The program was structured to offer a set financial award each semester to defray the cost of tuition and living expenses. Typical support amounts for the university were $4000 aid per semester. In addition, scholarship students could access additional financial support through participation in research experiences (paid at $12.50 per hour of participation) and were invited to access program-created free academic support for select math and chemistry classes. Additional social events and meetings were planned to further enhance peer-peer and peer-mentor relationships. Students were sustained with the scholarship program if they maintained an overall 3.0 grade point average, continued to be enrolled full-time as a student in good standing with the university, and continued successful progress toward their chosen physical science major.

Participants

In order to be admitted to the program, students had to have declared one of the program's designated majors. Initially, program administrators accepted students with any ACT Math score as long as the student was eligible to enroll in General Chemistry I their first semester. Students could enroll in General Chemistry I with either an ACT Math score of 24 or higher, or a grade of C or better in College Algebra. However, after the first cohort of students was not academically successful (see Results section), the program admittance guidelines for all further cohorts were revised to require ACT Math scores of 24 or higher. Of the remaining applicants, students chosen were those that demonstrated high financial need and best represented underserved student populations, including racial/ethnic excluded groups, women, and first-generation college students. Background information for all participants is shown in Table 1.

Characteristic	Number of Participants	
	First Cohort	Subsequent Cohorts
Gender		
Male	4	7
Female	2	18
Race/Ethnicity		
Black	3	4
Hispanic/Latino	0	2
White	3	19
Major		
Chemistry	5	12
Mathematics or Statistics	1	10
Physics	0	4
First Generation College Student	5	13
Community College Transfer Student	0	4

Note: The total for "Major" exceeds the 31 total students due to a double major.

Table 1. Participant Background Information

Program Elements

Mentoring and team-building course. In the fall semester of their first year, students were required to enroll in a 1-credit-hour mentoring and team-building course entitled "Mathematics as a Common Language in Science." The course was designed for the scholarship cohort to gain information on university resources, study skills and time management strategies for university success, and for discussion on mathematical thinking and application of ideas within the physical sciences. The outline of course topics by week is shown in Table 2.

The goals of the course were threefold:

1. Provide appropriate guidance and information on university resources and support centers to support student transition to university life.
2. Create a peer support network for the students.
3. Support students to develop mathematical language skills to increase comfort level with the description of physical problems.

The first goal was to provide appropriate guidance and information on university resources and support centers to support student transition to university life. Three of the class meetings were focused on time management, study strategies for science courses, and open discussion on student challenges they were experiencing at the university. University support resources such as the tutoring centers and writing center were shared and discussed to connect students in with appropriate support networks. An additional class meeting was devoted to survey assessment and instructor feedback on the course content.

The second goal was to create a peer support network for the students. All students for the scholarship program were co-registered in select science and math courses, starting in their first semester with General Chemistry I and a math course. The team-building course was designed to support the students to connect in groups for discussions and interaction so that they would feel comfortable connecting for support in their math and science

Week	Topic
1	Introduction to course, faculty and student cohort
2	Introduction to the derivative as a rate of change: Phase lines
3	How to study: specific tools for tackling science/math courses Introduction to university resources Time management: schedule, homework
4	Developing models for rate of change, Part 1: Chemical kinetics
5	Developing models for rate of change, Part 2: Population growth
6	Mid-point academic discussion: free discussion on successes, challenges, and goals Student essay on challenges, goals, and game plan
7	Equation models, Part 1: Chemistry
8	Equation models, Part 2: Physics
9	Systems of equations: Phase planes
10	Second derivatives: Higher order equations
11	Fermi problems/guesstimates, Part 1: Assigned student project
12	Fermi problems/guesstimates, Part 2: Student presentation of projects
13	Conservation laws: Higher order equations
14	End-of-semester surveys and course evaluations

Table 2. Course Outline for "Mathematics as a Common Language in Science"

courses. All three faculty mentors were present during each class meeting for individual discussions and mentoring of student participants.

The third goal was to support students to develop mathematical language skills to increase student facility with the description of physical problems. The primary mathematical theme of the course was that different science disciplines, especially chemistry and physics, all rely upon mathematics and specifically many of the same mathematic concepts, i.e., mathematics is a common language in science. The idea of the derivative as a rate of change was emphasized as an example of a mathematic topic with many important applications across disciplines. Although many of the students would not be taking differential equations until sophomore year of university, the idea of describing physical situations using rates of change could still be introduced.

Figure 1. S-STEM Scholarship Students Use Post-It Notes to Estimate Land Surface Area of the State

Figure 2. Middle School Science Students Participate in the Origami Activity

Content for the course was focused on the idea of the derivative as a rate of change and the construction of several one-equation mathematical models (differential equations), going from verbal descriptions to precise mathematical models. Students were tasked to do this both in class and as homework.

The course went on to develop phase lines as a way of analysis without solving equations and getting information from the models with only this simple tool. As the semester went on, more single-equation models were developed, often by the students as individuals or in groups, including models from biology, chemistry, and physics. Content then expanded to systems, progressing from stochiometric equations to differential equations. The course also looked at reducing the number of equations and explored phase planes as a means of analysis.

Toward the end of semester, students were assumed to have progressed enough in math to understand the product rule. Second derivatives were introduced as the rate of change of the rate of change in the physics context. The students then explored some conservation laws, using mechanics, as well as moving between first-order systems and higher-order equations.

In addition to these concepts, the physics mentor for our program taught classes that focused on Fermi problems (also known as "guesstimation" problems) and the use of estimation techniques to hone-in on more concrete answers. These classes also focused on exploring how to turn a conceptual question into a testable measurement.

Application of these modules included examples of people using Post-it Notes to estimate the surface area of a house and an automobile. Students were then split into small groups and tasked to use this approach to estimate the approximate land surface area of the state by covering large maps of the state with small Post-it Notes. (See Figure 1.) Students were able to make reasonably good estimates of the actual square milage. Afterward, the class brainstormed additional ways the surface area estimate could be improved, such as strategic placement of existing Post-it Notes, use of smaller Post-it Notes, and use of mixed-shaped Post-it Notes.

Additional discussion modules for the Fermi problems included the Drake Equation and an estimation of the number of intelligent civilizations that might exist within the Milky Way galaxy, and a discussion of how many licks it takes to get to the center of a Tootsie Pop. Homework assignments shared with students were individual Fermi problem estimates to be performed, such as estimating the number of Frappuccinos sold at the campus Starbucks within a 1-day period. Student presentations of their method and approach allowed for further discussion of how data could be quantified. One goal of these modules was to encourage students to consider the scale of their answers as they estimate, a skill often lacking with students performing calculations in their science classes.

Tutoring. Program resources supported academic tutoring, where students could access private tutors specializing in their registered courses. The tutoring component focused intensively during the first two semesters of university transition within gateway courses of chemistry, math and physics. The program would pay for student tutors to meet with scholarship students as needed. Early cohorts interacted intensively with this academic tutoring component and one of the faculty mentors developed intensive lesson plans and tutoring materials to supplement the resource. As students matured in the program, the academic tutoring intervention declined as students relied more extensively on peer interaction for academic support as needed.

Outreach. The program included outreach connection with the K-12 community to foster positive attitudes toward math and the physical sciences. Early interaction of the program involved faculty mentors, graduate students, and undergraduate scholarship students in middle school science classrooms where middle school students were engaged in several hands-on activities that encouraged positive thinking about math in the context of physical science. (See Figures 2 – 5.)

The first activity described the pH scale and used red cabbage juice indicator to assess the pH of a variety of household chemicals. (See Figures 3 and 5.) Students

Figure 3. Various Household Chemicals Mixed with Red Cabbage Juice pH Indicator

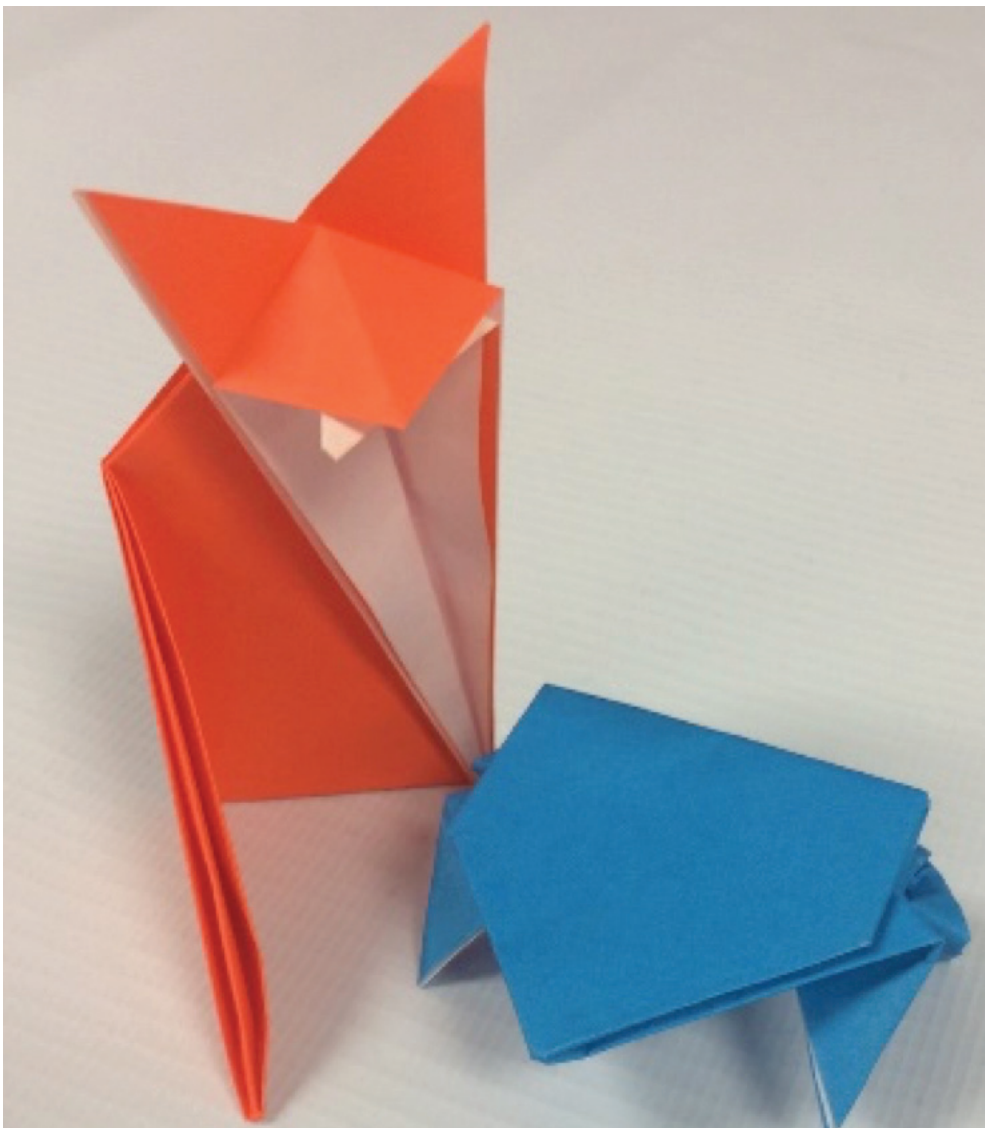

Figure 4. Figures Made in Middle School Science Classroom Origami Activity

were tasked to rank solution pH on an acidity scale as compared to a standard color chart provided. Discussions of pH, the math represented by the pH scale, and an assessment of relative acidity were included as part of the activity.

The second activity used origami and the creation of two figures; a fox figure and a jumping frog as a platform to discuss geometry, and angles. (See Figures 2 and 4.) During this activity, a brief video was shown that discussed the space-saving aspect of origami folding and the deployment of solar arrays in space.

Outreach at the state children's museum as part of an annual science celebration also included an interactive activity focused on the optics of the human eye and the correction needed for far-sightedness and near-sightedness. The activity emphasized physics and geometry as students learned how vision problems are corrected by selecting the appropriate corrective lenses to adjust the focal point of the eyes' lenses.

As the program matured, outreach evolved to include the student-led undergraduate clubs existing in each department. Scholarship students became involved as officers in these groups and led activities within the departmental groups at regional elementary and middle schools. Specific examples of these events included organized science nights at the museum, National Chemistry Week celebrations, fifth-grade classroom competitions for best artwork related to National Chemistry Week themes, and visits to children's museums in state.

Figure 5. Middle School Science Students Participate in the Red Cabbage pH Indicator Activity

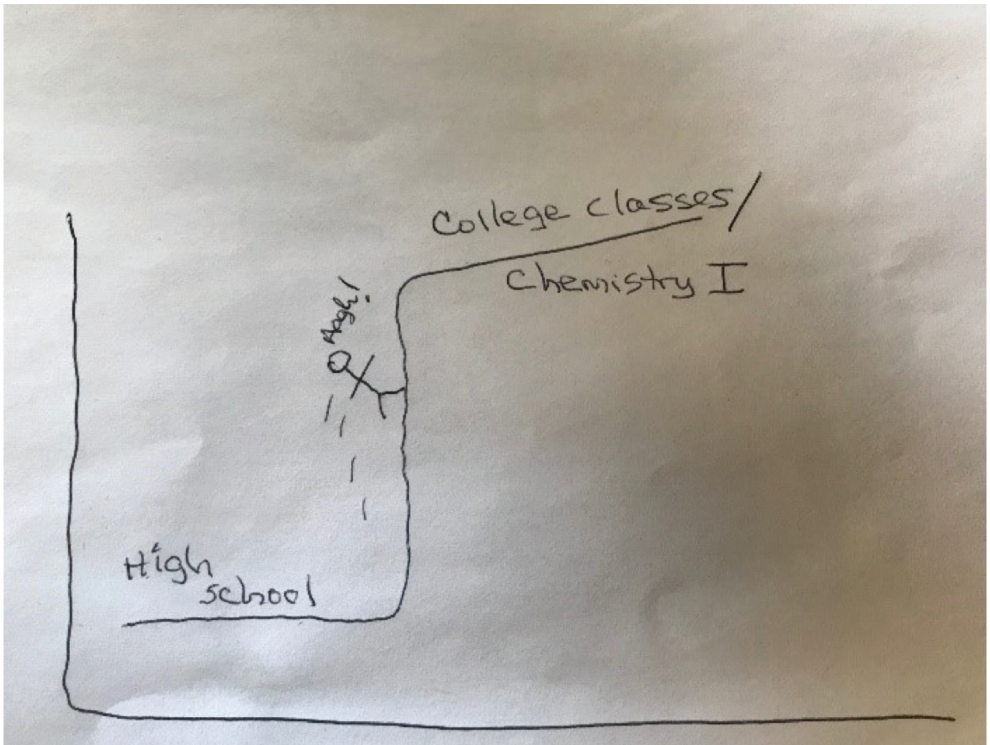

Figure 6. Re-creation of Student Drawing Indicating University Challenge

Note. This representation was created and discussed during the mid-point seminar that focused on student performance. The first student cohort expressed that university courses were so much harder than high school, it was impossible to bridge the difference.

Undergraduate research. Undergraduate research participation was also a core theme of the program, and this aspect was strongly emphasized as students matured in their programs. Each student was encouraged to connect with a research faculty mentor and submit a research proposal to the scholarship program. Requested support funds could be used for student salary support, materials and supplies for the research professor, and travel expenses to academic conferences to present the student work. Students successfully transitioning into graduate school opportunities all took advantage of this research support and the program strongly encouraged this participation.

Research Design

A mixed methods approach using both quantitative and qualitative data was used for this research study. Quantitative data included identification of participant demographic information and documentation of program experiences. Qualitative data was obtained through participant interviews with an external evaluator; each participant was interviewed individually at the midpoint of the spring semester each year. The two types of data were collected and analyzed to provide a complete understanding of the experiences most influential in supporting desired participant outcomes.

Student motivation was measured in students' first semesters by the Science Motivation Questionnaire II (SMQII) from the University of Georgia, which has been found reliable and valid (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). This measure was adapted for math majors by substituting "math" for "science" throughout questionnaire. The questionnaire contains 25 Likert items which assess five components: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation.

Results

Since our program modified our selection guidelines after the first cohort of students, we will discuss outcomes for the first cohort separately.

First Cohort

Initially, the decision was made to admit and support students that were eligible to enroll in General Chemistry I in the fall semester of their first year, regardless of Math ACT score. At this university, eligibility for General Chemistry I was an ACT Math score of 24 or higher, or a grade of "C" or better in College Algebra. Historically, many students with ACT Math scores below 24 have struggled academically in the university's chemistry courses. However, the program committee felt strongly that the academic tutoring and mentoring components of the program would support the students toward academic success and the scholarship program would be able to make a real difference for students that typically struggle on their STEM career pathway.

The first cohort consisted of 6 students and was admitted to the program in the Fall 2016 semester. Students chosen for admittance to the program fulfilled the selection criteria as first generation and excluded students majoring in the physical sciences with high financial need. (See Table 1.) The cohort had an average ACT Math score of 21 but were all eligible to register for General Chemistry I due to prior College Algebra credit. In their first semester, students were co-registered in math and General Chemistry I courses in addition to the 1-credit hour mentoring support class, and were encouraged to participate in all academic tutoring and mentoring activities for the academic year.

The prediction that intensive academic tutoring and mentoring components would support students to success did not accomplish our program goals. Of the 6 students entering in the Fall 2016 cohort, 4 quit classes and left the university after one academic year, 1 switched to a non-STEM major and graduated with a Bachelor of Science degree, and 1 continued as a mathematics major and graduated with a Bachelor of Science degree but was dropped from scholarship support as their grade point average fell below scholarship guidelines and was disqualifying for continued support. Tracking of each student indicates that the four students which left the university enrolled subsequently in community college courses. The non-STEM graduate is gainfully employed. The one student that graduated with a math degree became a high school math teacher and has a successful career.

Discussion with students during their first year courses on their challenges at university showcased the transition that they were struggling with. Figure 6 shows a student representation of the university transition, with particular emphasis given to the General Chemistry I course requirements.

No matter how intensively students were supported with tutoring and academic activities, the students as a group stated that the university transition felt like an unscalable cliff, with too big a transition being required all at once. When interviewed about their first year by the evaluator, five of the six students indicated General Chemistry I as the class that gave them the most difficulty, with comments suggesting that the material was hard and the course moved too fast for them; the sixth student indicated Biology I as their most challenging course due to the quantity of memorization. Five of the six students, the same ones struggling in General Chemistry I, utilized the tutoring support provided by the S-STEM program to assist with General Chemistry I and their enrolled mathematics course (Trigonometry or Calculus I).

Interviews with the first cohort established that all students indicated good time management and study habits, with a stated average of 25 hours per week devoted to studying outside of class; satisfaction with the tutoring services provided, with an average rank of 6.6 on

Scale or Subscale	Mean (*SD*) Recipient[a]	Mean (*SD*) Nonrecipient[b]	*t*	Significance
Total Motivation	90.08 (10.41)	78.37 (11.73)	-3.35	$p = .001$
Intrinsic Motivation	17.25 (2.22)	13.25 (3.48)	-3.39	$p < .001$
Self-Efficacy	17.92 (2.19)	15.53 (3.25)	-2.50	$p = .014$
Self-Determination	17.42 (3.18)	14.65 (2.95)	-3.11	$p = .002$
Grade Motivation	18.92 (1.73)	17.49 (2.60)	-1.86	$p = .064$
Career Motivation	18.58 (2.68)	17.49 (2.92)	-1.25	$p = .210$

Note. Science motivation was measured with the Science Motivation Questionnaire II (Glynn et al., 2011). Values of $p \leq .05$ are considered statistically significant. [a]$n = 12$. [b]$n = 147$.

Table 3. Differences in Science Motivation between Scholarship Recipients and Nonrecipients

a 7-point scale (from 1 = Very Dissatisfied to 7 = Very Satisfied); and satisfaction with the faculty mentoring and advising provided, with average rank of 6.0 on a 7-point scale. At the time of the interview (midpoint of second semester), 5 students indicated they still wanted to stay within their designated major and pursue their original career goals. However, as stated previously, by the end of the semester, 4 of the 6 participants dropped out of school, and 1 changed to a non-STEM major.

Subsequent Cohorts

After the first year of student mentoring, the faculty mentors and advisory committee revised criteria for student admittance to the program. While the demographic and financial need guidelines remained unchanged, the ACT Math requirement was increased to scores of 24 or higher. This meant students were eligible to enroll in either Trigonometry (with ACT Math ≥ 24) or Calculus I (with ACT Math ≥ 26) as their first semester math course. In their first semester, students were co-registered in math and General Chemistry I courses in addition to the 1-credit hour mentoring support class. Students had access to all academic tutoring and mentoring support activities provided to the first cohort. The four subsequent cohorts comprised a total of 25 students. Admission criteria were altered to best support student success within the courses needed for the designated majors. While additional support strategies could have been implemented to support lower Math ACT students, the committee determined that we didn't have additional resources that could support students to their needed level.

Motivation. One intended impact of the S-STEM program at this university was to promote motivation for graduation and career in the physical sciences. Students in both the S-STEM scholarship program and a Calculus I class were asked to complete the SMQII online during a spring term. Scholarship student responses (beginning with our Year 2 cohort) were compared to Calculus I student responses, which were used as a control group. For this merged data, the scale was checked and deemed reliable, total Cronbach's $\alpha = .927$, subscales ranged from Cronbach's $\alpha = .773$ to .892. In these comparisons, there were significant differences in terms of total motivation score ($p = .001$), intrinsic motivation ($p < .001$), self-efficacy ($p = .014$), and self-determination ($p = .002$), but not in grade motivation ($p = .064$) or career motivation ($p = .21$). The S-STEM scholarship recipients were found to hold higher levels of motivation for science or math in self-efficacy (confidence), intrinsic motivation (interest, meaning), and self-determination (effort, time) compared to peers. No differences in motivation were found between the groups for maintaining grades or science as career path. See Table 3 for descriptive statistics and t-tests on each of the components.

Hierarchical regression confirmed these analyses. In correlations, we found that race, work, and intended major were not correlated with the dependent variable of interest, motivation level. So, a hierarchal regression controlling for gender and classification level was performed. Scholarship recipience was confirmed to be a significant predictor of overall science motivation level ($p = .017$).

Student outcomes. Data was also collected through interviews with the scholarship recipients performed by an external evaluator. Student responses were inductively coded by the evaluator to identify potential themes. Questions focused on the mentoring and team-building course, mentorship by faculty, research involvement, whether students intended to stay in their major, their career goals, and their hours working in a job and extracurricular activities. At the time of the final interview (Spring 2020), it was determined that, of current scholarship recipients, 71.4% of cohort participants were involved in research, with most of those doing research as volunteers; 100% intended to stay in their STEM major; and 100% had career plans that involved STEM. Additionally, 71.4% were involved in STEM-related student organizations, with organization membership highest (100%) among the newest cohort. Finally, 57% of scholarship recipients intended to enter STEM-related graduate programs. When further STEM education was expanded to also consider professional school (e.g., medical school, pharmacy school), that number increased to 86%.

Tracking of participants continues. Of the 25 subsequent-cohort students, 20 have successfully graduated in their intended major and 3 are still attending classes and making progress toward their chosen major. One student had switched to a different STEM major outside of the program's designated majors and graduated. One student left school after just one semester due to financial distress. Of the 20 students that graduated in their intended major, 6 have entered graduate programs, 6 have entered professional school, and 4 are working STEM-related jobs. Employment and/or further education plans for the remaining 4 graduates is not known.

Student perceptions. Students expressed in interviews that the financial support was helpful, with one student saying, "I am extremely grateful for the scholarship program, because I am lucky enough to not have to work while I am also going to school." Another student even expressed that their continuance in their major had depended upon the scholarship, saying "I would not be able to have the flexibility and time if it was not for this scholarship. I probably would have already changed majors if it was not for this scholarship."

First-year students reported finding the team-building course intellectually helpful. One student said, "The class was very interesting and helped me make connections between math and science and real-world problems." Another student elaborated on the course further, saying,

> "The . . . math integration course was a tremendous experience for me. I learned to view math as more than simply memorizing steps to solve a given problem. [The mathematics faculty mentor] taught me that math is the tool which can be used to find answers across different science fields. Learning to think about math as a tool was an eye-opener."

One student even took time to rectify a slightly negative review from the previous year about the course, saying "I have realized that the class was useful to us . . . . [I] had great insights during the STEM class that I am still realizing today."

Students also expressed in interviews that they valued the community developed by the program and team-building course, saying that it contributed to a "healthy pressure to succeed in STEM classes." They also expressed gratitude for mentors who they viewed as "invested in them." One student reported,

> "S-STEM has been a huge blessing in terms of mentoring. My first year I was able to build relationships with scholarship advisors and fellow recipients, but in my second year, I really utilized those connections to thrive within my studies. The support system has really played a critical role in my success this year."

Overall, students spoke positively about the S-STEM program and its impact upon them.

One first-year student offered a synopsis of the program and what it meant to her:

> "My experience as a [*sic*] S-STEM scholarship recipient was profound. The scholarship alleviated a tremendous financial burden, which enabled me to devote more time [to] my studies both inside and outside the classroom. I received tremendous mentorship, which led to my pursuit of opportunities I would not even have envisioned on my own. Additionally, the math course offered during my first semester enabled me to alter how I used and considered math. This became greatly beneficial in my future endeavors both in academics and in research. The past year as a scholarship recipient helped to mold me into a better student and scientist, and I now feel more confident in the goals I am pursuing. The S-STEM scholarship provided me with all of the tools I needed to succeed in my sophomore year, and I know it will continue to impact me."

Discussion

Program recruitment goals regarding underserved student populations were reasonably well achieved (see Table 1). All students admitted had high financial need. Of participants, 29.0% were underrepresented excluded students and 64.5% were women, compared to 16.9% and 53.2%, respectively, of undergraduate enrollment for chemistry, physics, and math majors in the same period. Additionally, 58.1% of participants were first generation college students.

This S-STEM scholarship program attempted to support students that came in with lower math facility at the university level but was unable to successfully support these selected students. The transition for students in the first year of college has been identified as crucial for student success (Chen, 2013) and contributing to a significant amount of mental stress (Auerbach et al, 2018). Excluded students pursuing STEM majors appear to be even more vulnerable to these stressors (London, Rosenthal, Levey & Lobel, 2011). Success for the program came with the revision of the student selection criteria to require higher ACT Math scores; subsequent-cohort students had an average ACT Math score of 26. Our own program struggled to provide enough resources to support students entering in at lower Math ACT scores. The strong peer-peer and peer-faculty mentoring components were mentioned by students as important support structures that led to program success. It is speculated that the community created by the program helped increase a sense of belonging among the participants and fostered a less competitive, more cooperative environment. This correlates with other research studies that tracked student motivation and engagement for STEM fields (Andreev et al, 2020; Gok, T. (2021); Gladstone et al, (2022). A benefit of the scholarship program was seen in its potential for promoting students' personal beliefs related to STEM fields, i.e., their motivation, self-efficacy, and self-determination. We suggest that future coordinators of these student support programs strongly consider inclusion of undergraduate research components and work on building healthy peer-peer interactions. Our students indicated strong benefit from those components.

References

Andreev, V. V., Gorbunov, V. I., Evdokimova, O. K., & Rimondi, G. (2020). Transdisciplinary approach to improving study motivation among university students of engineering specialties. *Education and Self Development, 15*(1), 21-37. https://doi.org/10.26907/esd15.1.03

Astorne-Figari, C., & Speer, J. D. (2018). Drop out, switch majors, or persist? The contrasting gender gaps. *Economics Letters, 164, 82-85.* doi: https://doi.org/10.1016/j.econlet.2018.01.010

Astorne-Figari, C., & Speer, J. D. (2019). Are changes of major major changes? The roles of grades, gender, and preferences in college major switching. *Economics of Education Review, 70,* 75-93. doi: https://doi.org/10.1016/j.econedurev.2019.03.005

Carnevale, A. P., & Smith, N. (2018). Balancing work and learning: Implications for low-income students.

Chen, X. (2009). Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education. [electronic resource]: National Center for Education Statistics.

Chen, X. (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001. National Center for Education Statistics.

Fink, A., Frey, R. F., & Solomon, E. D. (2020). Belonging in general chemistry predicts first-year undergraduates' performance and attrition. *Chemistry Education Research and Practice, 21*(4), 1042-1062. doi:10.1039/D0RP00053A

Fisher, C. R., Thompson, C. D., & Brookes, R. H. (2022). Levels of Science Identity, Belonging and Experiences of Discrimination for Commencing Science Students at an Australian University. *International Journal of Innovation in Science and Mathematics Education, 30*(2).

Gladstone, J. R., Morell, M., Yang, J. S., Ponnock, A., Turci Faust, L., & Wigfield, A. (2022). You can't compare if you don't prepare: Differential item functioning in measures of grit, stem self-regulation, and motivation. *The Journal of Experimental Education*. https://doi.org/10.1080/00220973.2022.2062584

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching, 48*(10), 1159-1176. doi: https://doi.org/10.1002/tea.20442

Gok, T. (2021). The development of the STEM (science, technology, engineering, and mathematics) attitude and motivation survey towards secondary school students. International *Journal of Cognitive Research in Science, Engineering and Education, 9*(1), 105-119. https://doi.org/10.23947/2334-8496-2021-9-1-105-119

Kamer, J. A., & Ishitani, T. T. (2019). First-Year, Nontraditional Student Retention at Four-Year Institutions: How Predictors of Attrition Vary Across Time. *Journal of College Student Retention: Research, Theory & Practice, 23*(3), 560-579. doi:10.1177/1521025119858732

Louten, J. (2022). Fostering Persistence in Science, Technology, Engineering, and Mathematics (STEM): Creating an Equitable Environment That Addresses the Needs of Undergraduate Students. *Journal of College Student Retention: Research, Theory & Practice*, 15210251211073574. doi:10.1177/15210251211073574

National Center for Education Statistics. (2022, May 2022). College Enrollment Rates. Condition of Education. Retrieved from https://nces.ed.gov/programs/coe/indicator/cpb

National Science Board, & National Science Foundation. (2022). Higher Education in Science and Engineering (NSB-2022-3). Retrieved from https://ncses.nsf.gov/pubs/nsb20223/assets/nsb20223.pdf

Nguyen, D. J., & Herron, A. (2021). Keeping up with the Joneses or feeling priced out?: Exploring how low-income students' financial position shapes sense of belonging. *Journal of Diversity in Higher Education, 14*(3), 429-440. doi:10.1037/dhe0000191

Pearson, J., Giacumo, L. A., Farid, A., & Sadegh, M. (2022). A Systematic Multiple Studies Review of Low-Income, First-Generation, and Underrepresented, STEM-Degree Support Programs: Emerging Evidence-Based Models and Recommendations. *Education Sciences, 12*(5). doi:10.3390/educsci12050333

Riegle-Crumb, C., & King, B. (2010). Questioning a White Male Advantage in STEM: Examining Disparities in College Major by Gender and Race/Ethnicity. *Educational Researcher, 39*(9), 656-664. doi:10.3102/0013189X10391657

Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does STEM Stand Out? Examining Racial/Ethnic Gaps in Persistence Across Postsecondary Fields. *Educational Researcher, 48*(3), 133-144. doi:10.3102/0013189X19831006

Sovero, V., Buchinsky, M., & Baird, M. D. (2021). Playing catch up: A term-level investigation of the racial gap in STEM retention. *Economics of Education Review, 83*, 102146. doi: https://doi.org/10.1016/j.econedurev.2021.102146

Verdín, D., Godwin, A., Kirn, A., Benson, L., & Potvin, G. (2018). Understanding how engineering identity and belongingness predict grit for first-generation college students.

Whitcomb, K. M., & Singh, C. (2021). Underrepresented minority students receive lower grades and have higher rates of attrition across STEM disciplines: A sign of inequity? *International Journal of Science Education, 43*(7), 1054-1089. doi: 10.1080/09500693.2021.1900623

Deb Mlsna is an Associate Professor of Chemistry at Mississippi State University with a research focus in Chemical Education. Her B.S. degree is from Davidson College and her Ph.D. is from the University of Texas at Austin. She is co-PI of the REU-INFEWS Program and is responsible for student training and engagement with the summer research program. Dr. Mlsna has been awarded numerous teaching awards for her contributions in the classroom, including the Grisham Master Teacher Award of Mississippi State University.

Anastasia D. Elder is the Associate Dean of Shackouls Honors College and Director of Undergraduate Research and Creative Discovery at Mississippi State University. She is also a Professor of Educational Psychology and a Faculty Associate in the Center for Teaching and Learning. Her research efforts include investigating and assessing students' developing cognition, beliefs, motivation, and self-regulation. She has engaged in evaluation of education activities and teacher professional development in STEM since 2000. She earned her B.S. in Psychology from Duke University and her Ph.D. in Education and Psychology from University of Michigan.

Seth F. Oppenheimer moved to Augusta University after 33 years in the Department of Mathematics and Statistics of Mississippi State University. At Augusta University he is currently chair and professor of Mathematics and associate dean for Community and Alumni Relations for the College of Science and Mathematics.

Donna M. Pierce, PhD, is an Associate Professor of Physics and Astronomy at Mississippi State University. Her primary areas of interest are cometary science, astrochemistry, and student professional development. She was a Co-PI for the S-STEM project at MSU. She earned her MS and PhD in Astronomy from the University of Maryland College Park and held a postoctoral research position in the Department of Astronomy at the University of Texas at Austin prior to joining the faculty at MSU. She also earned a BS in Physics from the University of Kentucky.