Helping Academically Talented STEM Students with Financial Need Succeed

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***Abstract*—This Research to Practice Full Paper presents the experiences and lessons learned from five programs that provide financial awards and a holistic student support structure to low-income, academically talented students in Science, Technology, Engineering, and Mathematics (STEM). This report synthesizes the experiences of a diverse set of institutions, both public and private, that vary in size and geographic location. We have experience supporting students from a range of disciplines with an emphasis on students studying Computer Science. The goals of this work are to (1) outline the decisions that must be considered when designing a financial award program; (2) describe the interventions we have implemented and underline the institutional contexts that have led to their success; (3) describe the unique challenges posed by the COVID pandemic; and (4) highlight key elements necessary for successful program implementation. We specifically discuss the challenges we have encountered when implementing existing best practices. We report observations and results, some of which buttress those reported in the literature. Our work is intended to serve as a guide for educators who wish to implement programs to support students from financially disadvantaged and/or historically marginalized groups. By sharing our experiences and pain points, we hope to make it easier for them to design and implement effective programs adapted to their institutional needs and contexts.**

***Index Terms*—STEM, scholarships, mentoring, career development**

I. Introduction

Despite an increasing need for skilled professionals in Science, Technology, Engineering, and Mathematics (STEM) fields, retention and graduation rates for STEM students remains low [1]. A number of factors contribute to student attrition. First, financial cost is a barrier for many students. Though scholarships can help to alleviate financial burden, funding alone is not sufficient to ensure student success [2]. In addition, many STEM fields struggle to retain students from historically marginalized populations [3]. This is especially true in computing disciplines. Finally, students often identify with more than one historically marginalized group, and students with financial need are often first generation college students or students with racial or gender identities that are underrepresented in STEM majors. Retaining and graduating more students in STEM requires a holistic approach that considers both financial barriers and a broader need for student support.

There is a wide body of educational research that describes best practices for supporting students. However, strategies for implementing student support activities are often not clearly defined. A faculty team may design a program of student supports based on existing literature but face challenges when putting the ideas into practice. In addition, combining different kinds of support in a holistic way to support an intended population of students is not straightforward. If one is fortunate enough to have financial support to offer to students, there are often logistical challenges such as accessing student financial need data and working with an institution's financial aid office to make awards. Combining financial and other kinds of support can pose a number of challenges.

In this work, we report on lessons learned from five projects supported by the National Science Foundation Scholarships in STEM (S-STEM) program [4]. S-STEM grants provide institutions support for low-income, academically talented students in eligible STEM fields. Most of the projects in this report focus on computing, though our projects support a range of other STEM disciplines. In addition to scholarships, S-STEM projects are expected to provide necessary support to help students reach degree completion. A number of previous S-STEM principal investigators have published their experiences with the program [5]–[8]. Unlike previous work, however, this report synthesizes the experiences of multiple diverse institutions. Table I illustrates our institutional and program characteristics. Our institutions range from small with enrollment of 5,800 students to mid-sized with enrollment from 10,000 to 15,000 students. The highest degree awarded by all of our institutions is Master of Science (MS). Finally, we have experience with several different types of S-STEM awards. Type or Track 1 awards (renamed by the S-STEM program) are capacity-building awards made to a single institution that has not had previous support from the S-STEM program. Type 2 awards are larger but often typically made to a single institution. Type 3 awards are multi-million dollar awards meant to support multi-institutional consortia, for example programs that support a transfer pathway from a two-year

Institution	University of San Francisco	Central Connecticut State University	Northern Kentucky University	Ramapo College of New Jersey	St. Joseph's College New York
Institution Size	Mid-sized	Mid-sized	Mid-sized	Small	Small
Highest Degree Awarded	MS	MS	MS	MS	MS
Additional Institutional Characteristics	Private, Jesuit, Urban	Public, Urban	Public, Urban, Commuter	Public, Urban, Liberal Arts	Private, Catholic, Liberal Arts, Suburban, Commuter
Type of S-STEM Award	Track 1	Type 3	Type 3	Type 2	Type 1
Disciplines Supported	Computer Science	Computer Science, Math, Physics	STEM	Computer Science	Computer Science, Math

TABLE I
THIS TABLE ILLUSTRATES THE CHARACTERISTICS OF EACH OF THE INSTITUTIONS WHOSE PROGRAMS ARE DESCRIBED IN THIS REPORT; THE TYPE OF S-STEM AWARD SUPPORTING THE PROGRAM; AND THE DISCIPLINES SUPPORTED BY THE PROGRAM.

to a four-year institution. Though this work derives from our experience with S-STEM, we believe that the lessons we report are applicable to the design of any holistic program to support retention and degree completion of students in STEM.

The goals of this work are to (1) outline the decisions that must be considered when designing an award program; (2) describe the interventions we have implemented and underline the institutional contexts that have led to their success; (3) describe the unique challenges posed by the COVID pandemic; and (4) highlight key elements necessary for successful program implementation. This report describes lessons learned from a variety of programs implemented across a broad range of institutions. Though S-STEM funds low-income students, these practices can be extended to improve the retention of all students. Our experience reflects commonalities and differences at institutions of different sizes, in different geographic locations, and both public and private universities. We all support students majoring in Computer Science (CS), and some of our projects support students across a number of STEM disciplines.

Our work is intended to serve as a guide for educators wishing to implement programs to support students from financially disadvantaged and/or historically marginalized groups, and our lessons are particularly applicable to the computing field. When our observations and results confirm those reported in previous work, our report serves to provide additional evidence in favor of those practices and the desirability of their adoption. We also highlight the challenges we have encountered when putting into practice existing best practices from the field. By sharing our experiences and challenges, we hope to make program design and implementation easier for future S-STEM PIs or others wishing to implement similar programs.

II. SCHOLARSHIP AWARD DESIGN

S-STEM programs include up to four years of financial support for scholars as a mechanism to improve retention [9], [10]. Two critical design decisions for the scholarship are: (1) the duration of support; and (2) the amount of support. It is common for institutions to provide support for up to four years, provided the scholar continues to meet eligibility criteria. Some institutions may choose to provide scholarships for the first two years and waive tuition and fees for the remaining years. Some have also offered to waive tuition and fees for a fifth year should a scholar need it to complete the degree.

Scholarship funding amounts are defined and managed in different ways to meet overall program goals. Scholarship values vary between $500 and the maximum award of $10,000. Programs with the goal of providing scholarships to the largest number of students offer smaller amounts covering only a part of a student's cost of attendance, but such support may provide less incentive to attract/retain scholars. Programs offering larger scholarships tend to use the scholarship as a recruiting tool to attract prospective and/or admitted students to the institution. They sometimes waive tuition and fees in excess of the maximum scholarship amount of $10,000. It is also common for programs to tailor scholarships based on a student's unmet financial need, thereby awarding a different amount to each student. Table II shows the percentage of costs covered by the maximum scholarship amount at each institution included in this report. As illustrated in Table I and Table II, when determining scholarship amount it is helpful to understand not just the cost of tuition but also the total cost of attendance. For institutions with on-campus housing, this may include the additional cost of residential housing.

Scholarship support helps defray costs of the scholars and their families. It also provides scholars with motivation to engage with the S-STEM project team and participate in student support activities. Unfortunately, while a key goal of providing funding support is to reduce a scholar's need to work, it is exceedingly common that scholars continue to engage in paid outside work. This is discussed in more detail in Section V.

The rationale behind the disciplines each program supports is varied. Some programs support students from a single

Institution	University of San Francisco	Central Connecticut State University	Northern Kentucky University	Ramapo College of New Jersey	St. Joseph's College New York
Award	$8,125	$10,000	$500-$5,000	$10,000	$10,000
Tuition and Fees	$53,000	$11,068	$10,000	$14,678	$29,190
% Tuition Covered with Institutional Support	15%	97.5%	5%-50%	100%	34%

TABLE II
THIS TABLE ILLUSTRATES THE SIZE OF THE SCHOLARSHIP AWARD, THE TOTAL A STUDENT MUST PAY IN TUITION AND FEES AT THE INSTITUTION, AND THE PERCENTAGE OF TUITION AND FEES COVERED BY THE AWARD.

STEM major while others include students from multiple disciplines. As a result, though there is typically a single program lead that assumes overall management responsibility, the project may involve one department, multiple departments, or even multiple institutions.

The process of selecting scholars varies by institution. Most programs require an application essay and/or interview and select scholars based on academic potential, commitment, and other qualities that indicate student success. Additional recommendations for scholar selection are discussed in Section V.

Challenges: Small scholarships (e.g., award amount of $500) are not effective. In our experience, small award amounts are not sufficient to encourage scholars to participate in program activities such as cohort building and meeting with advisors. Though the minimum award size may differ by institution, an award should be designed to ensure that students will engage with the program.

III. Interventions: Curricular, Extra-Curricular, and Career-Oriented

Interventions implemented by our institutions generally fall into one or more of the following categories: curricular, co-curricular, and career-oriented. Figure 1 illustrates the interventions implemented in the projects described in this report.

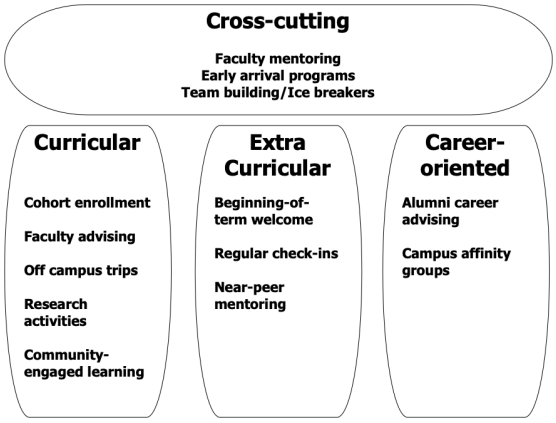

Fig. 1. The projects described in this report employ a range of interventions and high-impact practices supported by the literature. A number of cross-cutting cohort-building strategies are used, as well as curricular, extra-curricular, and career-oriented interventions.

One of the most important components of all S-STEM programs is cohort building, which is implemented in various ways by all the institutions represented in this report. Some institutions begin cohort building even before scholars start their first semester as members of the scholarship program. One cohort-building model that we have found to be successful is a one-week early arrival program designed to introduce scholars to resources available to them in the department and at the university, and to expose them to some of the technical content they encounter in the first semester of study. Activities of this all-day, week-long program include programming instruction and practice; presentations by representatives from campus resources such as the writing center; and an opportunity to meet faculty in the department via a scavenger hunt. Student feedback about the program indicates that it plays a role in helping to build confidence. When asked about their experience in the program, a student replied as follows:

> "Because of the Head Start week… when in my first semester we did visual coding, I thought, 'I got this in the bag!'."

Many institutions employ some form of introductory team-building activities at the very beginning of each cohort's first semester to jump-start the cohort or to help a new group of scholars join an existing cohort. Some activities found to be helpful include having previous graduates from the same scholarship program talk about their experience and success; teaming up a small group of 2–3 incoming scholars with a near-peer from the current cohort in playful ice-breaking activities, or having the near-peer share their scholarship program experience.

Challenges: Cohort building can be challenging if some scholars live on campus while others commute. One solution, made recently possible by the need to adapt to pandemic restrictions, is to hold more online meetings and presentations so that both groups can participate.

A. Curricular Interventions

One of the most successful curricular practices in building and sustaining a cohesive cohort is cohort enrollment – enrolling students in at least one academic course together. A pre-requisite for cohort enrollment is that all first year scholars must join the institution at a comparable academic level and/or are in the same academic discipline. In order to implement cohort enrollment, the institution must have the necessary group enrollment infrastructure in place. When incoming scholars are at varying levels of academic preparation (e.g., see [7]), one viable alternative is to create comparable experiences on a smaller scale where groups of 2–4 students within the cohort

are enrolled in the same class(es). This approach can lead to forming very effective study groups and can also involve scholars who have already taken the same course acting as tutors for the group. Such study groups may re-constitute each semester with new connections and linkages across groups. A combination of such inter-weaved relationships combined with cohort-wide end-of-semester review and planning can be a meaningful substitute for cohort-wide enrollment into a single class.

A first-semester cohort course is another intervention we have found successful. One institution offers an *Introduction to CS* course that introduces students to departmental and campus resources and connects them to program alumni. As part of an effort to evaluate how to scale successful practices, another institution implemented a semester-long course which incorporated activities similar to orientation. It offered the course to students across the CS discipline demonstrating the potential to institutionalize the interventions implemented as part of S-STEM projects.

Some of the other curricular activities include:

- Faculty mentoring takes a number of forms centered around close and frequent student interaction with faculty [11]. Depending on the number of students in the cohort, some institutions practice one-on-one and/or small group interactions with faculty. The topics typically focus on academic performance (which is best suited for one-on-one meetings), degree planning and research topics.
- Attendance and participation in academic-focused on- and off-campus events such as research seminars, guest lectures, conferences, programming contests and research competitions is an excellent way to bring the entire cohort together. Frequently, the academic-centered part of the event is complemented with a social activity, such as a pre- or post-event meal. Group trips to off-campus conferences and competitions are an especially productive way to increase cohort cohesion because they provide the opportunity for students to socialize and spend more time together outside the classroom. Field trips are also an excellent way to increase the sense of community by breaching the boundaries of curricular and co-curricular activities and naturally blending learning and topical activities with socializing [12]. S-STEM awards are typically structured so that their budget can cover these kinds of enrichment activities.
- Research-centric experiences help broaden students' perspectives on how various theoretical course topics can be applied in practice, while helping bring students closer with each other and with their faculty [13]. Faculty colloquium is one way to get students interested in participating in research, wherein, faculty members talk about their research projects and how students can get involved in them. Another option is Research Experiences for Undergraduates (REU) program supported by the NSF: students are introduced to REU programs at various institutions and either faculty at those institutions or, more effectively, current and past REU-participants from the scholars' institution are invited to promote the REUs, and answer questions.
- Community-engaged learning is especially useful for scholars from traditionally marginalized groups. Placing teams of scholars in courses that include concepts of computing for the social good or senior design courses that incorporate projects sourced from local non-profits allows them to develop even stronger bonds with the community, a sense of belonging, and the satisfaction of giving back to the community [14].

Challenges: Not every scholar may be interested in participating in research activities. Some may prefer industry internships or co-ops. Others may prefer to spend the summer working to earn money for the next semester. The challenge of designing interventions is to make them interesting and useful enough to attract maximal participation without leaving anyone feeling coerced into participation. Requiring scholars to attend too many curricular or extracurricular activities may have the counterproductive effect of robbing them of a sense of agency in their own affairs. For a larger cohort with divergent interests, a possible solution may be to offer several kinds of activities that would appeal to certain subsets of scholars. However, in order to avoid cohort fragmentation, it is important to involve scholars in enough activities attractive to various combinations of the scholars' interests, thus allowing these possible cohort subsets to intermix.

B. Extra-Curricular Interventions

In addition to curriculum-focused activities, a wide array of extra-curricular activities is helpful to engage students and keep them closely knit with their cohort. In fact, it is very important to diversify cohort-building and sustaining activities and ensure that they are not focused solely on academics. This can help the scholars identify common interests and traits in each other and leverage these commonalities to interact more on and off campus on topics that go beyond academics. Informal events such as bonfires, cookouts, games, and hackathons are good examples of such activities.

Most S-STEM cohorts are not sustained over the summer when students move off-campus and/or do not take any classes. Therefore, it is important to renew the "cohort feeling" at the beginning of each academic year. Most of our programs choose to do so with some sort of informal "welcome back" event. During this event, students get re-acquainted with each other, program faculty announce plans for the upcoming academic year to the entire cohort, and students sign their annual scholarship contract and any IRB forms required by the institution. New scholars meet with current scholars, may be paired with a continuing scholar and a faculty advisor, and are advised by faculty on how to succeed in college.

All S-STEM programs represented in this report employ a combination of several periodic visits/check-ins with individual students. It is important for faculty mentors to get to know students outside the academic context to enable them to see a better and broader picture of the scholar's well-being. There are many possible scenarios where extra-curricular factors

could impact a scholar's academic success. Does their family situation impact their studies? Do they manage their time well to focus on the coursework? Is their schedule impacted by other obligations, e.g. family, childcare, work, etc.? Are they or their loved ones impacted by food insecurity? Is their housing situation conducive to academic success? Regular one-on-one meetings with faculty mentors used by all of us help build closer relationships between faculty and students, and, most importantly, have been proven to be one of the most effective ways of identifying any red flags in a scholars' academic life. [15] The earlier such potential problems are identified, the earlier a meaningful intervention can take place, thus minimizing the chance of a negative outcome for the student.

Regular near-peer mentoring has also been employed by several of our institutions. This approach has been shown to be effective at ensuring a successful transition to campus life for incoming scholars—both fresh admits and transfers [16], [17]. For example, one of the institutions represented in this report has a peer mentoring program that pairs juniors and seniors with incoming first-year and transfer students based on a similarity metric that takes into account factors such as a students' major, gender, native language, ethnicity, hometown, hobbies and interests. During weekly or biweekly meetings with their near-peers, students learn about the best practices of using campus resources, solving everyday problems, and generally "surviving" their first semester on campus. Based on student feedback, this practice has been very effective, especially for first-generation students and students from historically marginalized groups.

Challenges: While scholars typically have no problem opening up and discussing their issues with their near-peers, they may not always be open to establishing a closer relationship with faculty mentors. One approach to building this relationship could be through a sequence of meetings with a decreasing number of participants, starting with the entire cohort, then a smaller group including some peers with whom the faculty mentor already has a good rapport, and finally an individual meeting, by which time students are often more at ease when talking with their faculty mentors.

C. Career-oriented Interventions

Career preparation is a very important component of any STEM program. Each S-STEM program employs a combination of several cohort activities geared towards helping graduating seniors find successful employment in industry.

As with many other activities, students tend to respond very well to advice given by their near-peers—in this case, by alumni of the same program. All the programs represented in this report organize cohort activities with alumni who tell current students about how their time in college helped prepare them for joining industry, best practices for job hunting and interviewing, information about their current jobs, and the skills they have (or they wish they had) that are the most useful in the industry. At many such events, alumni are joined by other industry professionals affiliated with the same company to provide a broader picture of the opportunities and projects at that company. Pairing scholars with alumni and other working professionals for regular mentoring or job shadowing has also proven very effective. Encouraging students to participate in campus affinity groups (e.g., Women in Computing) can help them connect with role models and develop their professional identity.

Some of us offer our scholars "VIP sessions" exclusively before on-campus CS-focused career fairs that are otherwise open to everyone. Feedback indicates that scholars greatly appreciate this kind of specialized treatment, not to mention the one-on-one attention they get from the companies participating in the career fairs.

Challenges: One potential problem with pairing a scholar with an alum is that their professional interests or other identities may not align: the scholar may not be interested in the same company/business as the alum or may prefer to connect with an alum who shares other identity characteristics. An alternative is to have a regularly scheduled rotating panel of alums advising scholars in a many-to-many fashion so that the scholars are exposed to a broad range of companies, interests, and identities.

D. Formative Findings

Our projects collect a variety of qualitative and quantitative evidence to evaluate the effectiveness of the interventions we implement. Project staff as well as external project evaluators utilize tools such as surveys, interviews, and focus groups to understand the impact of the project activities. Most of the evidence presented in this work is derived from free-form comments solicited in informal end-of-year surveys. In this subsection, we highlight a few of our key findings and observations.

Mentoring is Key: Mentoring is often rated as the most helpful element of the program, and students acknowledge its impact. At one institution, students were asked to rate a series of questions about the effectiveness of faculty advice on academics, academic challenges and adjusting to campus life, on a Likert scale of 1 (least effective) to 5 (most effective). Students rated most of the questions 4.7 or higher, with 4.6 on two questions about advice on general education requirements and extra curricular activities. At another institution, a student described the value of the mentorship experience as follows:

> "The attention that I get from my cohort and the monitoring by the professors is strong. ... The faculty to student relationships is what makes the difference"

Impact Can Last Beyond the Intervention: It is a testament to the benefit of many interventions that students take the initiative to continue them even after they are no longer required or supported by the program. In one case, scholars implemented their own version of cohort enrollment by ensuring that they took the same sections of core and elective classes as other scholars. In another case, scholars formed

study groups each semester and offered near-peer advising to junior students.

First-Semester Courses Can Improve Retention for Scholars and Non-scholars: The first-semester *Introduction to college* course offered by one institution resulted in a 95% retention rate from fall to spring semester for scholars who completed the course. Moreover, across the CS discipline, the addition of the course resulted in the best retention rates for first-fall to first-spring and first-fall to second-fall semester in over 15 years at the institution. Compared to the average of the five previous years, there was an 8% increase in overall retention from first-fall to first-spring for first-year students in the CS department. There was a 19% increase in first-fall to second-fall from the average of the five previous years. Though this gain was not observed for the 2020-2021 academic year when the course was moved online, Section IV further describes the challenges introduced by COVID and how our programs have adapted to address those challenges.

Students Benefit from the Scholar Peer-Support Network: It is common for scholars to form a tight-knit social group and support one another both academically and socially. Most scholar groups have group chat channels and socialize outside of S-STEM events. At one institution, this peer support network has provided students with the confidence to take on broader leadership roles within ACM and Math clubs as well as within the student government.

Career Interventions Lead to Improved Internship Placement and Confidence: The impact of the job shadowing program implemented at one institution was mixed, with some students obtaining internships as a result of the program and others reporting that the experience was not helpful. At another institution, however, the career mentoring program has resulted in an improved internship placement rate for scholars. At a third institution, scholars have reported the impact of the program on their career path and confidence:

> "It has helped me stick with my major, and it's grounded me and helped me visualize seeing myself in the career."

IV. COVID-related Modifications

COVID-19 brought unforeseen challenges to our S-STEM programs. Ways to foster cohort building, support our scholars academically, and recruit new students all had to be modified.

In mid-March 2020 all the institutions represented in this report transitioned to fully remote instruction for the remainder of the spring 2020 semester. All S-STEM program in-person events were cancelled. Faculty mentor meetings with scholars moved online, and we tried to maintain or increase the frequency of these interactions. Some of our programs adopted a remote bi-weekly check-in with scholars and continued academic support services online such as math and computer science tutoring. With cohort building being the cornerstone of our S-STEM programs, we needed creative ways to avoid scholars feeling isolated by keeping them connected and engaged remotely, while being mindful that we did not want to overburden scholars or faculty during this stressful time. Optional events such as weekly scholar "tea time" meetings provided students and faculty an opportunity to connect. These sessions were well attended with some scholars attending regularly and some just dropping in for a few minutes. Many program activities were reimagined, focusing more on social interaction among students and faculty rather than having a curricular purpose. We moved cohort events like Escape rooms online and used *Kahoot* and *Quizizz* games for cohort building. Virtual study groups were established as a new way for scholars to connect and support each other. Online speaker series and alumni interactions replaced industry field trips and in-person conference attendance.

Helping scholars succeed academically took on new meaning. Remote synchronous instruction remained the primary teaching modality during fall 2020 at our institutions. Access to computers and high speed internet connections were areas of need for some of our most economically disadvantaged scholars. Having a laptop was especially necessary for students in Computer Science classes who needed access to software (such as IDEs) that could not be installed or run on a smartphone or tablet.

In spring 2020, students in many schools were able to opt for Pass/Fail grades, so their grade point averages (GPAs) were not affected. All the institutions represented in this report returned to the traditional letter grading scheme in fall 2020. Although there have been findings that student GPAs have risen during the pandemic [18] we did not find this to be true with our S-STEM scholars. Among the institutions included in this paper, three noted a drop in scholars' GPAs and two noted GPAs remaining the same. There have been findings that online instruction negatively impacts students' ability to learn and that students report a decreased preference for online instruction as a result of their recent experiences [19], [20]. Since the start of the pandemic, four of our institutions failed to retain all our scholars. Among them, two attributed scholar drop-out to COVID-related issues. Additional data analysis is needed to fully understand the impact of COVID on retention and performance of S-STEM scholars.

Our programs have continued to recruit new students during the pandemic. Interviewing candidates online has become the common practice. Although it was not a perfect substitute for meeting students in person, it enabled faculty to interact one on one with prospective students. Some of our institutions extended our Admissions cycle with the goal of recruiting more scholars. One institution reported receiving fewer applications than in previous years. Multiple factors can be attributed to this decline including overall decrease in the number of incoming freshmen due to declining demographics, some students opting for a gap year, transition to all-virtual recruitment activities, and the general shock caused by the pandemic.

Our institutions have continued with online instruction and remote scholarship events through fall 2020 and spring 2021.

Challenges: Due to recent changes in NACAC's (National Association for College Admission Counseling) college ad-

missions process, students can continue to be recruited by competing schools even after they have committed to attending an institution, Moreover, the pandemic has resulted in many institutions dropping standardized test requirements—more than 1,570 schools have made test scores optional for 2021 according to the National Center for Fair and Open Testing (fairtest.org). Though these changes can be beneficial for students, they are expected to make recruitment of scholars more challenging and unpredictable in the years to come.

V. Keys to Successful Program Implementation

Implementing an S-STEM program is an incredibly rewarding but challenging experience. Managing the logistics of scholarship allocation and distribution, for example, is a task that is new to most project leads and brings a host of challenges. In addition, putting into practice interventions from the literature is not always straightforward. In this section, we offer our recommendations for achieving successful project implementation based on our breadth of experience implementing a variety of programs across a range of institutions.

A. Seek administrative support

Administrative support from the Department Chair, Dean, and other campus organizational units is necessary for the success of a project, and involving administration early in the project design process can help ensure that necessary resources are available. Adequate time should be set aside for administering the project, either through release time written into the budget of the project or negotiated with the institution's administration. For large, multi-institutional projects, including budgetary support for a grant or project manager can be especially helpful.

Many interventions may require the support of campus organizational units such as the registrar, admissions, financial aid and student housing. Though these organizational units will often not need to go beyond their regular duties to assist with S-STEM activities, our experience shows that ensuring their cooperation well ahead of time is key to a successful partnership. The registrar's office for example may assist with getting students into the same section of a particular course. Working with campus housing may be necessary to ensure that scholars are housed together. Admissions staff can best advise how prospective scholars can be reached. Financial Aid staff know the ins and outs of how to disburse scholarship funds within the constraints of the institution (e.g., see [7]). Student Affairs staff are experts in organizing extra-curricular social activities—vendors, reservation of space, payments, etc. In order to comprehensively support low-income students without reinventing the wheel, one is well advised to seek out and involve expertise from all the units of the institution.

B. Provide a holistic student support structure

Academic support *alone* is not sufficient to ensure the success of the population of students served by our programs. We have formed deeper connections with our scholarship students than any other students we have taught in our careers. Often, low-income students face difficult living conditions, finance-related stresses, food insecurity, or health issues not treated due to poor healthcare support. Moreover, they may fail to meet the academic expectations of the scholarship award not because of their inability to master the material in a course, but because of non-academic issues such as working too many hours on a job, coping with living conditions, or the pandemic. It is necessary to establish a holistic support structure that provides an open, non-judgemental and supportive environment where students feel comfortable discussing their struggles, both personal and academic. This establishes the foundation to offer support where possible, for example by providing a computer to a student who does not have one at home, or to refer students to on-campus counseling or other services where appropriate.

Holistic support also includes meeting students where they are, and communicating via channels most convenient for them. We have found that traditional channels such as email can be ineffective, and relying on email can risk having students fall through the cracks. Using platforms such as Slack or text messaging was embraced by scholars in some institutions and has proven more effective.

C. Expect students to continue outside work

Designing program activities that accommodate students' work hours is necessary to ensure participation. Though we all designed our programs with the assumption that a scholarship would enable students to reduce their work hours, most of us have found that students do continue to work for a variety of reasons. This is particularly true for non-residential, commuter campuses. Some of us have found that offering more condensed activities, for example day-long intensive cohort-building rather than ongoing events, encourages more participation. Other strategies for addressing this challenge include paying students to participate in program-related content such as student research; offering a stipend to students who participate in longer activities such as multi-day workshops; and providing substantial meals during program activities.

D. Watch for faculty burnout

Implementing an S-STEM project can be a labor of love, and the project team often invests significant time and effort in the process. Faculty can easily get burned out, even when monetarily compensated for their effort. It is a good idea to have a few faculty involved with the project at a time, with a deep bench of replacements for those who want to cycle out of their duties for a semester or year. We have also found that paying faculty *à la carte* for the various activities (e.g., one-on-one advisement, recruitment and selection activities) can better incentivize faculty than compensating everyone at the same rate. Paying faculty stipends instead of giving them release time can better facilitate such *à la carte* payment. Whatever the mode of compensation, in order to ensure continued participation, faculty must feel that they are fairly and adequately compensated for their time and effort. Faculty participation is critical to the success of scholarship grant projects. Thus, faculty compensation must be carefully

designed, and if necessary, modified on the fly during the project.

E. Look for disciplinary interest during recruiting

A carefully designed recruiting process that assesses a student's disciplinary interest helps to ensure that students selected to participate are a match for the program. In most cases, our recruiting processes have evolved over time. Some of us, for example, found the first cohort of scholars to be less prepared than subsequent ones and have adapted recruiting practices to better suit our local context. It is common to publicize programs at local high schools, on the College Board list of high school graduates intending to major in a STEM discipline, and within one's network of high-school teachers and guidance counselors. For Computer Science in particular, we have found that it can be informative to interview prospective scholars face-to-face and discuss the program along with its requirements. While some students may have taken AP Computer Science, many do not have a clear understanding of the field of computing. Ensuring that they understand the expectations of the major and scholarship program upfront can improve their chances of succeeding.

F. Document project activities and student interactions

Documenting all the project activities builds institutional memory in the event of changes in the project team. It also provides raw data for formative evaluation of the program. Student-related documentation can include logs of faculty advisement, logs of participation in curricular, extra-curricular and career-oriented activities, records of probation and reinstatement, end-of-the-semester opinion surveys, award documents and transcripts of exit interviews. Project-related documentation can include contracts with external project evaluators and their periodic reports, record of curricular, extra-curricular and career-oriented activities conducted, and reports to funding agencies. Data such as grades, transcripts and scholarship amounts can be readily accessed from the institution's enterprise software. A shared Google Drive can be used to maintain logs. Project management tools such as Trello can provide a platform for documentation as well as communication.

G. Be prepared to feel rewarded

For all of us, leading an S-STEM project has been one of the most rewarding experiences of our careers. Faculty advisors serve *in loco parentis*. While one-on-one faculty mentoring is essential for the success of scholars, we have found that it is also a uniquely gratifying experience for the faculty who feel that they are making a difference in the lives of the scholars.

The following quotations from scholars allude to the impact the projects have had on their success:

> "I cannot stress enough how nice it is to have a personal advisor to go to with my first-year problems to help guide me through the college system and get me on the right path. That single-handedly [*sic*] took at least 50% of the stress out of freshman year because I had one person to go to with any questions who could either help me directly or point me to the right on-campus resources to solve my problems. She was like a personal Google for on-campus resources."

> "The community part is a lifesaver and helps me stay focused to have good guidelines leading me to where I need to go."

> "…the peers around me are some of the best people I've met. It's nice to be surrounded by people who have common interests with you. I know part of SOAR included adversity/hardships so to say [*sic*] I know that some of my peers have had some of the same struggles that I've had."

> "The rest of my cohort and the staff are like family for me."

> "It was really nice beneficial to have Professor X as my faculty advisor because I was able to talk to her about not only my courses but things outside of school and she proved to me that institution Y was one of the best decisions I could have made."

VI. Summary

Retaining and graduating STEM students and especially low-income students requires a holistic approach that combines financial assistance with student support. With the intention of benefiting the STEM education community, we have described some best practices and provided recommendations for both based on the breadth of our experience across a range of institutions. While we believe that they will be of interest to educators who want to support students in STEM programs, *we caution that one size does not fit all*. Educators must consider the unique needs of their student populations and the extant resources of their institutions that can be leveraged to provide student support. We hope that our collective experience will help them decide what approaches to adopt and how to adapt them. Although our programs were built on best practices from the literature, we recount the challenges we have addressed to implement them in our institutional contexts. These include the challenges posed by the unprecedented COVID pandemic. We hope that our account will help educators prepare themselves for similar challenges. Diverse as our institutions and scholarship programs are, we are all in consensus: while the task of administering scholarship programs is undeniably demanding, the experience is unarguably gratifying and rewarding.

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