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S-STEM as the Culmination of a Multi-Institutional, Multi-Grant Program for the Success of Underrepresented Students

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Abstract

Although numerous programs exist in many institutions of higher education aimed at helping students from underrepresented groups achieve their goals of successfully graduating in a science, technology, mathematics, or engineering (STEM) field and moving on to the next educational level or a career, few are set up to support students across schools, from their entry into postsecondary education at the community college through the completion of their four-year degree at a university and beyond. Furthermore, few programs are able to offer the full range of support that has been shown to be optimally effective toward promoting student success, as in, for example, the Building Engineering and Science Talent (BEST) model laid out by Chubin and Ward (2009). The reason for this is simple: rarely are the funds available from any given source to allow a program to provide all the supports students need. In this paper, we provide an example of how this problem was (at least partly) solved by the close interaction of two Louis Stokes Alliances for Minority Participation and an S-STEM program, working within the context of other support opportunities at three community colleges and one university in Northern New Jersey. The programs and the mechanisms through which they support students are described and preliminary data examining their impacts are presented.

Introduction

As many as four out of five students who begin their postsecondary careers at two-year schools do so with the intent of transferring to a four-year school to pursue a bachelor's degree (Horn & Skomsvold, 2011). From our own surveys, we know that quite a number of these also hope to ultimately earn a graduate degree. Yet only one in four community college students transfer to a four-year school (Jenkins & Fink, 2015), and one in ten earn bachelor's degrees within six years (Horn & Skomsvold, 2011). The challenges faced by community college students are at least in part because many, particularly students from underrepresented groups (UGs), enter college without the academic capital (Bordieu, 1984) required to navigate the completion of an associate's degree in STEM, the transition to the four-year school (Laanan et al., 2011a; Laanan et al., 2011b) and, ultimately to graduate school. Additionally, these students may face external pressures such as employment and caregiving (Nelson et al., 2013). Many students fail in these transitions despite such students proving capable of excelling (Bowen et al., 2009; Glass & Harrington, 2002; Melguizo, Kienzl, & Alfonso, 2011).

Much has been studied regarding what interventions are effective at assisting diverse students pursuing undergraduate STEM degrees at 2- and 4-year institutions of higher education (IHEs) and thus broadening who participates in those fields. As laid out by Kuh (2008), research has identified many high-impact practices beneficial to UGs (first year seminars and experiences, learning communities, etc.). Many IHEs have developed comprehensive programs that combine these supports to enhance their impact across the educational experience. As laid out by Chubin and Ward (2009), the characteristics associated with the success of such programs include institutional leadership, targeted recruitment, engaged faculty, personal attention, peer support, enriched research experiences, bridging to the next level, continuous evaluation, comprehensive financial assistance for students in need, and the use of evidence-based practices.

Creating a program that includes these components within a single institution is challenging but possible, as evidenced by successful programs at community colleges (Fromherz et al., 2018; Gupta, 2017; Leggett-Robinson et al., 2015) and four-year schools (Bayliss et al., 2009; Blaylock & Bresciani, 2011; Maton et al., 2012). But programs located exclusively at the community college do not provide comprehensive support for the success of students transferring to four-year schools, particularly the low-income, first-generation, and nontraditional students who make up a large proportion of these students (Bahr, 2013, Mervis, 2006).

As a result, there has been a growing movement toward the development of IHE alliances (Santangelo et al., 2021). This movement is exemplified by the National Science Foundation's Louis Stokes Alliance for Minority Participation (LSAMP) program, which includes both the Bridges to the Baccalaureate program for community colleges and the Bridges to the Doctorate program for supporting beginning doctoral students (National Science Foundation, 2021a). There is considerable evidence that LSAMP alliances across the United States have had a profound effect on the college success of UG (Clewell et al., 2006). These alliances are opportunities to fund interventions and knowledge-sharing, and are constructed so that students can flow between institutions with uninterrupted support.

In this article, we present the case of an alliance of four schools in northern New Jersey: three community colleges (Essex County College (ECC), Hudson County Community College (HCCC), and Passaic County Community College (PCCC)) and one four-year university (Rutgers University-Newark (RUN)). These four schools are part of a larger pair of alliances, the Garden State Louis Stokes Alliance for Minority Participation (GS-LSAMP; Gates & San Miguel, 2019), which includes ECC and seven four-year schools (including RUN), and the Northern New Jersey Bridges to the Baccalaureate (NNJ-B2B; Passaic County Community College, 2015), an alliance of four community colleges, including HCCC and PCCC.

These twelve alliance schools work closely together, but the four included here are of note because of the institution of the Northern New Jersey S-STEM program (National Science Foundation, 2021b). This program provides financial and programmatic support for students across their 2- and 4-year institution experiences, while pointing them toward graduate level supports such as the LSAMP Bridges to the Doctorate. This has been an evolving alliance, and work is still underway to broaden its reach to more and more underserved students. Though the S-STEM program is new, having only admitted its first cohort of students in the summer of 2018, there are indications that it has proven successful in achieving at least some of its aims.

All four S-STEM alliance schools are situated areas of great ethnic and socioeconomic diversity and disparity. Area communities range from cities such as poverty-stricken Newark to the relatively affluent Bedminster. Other areas served include West Caldwell, Jersey City, and Paterson, NJ. As seen on Table 1, these schools serve communities with high levels of low-income individuals, as indicated by the high proportion of recipients of Pell grants, as well as

	Essex	Hudson	Passaic	Rutgers
Total undergraduate enrollment	6,360	7,039	5,549	9,118
Seeking a degree or certificate	86%	93%	89%	97%
Full-time students	45%	54%	38%	87%
American Indian or Alaska Native*	0%	0%	0%	0%
Asian	3%	9%	6%	17%
Black or African American*	46%	13%	11%	16%
Hispanic*	27%	54%	57%	24%
Native Hawaiian or Other Pacific Islander*	0%	0%	0%	0%
White	8%	14%	18%	25%
Two or more races	1%	2%	1%	2%
Race/ethnicity unknown	6%	7%	6%	3%
Non-resident alien	9%	1%	0%	11%
Underrepresented minority (groups followed by *)	73%	67%	68%	40%
24 and under	63%	63%	65%	81%
Pell grant recipients (Nat'l Avg. 34%)	53%	77%	56%	62%

Table 1: Institutional characteristics (including non-degree seeking students), fall 2020[1]

[1] Source: National Center for Education Statistics, 2021

high proportions of UGs. College students from these communities often enter with little academic capital or support and must frequently hold full-time jobs or care for family. Many of these students do not successfully complete their community college degrees or continue their education as a result.

Table 2 shows the number and proportion of degree recipients from these schools in 2019-2020 falling into the given racial/ethnic categories. Essex and Passaic follow national trends in that degree recipients are slightly less likely to be from UGs than are enrolled students (5% for Essex, 4% for Passaic), but there are no differences at Hudson and Rutgers, suggesting that the two have achieved equity of outcomes in this instance. We hypothesize that this is at least partly attributable to the program activities described in this paper, though they only impact the STEM fields on the campuses while Table 2 covers all fields.

	Essex	Hudson	Passaic	Rutgers	National
Grand total	864	1,046	635	2,234	2,974,662
American Indian or Alaska Native*	0%	0%	0%	0%	1%
Asian	3%	10%	6%	16%	7%
Black or African American*	40%	13%	11%	16%	10%
Hispanic*	27%	53%	51%	26%	18%
Native Hawaiian or Other Pacific Islander*	0%	1%	0%	0%	0%
White	11%	12%	24%	23%	53%
Two or more races	1%	3%	1%	2%	4%
Race/ethnicity unknown	6%	7%	7%	2%	3%
Non-resident alien	13%	1%	0%	15%	4%
Underrepresented minority (groups followed by *)	67%	67%	62%	42%	29%

Table 2: Undergraduate degree recipients, 2019-2020[2]

As Table 3 shows, graduation and transfer out-rates among degree-seeking students within four years are not as high at the community colleges compared to graduation rates among degree or certificate-seeking students within 150% time at Rutgers. This comparison was chosen due to differing priorities and constraints between community colleges and 4-year institutions; many students seeking degrees at community colleges take longer than three years to complete, and in some cases transferring, not degree completion, is the goal. However, it should be noted that graduation rates are still much lower than the average completion rate of 36% nationwide for community colleges in the same time frame, and they don't even reach that percentage for full-time students after eight years following entry (National Center for Education Statistics, 2021). Although these data are for all fields and not just for STEM, they do speak to some of the challenges faced by the campuses. If they graduate, there are ample avenues for transfer and receipt of baccalaureate and graduate degrees, as nearly all students from these community colleges live within a few miles of schools offering programs that match their ambitions. Yet many students do not take these paths, as shown by the transfer-out rates on Table 3.

[2] Source: National Center for Education Statistics, 2021

	Essex	Hudson	Passaic	Rutgers
Total	30%	33%	40%	65%
American Indian or Alaska Native*	0%	25%	0%	-
Asian	48%	58%	42%	70%
Black or African American*	27%	37%	32%	61%
Hispanic*	26%	28%	38%	59%
Native Hawaiian or Other Pacific Islander*	0%	63%	0%	0%
White	45%	41%	48%	68%
Two or more races	24%	34%	60%	61%
Race/ethnicity unknown	14%	26%	42%	60%
Non-resident alien	46%	39%	-	78%
Transfer out-rate	10%	9%	11%	12%
Graduation rate (150% of normal time)	10%	12%	16%	65%
Graduation rate (8 yrs)	19%	19%	23%	-

Table 3: Overall transfer out and graduation rates within 200% of normal time for community colleges (2017 cohort) compared to overall graduation rates within 150% of normal time for Rutgers (2014 cohort)

There are many reasons why talented, STEM-focused community college students do not achieve their academic ambitions of completing a bachelor's degree or beyond, both here and elsewhere. These include needing additional developmental courses (Attewell et al., 2006; Bailey et al., 2010), being first-generation and thus lacking familial knowledge of the college process or not receiving adequate advising (Handel, 2013; Jaggers & Fletcher, 2013; Kadlec et al., 2013), imposter syndrome (Canning et al., 2020; Nance-Nash, 2020; Parkman, 2016), or lacking knowledge of and role models in the STEM workforce (Student Research Foundation, 2019). In recent years, much has been undertaken to help students overcome these barriers.

Student Support Before S-STEM. The most far-reaching programs at the four campuses are the GS-LSAMP and its partner alliance, NNJ-B2B. Both RUN and ECC are part of GS-LSAMP, while HCCC and PCCC are in NNJ-B2B. Both alliances seek to increase the number of UGs from partner schools who receive STEM degrees, however NNJ-B2B also seeks to substantially increase the number of students who transfer to four-year programs, especially at GS-LSAMP schools. As research has shown, there is no singular intervention that can achieve these goals, but multiple interventions can have an additive effect (Martin et al., 2018). While resemblance to Chubin and Ward's BEST model is unintentional on the part of project leadership, the alliances have funded a range of interventions that parallel this model, including:

- **Funded undergraduate research experiences***, where students participate in faculty research labs. The benefits of undergraduate research experiences are clear (e.g., Bergquist & Pawlak, 2008; Bowman & Holmes, 2018; Carrero-Martinez, 2011; Grabowski et al., 2008; Leggett-Robinson et al., 2015; Hurtado et al., 2011; National Research Council, 2012; and Thiry et al., 2012), and student feedback from our own programs suggests that the benefits are felt here as well (San Miguel & Gates, 2021).

- **Cross-campus peer mentoring***, where former community college students at the four-year alliance schools mentor community college students about the transfer process. Such mentoring can ease college transfer (Lisberg & Woods, 2018; Yomtov et al., 2017), and there is strong evidence in our own programs that it has led to higher transfer rates (Smart & Gates, 2018).
- **Transfer and graduate student fairs***, where students can meet with representatives from four-year and graduate schools, mainly within the alliance.
- **Speaker seminars** where STEM professionals, usually from underrepresented groups, explain their careers, research, and career paths. Selected because they come from backgrounds like those of the students, the speakers serve as role models who can make the achievement of goals feel attainable (Lawner et al., 2019; Zirkel, 2002).
- **Academic support using the ALEKS system**, an online program providing support in math and chemistry (Canfield, 2001; McGraw-Hill, 2021) that has been shown to enhance student performance (Hagerty & Smith, 2005; Stillson & Alsup, 2003).
- **Supplemental Instruction** (Martin & Arendale, 1992) **and Peer-Led Team Learning** (Gosser et al., 2001), which are proven academic support interventions designed to enhance student success in difficult STEM classes (e.g., Arendale, 1997; Eroy-Reveles et al., 2019; Gosser & Roth, 1998; Rath et al., 2007; Rath et al., 2012; Triesman, 1992).
- **The sySTEMic challenge***, a competition in which student teams are judged on their proposals for STEM-based solutions to a problem of societal importance. Challenge competitions have been shown to have numerous benefits (Mackenzie & Mastem, 1996; Padgett, 1997; chuster et al., 2006; Umble et al., 2008), and student feedback from our program speaks to motivational and skill-building impacts of this event (San Miguel & Gates, 2021).
- **Workshops** to help students build specific skills, such as building resumes, preparing for the GRE, and finding and applying for research experiences.
- **General participant meetings** that cover a variety of topics (such as research presentations, preparation for the next academic level, or specific skills) and serve to build community among the students.
- **STEM clubs**, which are run by the students rather than the program. These act as learning communities for students and sponsor activities such as speakers and community outreach.
- **Annual research conference*** where students present the findings from their research during the past year to peers and faculty members from across the alliance. It also includes keynote speakers and a graduate student panel on how to prepare for graduate school.

Some of these activities (marked with asterisks) have been available every year to students on all campuses. The others are locally managed and have been implemented by individual campuses, so not all students had access to all activities each year.

In addition to GS-LSAMP and NNJ-B2B, there are several other programs on these campuses designed to support students. An overview of these is found on Table 4.

Program	Schools	Description
Educational Opportunities Fund	ECC, HCCC, PCCC, RUN	Provides financial assistance and funds support services such as counseling, tutoring, and developmental course work, to students from disadvantaged backgrounds (Office of the Secretary of Higher Education for the State of New Jersey, 2018).
Community College Opportunity Grant	ECC, PCCC, HCCC	Provides free tuition to community college students below a certain income threshold; unlike the other programs, implemented after S-STEM was funded
New Jersey Space Grant Consortium	PCCC	Funds independent research studies in chemistry, peer tutoring in chemistry, lab equipment, and scholarships for women and underrepresented minority students (New Jersey Space Grant Consortium, 2021).
PCCC Takes Flight	PCCC	Developed an Aeronautics concentration within Engineering and provided selected students with summer internship opportunities with NASA (Passaic County Community College Scholar Academy, 2021).
G-RISE	RUN	Funds and trains doctoral students in biomedical-related fields by paying them to take part in research and providing supplemental activities including workshops on research communication and writing and seminars on research career preparation and responsible conduct of research.
Student Support Services	RUN	Provides academic support services to low income and disabled students, such as academic advising, advocacy, tutoring, and workshops on financial literacy and planning (Rutgers University-Newark, 2021).
Dynamic Urban Environmental Science and Sustainability REU	RUN	Provides summer undergraduate research experiences in environmental sciences and recruits heavily from among GS-LSAMP and NNJ-B2B students (San Miguel & Gates, 2021).
LSAMP Bridges to the Doctorate	RUN	Supports STEM doctoral students from LSAMP programs for the first two years of their studies, providing them with a stipend, tuition, and mentoring support from the program leaders and industry representatives (Gates & Henderson, 2021).
McNair Scholars Program	RUN	Supports junior or senior-level, low-income, first-generation students annually, providing advising and graduate school preparation (Nobles, 2021).

Table 4: Other programs that supported STEM students at the four institutions beyond GS-LSAMP and NNJ-B2B during the study period

Because of these various efforts, the four schools have seen substantial progress toward their goals of increasing STEM degrees among UGs and increasing the transfer rates of these students from two-year to four-year schools. As Figure 1 shows for the community colleges, although there was substantial variation over time, there has been a general pattern of increasing numbers of URM STEM transfer students to four-year schools since the introduction of LSAMP and B2B.

Figure 1: Number of underrepresented minority STEM students transferring to four-year schools from ECC, PCCC, and HCCC[3]

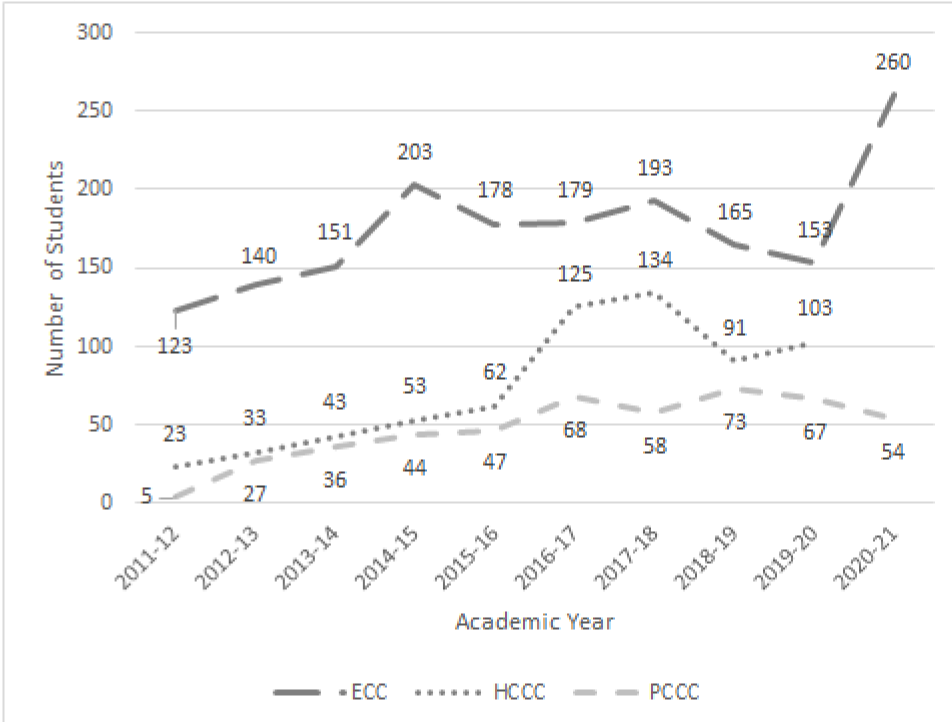
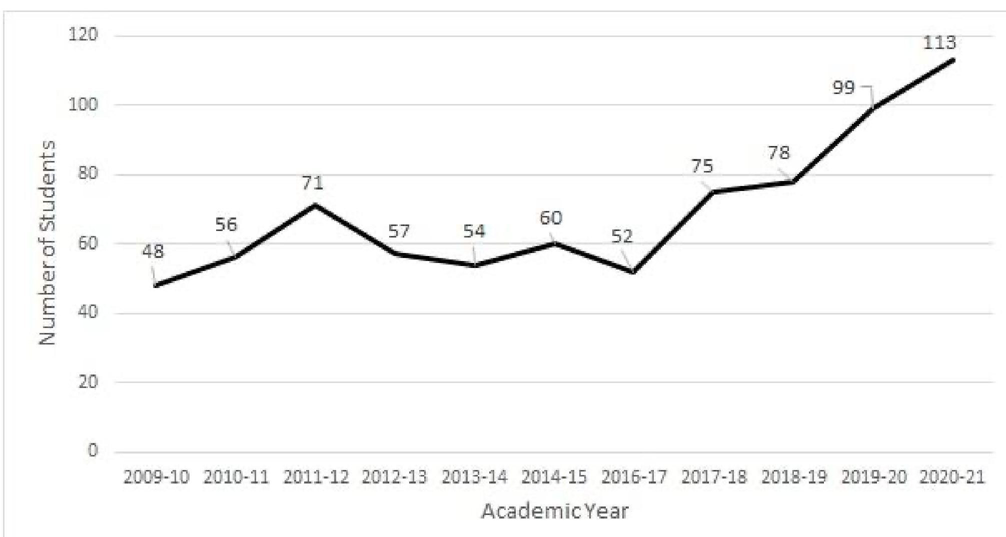


Figure 2 shows the number of URM STEM students who graduated from Rutgers-Newark from the beginning of the LSAMP program in 2009-2010 through 2020-2021. Once again, there was considerable variability, but by the end of the period the number of URM STEM graduates more than doubled.

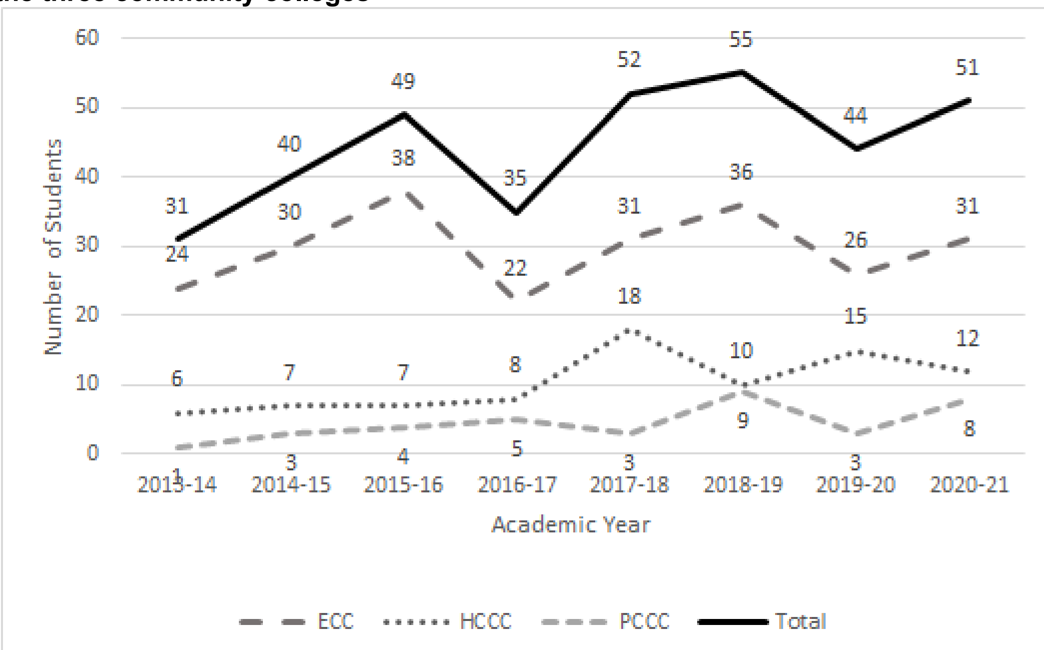
Figure 2: Number of underrepresented minority STEM students graduating from Rutgers-Newark each year



[3] Transfer data were not available for HCCC for 2020-21 at the time of writing.

Figure 3 shows the number of UG STEM students who transferred into Rutgers-Newark during the period from 2013-2014 to 2020-2021 from the three community colleges. A general trend of increasing numbers can be observed, such that the number of transfers nearly doubled over the timeframe. It should be noted that any additional impacts of S-STEM on transfer rate would not begin to be seen until the last two years of data.

Figure 3: Number of underrepresented minority STEM students transferring into Rutgers-Newark from the three community colleges



There is thus strong evidence that these programs, working together, have been successful at improving outcomes for UGs at the four institutions. This is exactly what would be predicted with the enactment of the design principles of the BEST framework (Chubin & Ward, 2009). In fact, these programs do serve to fill many components of this framework. The mapping between program offerings at the four schools and BEST is shown on Table 5.

As can be seen, most of the points on the framework were well-covered by the existing GS-LSAMP programs with the exception of personal mentoring and advising, especially at the community college level, and comprehensive financial assistance that continued from the community college to the four-year school. The aim of the S-STEM program was to fill those gaps.

Design Principle	Program Activities
Institutional leadership	LSAMP and B2B programs are prominently placed and well-integrated into the STEM programs, though the prominence given to the programs and the support provided by the administration varies somewhat based on the campus. Generally, though, they are seen as integral to the schools' missions of promoting STEM and inclusiveness.
Targeted recruitment	Recruitment of STEM students begins in the community colleges and freshman year at RUN, sometimes even before they have made the decision about what major they will pursue. Through the transfer fairs and cross-campus peer mentoring, RUN (and other GS-LSAMP schools) directly targets community college students to complete their undergraduate degrees at the institution.
Engaged faculty	LSAMP and B2B are led by faculty at the campuses, though coordinators are sometimes staff members. Faculty are also engaged in offering research experiences and talking at speaker series'. Faculty involvement is somewhat limited by the lack of funds to pay for release time.
Personal attention	Personal mentoring is provided occasionally by the GS-LSAMP and NNJ-B2B site coordinators (particularly at RUN and HCCC) and more frequently by research mentors. For those in the program, McNair provides considerable advising.
Peer support	In GS-LSAMP and NNJ-B2B, group meetings and clubs provide a STEM community for students from underrepresented backgrounds. Cross-campus peer mentors provide direct support for the transfer process. Peers are also involved in providing academic assistance through Supplemental Instruction and Peer-Led Team Learning. McNair also provides some peer support.
Enriched research experience	Research experiences, usually over the summer but sometimes also during the school year, are the most important offering of the GS-LSAMP and NNJ-B2B programs. Some opportunities are funded directly by these programs, while students are also encouraged to apply for opportunities provided by the New Jersey Space Grant Consortium, PCCC Takes Flight, and the Dynamic Urban Environmental Science and Sustainability REU.
Bridging to the next level	Within GS-LSAMP and NNJ-B2B, transfer fairs, speaker panels, and cross-campus peer mentoring help to prepare students for the transition from the two-year to the four-year school. Graduate fairs, speaker panels, and numerous workshops help prepare students for graduate school. Additionally, the McNair Scholars Program prepares students for graduate school, while those who choose to attend at RUN can find support for their continued education through the G-RISE and LSAMP Bridges to the Doctorate programs.
Continuous evaluation	External evaluation has been an important aspect of GS-LSAMP and NNJ-B2B since their inception, and the evolution of the programs over time has been greatly informed by the evaluation findings.
Comprehensive financial assistance for students in need	Although research experiences do provide a stipend and scholarships are available through Educational Opportunities Fund and the Community College Opportunity Grant, GS-LSAMP and NNJ-B2B do not currently have sufficient funds to comprehensively support students' financial needs, especially across the transition from community college to four-year schools.
Use of evidence-based practices.	As demonstrated above, there is considerable evidence in the educational research literature in support of most of the activities provided.

Table 5: BEST Framework and corresponding activities

The Addition of S-STEM. The S-STEM program was first funded in 2017, with the first cohort of students receiving scholarships in the 2018-2019 academic year. The program provides two-year scholarships of $5,000/year to approximately 200 community college STEM students who are Pell grant eligible, have maintained a GPA of at least 3.2, and who are planning on transferring to a four-year program. Should they choose to transfer to RUN, their scholarship continues and increases to $10,000/year for an additional two years. In addition to providing scholarships for approximately 70 S-STEM community college transfers to RUN, the program was also designed to fund around 20 non-S-STEM transfer students at RUN. Effort is made in trying to recruit students at the community colleges who are pursuing majors that are offered at RUN in preference to those that are not.

S-STEM scholars are also given access to a coordinator at their institution who provides direct advising and mentoring. Community college and RUN scholars are also highly encouraged to apply for summer and academic year research positions through GS-LSAMP and NNJ-B2B, though they are not guaranteed to receive a slot. While in community college, they are expected to have a peer mentor at a four-year school, usually RUN, who can give them advice about the transfer process. RUN S-STEM students are expected to serve as mentors for S-STEM, LSAMP, and B2B students. Once at RUN, S-STEM scholars are enrolled in a career preparation program designed to prepare UGs at large state universities for the increasingly competitive global workplace (Braven, Inc., 2021). Finally, the scholars are directed toward the variety of other opportunities offered by the other funding sources on campus.

It should be noted that S-STEM is not the only source of financial aid for students. The Community College Opportunity Grant, implemented in 2019 by the state of New Jersey, provides free tuition for students whose household income is at or below $65,000. We believe that this contributed to difficulty in recruiting target numbers of S-STEM students for a time, however targets were met after expanding S-STEM aid to cover educational expenses beyond tuition, such as textbooks and living expenses.

Regardless, the program appears to be working as designed. It fills in the missing pieces of the BEST model, as shown in Table 5, providing both personal mentoring and advising and continuous funding through the end of the community college experience and, if the student transfers there and graduates on time, the four-year experience at RUN. As of the 2020-2021 academic year, 103 community college students received and completed S-STEM scholarships, 30 at ECC, 52 at HCCC, and 21 at PCCC. Moreover, 40 S-STEM scholars from the community colleges graduated and transferred to RUN, including all 20 RUN S-STEM scholars in 2020-2021. But the question remains, do the S-STEM scholarships provide educational benefits for the students by filling the gaps in the BEST framework that the limited resources of NNJ-B2B and GS-LSAMP cannot, or are they merely providing them with recognition and money, but little else?

Effectiveness of S-STEM. As of this writing, we have not yet completed our planned multi-year examination of the impact of S-STEM scholarships, but we have collected data from the first two full years of the research study (2019-2020 and 2020-2021) from both S-STEM scholars and comparison students at the four schools. We have been able to start to address the following:

> Research Question 1: Did participating in S-STEM result in a decrease in time needed to be spent working at a job?

> **Research Question 2:** Did the S-STEM students spend more time in STEM classes, studying, doing homework, or participating in S-STEM, GS-LSAMP, and/or NNJ-B2B activities outside of class?
>
> **Research Question 3:** Did S-STEM students feel an increase in their sense of connection to a STEM community?
>
> **Research Question 4:** Did S-STEM students feel a stronger sense of identity within STEM, an increase in their STEM self-efficacy, and/or their confidence in their ability to succeed in STEM?

To account for potential selection bias, we selected our comparison group from among students actively participating in the GS-LSAMP and NNJ-B2B programs (but not S-STEM) at the four campuses with the aid of S-STEM/GS-LSAMP site coordinators. Comparison students were those who would have qualified for S-STEM save for one small difference (such as income or GPA), and in fact a few transitioned from being a comparison to an S-STEM student over the course of the year. We feel that since the pandemic impacted all students in similar ways, the S-STEM and comparison groups are still comparable despite COVID's interruption.

To answer our four questions, we conducted two studies. The first examined how students' use of their time in the ways outlined in the first two research questions differed between S-STEM and comparison students, while the second examined how key STEM-related measures related to the third and fourth research questions changed relative to S-STEM participation.

Methodology

Participants. For the years 2019-2020 and 2020-2021, 125 students in the S-STEM program and 98 comparison students provided at least some survey data across the four campuses. Table 6 provides an overview of the students from these groups at each of the schools. Students are placed in a column based on which school they started in the study, even if they transferred later. Because of this, the categories of students on this table do not always match up with their categories in the individual studies. Percentages are based on the number of students from that category who provided the data being examined.

Study 1. The first two research questions were addressed using a Time Usage Survey, which asked respondents to estimate how many hours per day they spent in the week prior to the survey working, attending, studying, or doing homework for STEM classes, and STEM activities outside of class (research, tutoring, clubs, etc.). This was done so that anything that broadly interrupted academic life (e.g., a snow day) would have affected all students at the same school equally. The surveys were administered online, and all students funded by S-STEM or in the comparison group were invited to take them. No compensation was offered for taking the survey

	S-STEM				Comparison		
	Essex	Hudson	Passaic	Rutgers	Essex	Hudson	Passaic
N	30	51	26	18	25	28	20
Female	48%	63%	65%	65%	35%	48%	53%
Male	52%	37%	35%	35%	65%	52%	47%
Other	0%	0%	0%	0%	0%	0%	0%
African American or Black	66%	22%	0%	65%	48%	37%	0%
Asian	7%	9%	4%	0%	0%	7%	21%
Hispanic, Latino, or Chicano	17%	41%	69%	18%	48%	41%	58%
White	9%	20%	27%	0%	4%	7%	16%
Mixed Race (URM)[4]	3%	9%	0%	18%	0%	7%	0%
Mixed Race (non-URM)	0%	0%	0%	0%	0%	0%	5%
In an underrepresented minority group[5]	86%	72%	69%	100%	96%	85%	58%
English is not a first or native language	55%	67%	81%	59%	26%	48%	58%
Grew up in economically disadvantaged conditions	71%	80%	89%	88%	78%	81%	63%
No parent or guardian received a baccalaureate degree	59%	74%	81%	76%	74%	63%	79%
Had at least one condition of disadvantage[6]	89%	98%	100%	94%	91%	96%	90%
Participated in S-STEM for more than one year	27%	28%	58%	39%	Not applicable		
Transferred to Rutgers while in S-STEM	23%	12%	42%	NA			

Table 6: Characteristics of S-STEM and comparison students who took part in the study

except on those occasions on which it was attached to the compensated end of year survey (see below). For this reason, compliance with taking this survey was inconsistent.

The Time Usage Survey was run seven times over the course of the study. Table 7 shows the breakdown of responses to each survey by date, school, and S-STEM status. The total number of students changed from one semester to the next as students left or joined. Also, the two April implementations were done through the end-of-year survey, which was much more heavily emphasized and for which comparison students received incentives to participate, accounting

[4] Respondents are considered to be of mixed race if they clicked more than one response in the list of possible racial or ethnic categories provided on the survey, "Mixed Race (URM)" if one of those categories fit the definition for a member from an underrepresented minority group (see next footnote), and "Mixed Race (non-URM)" if none of them did.
[5] We used the National Science Foundation definition of underrepresented minorities for this paper. By that definition, individuals who identify as African American/Black, American Indian/Native American/Alaska Native, Hispanic/Latino/Chicano, and Native Hawaiian/Pacific Islander are considered underrepresented in STEM.
[6] This means they self-identified as coming from a background with one or more conditions that have been shown to put students at a disadvantage in postsecondary education, namely not having English as a native language (Engle & Tinto, 2003; Stassun et al., 2010), growing up in conditions of economic disadvantage (Bordieu, 1984), and having no parent or guardian who had received a baccalaureate degree (Engle & Tinto, 2003; Stassun et al., 2010).

for the high response rate in April 2020. Response rates in April 2021 were not as strong, particularly for S-STEM students, which appears to be a consequence of changes in the students' educational and social experiences brought about by the pandemic.

Funding	School	Data	Oct 2019	Dec 2019	Feb 2020	Apr[7] 2020	Dec 2020	Feb 2021	Apr 2021	Total
S-STEM	ECC	N	11	10	6	11	9	6	3	56
		%	100%	91%	46%	85%	69%	46%	23%	64%
	HCCC	N	8	0	7	21	6	4	9	55
		%	42%	0%	28%	84%	46%	22%	50%	40%
	PCCC	N	10	10	11	11	7	6	3	58
		%	83%	83%	79%	79%	58%	50%	25%	66%
	RUN	N	14	17	14	20	7	8	9	89
		%	74%	89%	67%	95%	54%	62%	69%	75%
Comparison	ECC	N	3	3	1	6	2	1	2	18
		%	15%	15%	5%	30%	20%	10%	20%	16%
	HCCC	N	0	5	3	11	2	2	4	27
		%	0%	21%	11%	41%	29%	29%	57%	22%
	PCCC	N	6	8	10	9	2	3	4	42
		%	40%	53%	67%	60%	33%	50%	67%	54%
	RUN	N	1	8	8	7	4	2	5	35
		%	7%	57%	57%	50%	29%	14%	36%	36%

Table 7: Number of respondents (N) and response rates (%) for the time usage survey

We combined the data first into two groups based on whether the students were in a community college or at Rutgers-Newark when they took the survey, and then based on whether they took the survey prior to or during the pandemic. The former was done because we felt that the community college students' pandemic experiences were more like each other than to those at the university. The latter was due to pandemic-induced changes in their work and academic situation, which presumably were relatively uniform across groups.

Results of Study 1. We ran independent-samples t-tests comparing the groups, with Cohen's d (Cohen, 1992) used to examine the sizes of the effect. Tests were run for students and the community colleges separately, and for the times prior to and during the pandemic separately. The results are shown on Table 8.

The S-STEM students spent more time than their comparison peers attending STEM-related classes both before and during the pandemic, though the difference at Rutgers during the pandemic was not statistically significant. The S-STEM community college students also spent more time on homework and studying than their comparison peers, though this was again not the case at Rutgers. Finally, prior to the pandemic, S-STEM students at all campuses spent less time working than their peers, though this difference vanished with the pandemic as the comparison group worked less. As these patterns are consistent across the various implementations of the survey, we feel confident saying that being in S-STEM allows students to take more STEM classes, likely because not having to work as much frees up more of their time.

[7] COVID-interrupted data begins here.

Interestingly, this difference persisted through the pandemic, even though the comparison students were no longer spending more time working.

Group	Pandemic	S-STEM			Comparison			p-value
		N	Mean Respons e	Standard Deviation	N	Mean Response	Standard Deviation	
Attending STEM-related classes								
CC[8]	Pre-COVID	73	14.83	6.25	39	9.59	6.50	<0.001
	COVID	96	13.41	6.59	48	9.72	7.77	0.003
Rutgers	Pre-COVID	45	13.71	5.19	17	8.28	6.98	0.001
	COVID	44	15.50	9.70	18	11.02	7.61	0.085
Homework and studying for STEM-related classes								
CC	Pre-COVID	73	21.30	12.65	39	14.81	12.87	0.013
	COVID	96	20.97	12.70	48	15.80	12.37	0.022
Rutgers	Pre-COVID	45	21.46	12.70	17	21.37	12.15	0.980
	COVID	44	20.35	10.71	18	23.71	18.85	0.486
STEM activities outside of class (such as research, tutoring, clubs, etc.)								
CC	Pre-COVID	73	5.85	5.11	39	5.03	6.93	0.480
	COVID	96	5.13	7.46	48	5.05	7.62	0.952
Rutgers	Pre-COVID	45	5.03	6.64	17	7.92	16.59	0.328
	COVID	44	5.36	7.10	18	4.91	6.53	0.816
Working at a paid job								
CC	Pre-COVID	73	10.56	12.20	39	16.73	15.68	0.037
	COVID	96	9.71	12.29	48	11.96	16.94	0.365
Rutgers	Pre-COVID	45	8.94	10.95	17	24.29	31.57	0.006
	COVID	44	9.85	11.07	18	6.89	9.36	0.322

Table 8: Comparisons of the time spent over the entire week surveyed (in hours) between S-STEM and comparison students based on type of school and whether the week was before or during the pandemic

Study 2. To answer Research Questions 3 and 4, we looked at the change in survey constructs over the students' first year in the study. All S-STEM and comparison group students were asked to take a baseline survey. S-STEM students were invited to take the survey as soon as they were accepted into the scholarship program. No incentive was provided. Comparison students were sent an invitation after being identified and were given a $5 gift card for participating. Only those comparison students who took the baseline survey were part of the study.
This baseline survey was followed at the end of the academic year by a second survey with nearly identical questions. The S-STEM students did not receive extra incentives for doing so, but comparison students were given gift cards for $35. Table 9 reviews how key constructs were operationalized within the surveys.

The Self-Efficacy construct from Scholtz et al. (2002) was modified in asking that students respond to the questions with respect to their STEM education. It is designed around the idea that perceived self-efficacy examines the extent to which individuals see themselves as being able to succeed in general terms. Our confidence measure was designed to look at the students' sense that they could accomplish the various steps needed to be a successful STEM professional. We

[8] Community College

see these two constructs and the Science Identity construct as being likely psychological predictors of future STEM success, which can answer Research Question 4. The last construct examines the students' STEM network and allows us to answer Research Question 3.
In the case of each of these four batteries, we created a construct based on the average of the responses to each of the items in the battery. Respondents who did not respond to all items in the battery were excluded.

Construct	Items	Scale
Self-efficacy (Scholtz et al., 2002)	• I can always manage to solve difficult problems if I try hard enough. • If someone opposes me, I can find the means and ways to get what I want. • I am certain that I can accomplish my goals. • I am confident that I could deal efficiently with unexpected events. • Thanks to my resourcefulness, I can handle unforeseen situations. • I can solve most problems if I invest the necessary effort. • I can remain calm when facing difficulties because I can rely on my coping abilities. • When confronted with a problem, I can find several solutions. • If I am in trouble, I can think of a good solution. • I can handle whatever comes my way.	Not at all true (1) to Exactly true (4)
Science identity (Hanauer et al., 2016)	• I have a strong sense of belonging to the community of scientists. • I have come to think of myself as a "scientist." • My social network includes a lot of scientists and/or science students. • I enjoy doing research.	Strongly disagree (1) to Strongly agree (5)
Confidence (Created for study)	• Get good grades in STEM courses at your institution • Be able to transfer successfully to a four-year school (community college only) • Be able to successfully get into graduate school • Find a career in STEM that you enjoy • Develop a strong network of people in STEM • Meet all of your educational and career goals	Not at all (1) to Very (4)
Connection to STEM communities (Created for study)	• STEM students at your college or university • STEM faculty members at your college or university • Students and/or faculty members at other colleges or universities • Your field of study as a whole	Not at all (1) to A great deal (4)

Table 9: Key constructs with items from the surveys used in the study

The Self-efficacy and Science identity constructs have been tested elsewhere (Hanauer et al., 2016; Scholtz et al., 2002), but the other two had not. To test reliability, we ran the Cronbach's alphas (Taber, 2018) for the Confidence construct (0.856) and the Connection to STEM Communities construct (0.812). The resulting values indicate a high level of reliability for both constructs. Unfortunately, because of the small sample size, we are unable to establish reliability or validity more rigorously. We hope that we will be able to conduct more rigorous tests in future studies.

Table 10 shows the number of students who responded to both the baseline and end of year survey from each of the campuses and the percent that these represent of the total students in the sample. In our analysis, we looked at only the first year for which students provided data. In a small number of cases, students started at the community college and took the baseline survey there, but transferred to Rutgers after the fall survey and finished the end of year survey there; these students are counted as having come from the community college.

	Essex	Hudson	Passaic	Rutgers
S-STEM	17	22	15	12
	74%	46%	88%	52%
Comparison	6	12	13	13
	22%	38%	65%	50%

Table 10: Number and percentage of students who provided both baseline and end of year surveys

Results of Study 2. We divided the respondents into groups based on whether they started at one of the community colleges or at Rutgers. Because of the small number of students for whom we have complete data who started at Rutgers (12 S-STEM and 13 comparison students), we will only discuss pooled results for community college students.

Table 11 shows the changes for these community college students who entered the program in either 2019-2020 or 2020-2021 between scores on the baseline survey and the survey at the end of their first year in the program on the constructs described in Table 8. No constructs showed a statistically significant change or meaningful effect size over the course of that time.

Construct	Group	N	Baseline Mean	Baseline SD	EOY Mean	EOY SD	Difference	P of difference	Effect size
Self-efficacy	S-STEM	47	3.53	0.33	3.57	0.42	0.04	0.509	0.106
	Comparison	26	3.51	0.35	3.45	0.38	-0.06	0.404	-0.167
Science identity	S-STEM	50	4.11	0.58	4.28	0.59	0.17	0.089	0.291*
	Comparison	28	3.96	0.80	3.79	0.99	-0.16	0.400	-0.189
Confidence	S-STEM	49	3.76	0.38	3.74	0.38	-0.02	0.803	-0.053
	Comparison	29	3.66	0.41	3.67	0.39	0.01	0.907	0.025
Connections to STEM communities	S-STEM	46	2.96	0.68	3.07	0.71	0.11	0.389	0.158
	Comparison	25	2.99	0.93	2.97	0.84	-0.02	0.912	-0.023

Table 11: Comparison between the mean values of the constructs at baseline and end of the year for both study groups (community colleges only)[9]

Although the changes were small, they were often in different directions; apart from confidence, S-STEM scores tended to increase while comparison scores tended to decrease. Table 12 shows

[9] Because only students who completed all questions that went into the construct are shown, the number of students varies from one analysis to the next and is less than the total number of baseline and end of year survey completers in all cases.

a comparison between the difference scores (calculated by subtracting the baseline score from the end of year score) for the S-STEM and comparison students.

	S-STEM N	S-STEM Mean	S-TEM SD	Comparison N	Comparison Mean	Comparison SD	P of difference	Effect size
Self-efficacy	47	0.04	0.44	26	-0.06	0.35	0.319	0.145
Science identity	50	0.17	0.67	28	-0.16	0.99	0.089	0.248*
Confidence	49	-0.02	0.49	29	0.01	0.36	0.814	-0.041
Connections to STEM communities	46	0.11	0.85	25	-0.02	0.90	0.967	0.089

Table 12: Comparison between the baseline to end of year differences of S-STEM and comparison students (community colleges only)

Here too, the change from baseline to end of year survey responses was not statistically significant for the two groups for any of the four constructs.

Discussion

Research Question 1: Did participating in S-STEM decrease the time spent working at a job? Prior to the COVID-19 pandemic, S-STEM students spent less time working than their peers in the comparison group. Community college S-STEM students worked on average five fewer hours per week than comparison students, and RUN students worked on average thirteen hours less than comparison students. The greater difference at RUN is likely due to the larger scholarship, which had greater impact on student finances. Also, some comparison students at the community colleges might have had their tuition paid by the Community College Opportunity Grant, thus making their financial situation not as different from the S-STEM students.

With the onset of the pandemic, this difference in hours worked became statistically insignificant. It appears that the pandemic had a substantial impact on the ability of students to work. This decrease in work hours was almost entirely felt by the comparison students, while the S-STEM students had little change in the hours worked per week. The data do not provide enough information to explain this.

Overall, the data appear to provide substantial support for the hypothesis that, outside of wide-scale shutdowns, the S-STEM scholarship does allow students to spend less time working while still being financially stable.

Research Question 2: Did participating in S-STEM increase the time spent attending STEM classes, studying for these classes, and participating in STEM outside of class? There is mixed evidence that S-STEM results in additional time devoted to STEM activities. Statistically significant impacts seem to be limited to spending time in classes and doing the work necessary to succeed in those classes both prior to and after the pandemic. Despite the extracurricular opportunities available through S-STEM or otherwise, S-STEM students are no more likely to participate. At RUN, comparison students spent slightly more time at these activities than S-STEM students. An explanation for this may be that both groups are already highly involved in such activities, but it seems unlikely that any of these students were involved in activities to the greatest extent they could have been, given the low attendance at many of the activities observed during that time period. It may be the case that either having more classes (for the S-STEM students) or working more (for comparison students) leaves similar time available for attending other extracurricular activities.

Research Question 3: Did participating in S-STEM increase the students' network of STEM connections? From the comparison between Baseline and End of Year surveys in Study 2, we see no statistically significant changes in the extent to which students are connected to STEM communities for either S-STEM or Comparison participants. Therefore, there is no compelling evidence that being in S-STEM has any meaningful impact on students' STEM connections over the comparison group.

Research Question 4: Did participating in S-STEM have a positive impact on students' sense of STEM identity, self-efficacy, and confidence that they could succeed? We saw no significant changes between the Baseline and End of Year surveys for either the S-STEM or Comparison groups on any of the constructs used to answer this question, namely Self-efficacy, Science identity, and Confidence. For the first two constructs, only the S-STEM increase in Science identity was large enough to have even a small effect size (Cohen, 1992). Results for Confidence had statistically insignificant effect sizes. We have no compelling evidence that being in S-STEM affects any of these areas, which may again serve as testimony to the effectiveness of GS-LSAMP and B2B in forging students' science identities rather than a failure of S-STEM.

The conclusion, then, is that S-STEM is making some difference. Under non-pandemic circumstances, receiving the scholarship provided a certain amount of financial security that allowed students to work less and have more time for STEM classes. Though we do not have the data to be certain, what we see from our results suggests that the scholarship allowed the S-STEM students to be more financially secure during the pandemic even though time availability wasn't that different. That S-STEM community college students continued to spend more time in class suggests that they were more able to pay to be full-time than their comparison peers. Thus, S-STEM seems to be fulfilling the role in the BEST model of providing at least some financial assistance for students in need. This will be confirmed in more comprehensive future studies on graduation rates.

S-STEM does not seem to make for a substantially *different* educational experience within STEM, however. Although there is some suggestion that S-STEM students spend more time doing homework and studying for STEM classes than their comparison peers, at best this is explained by them spending more time in STEM classes. When taking the greater number of class hours into account they may actually be spending slightly less time out of class per class hour than their peers. Furthermore, there is no difference in the time spent on extracurricular STEM activities, and with no clear difference in what they are doing, there is no reason to expect that there would be differences in their psychological outcomes or connections.

Of course, this does not mean that we would see the same thing if we were to have chosen a comparison group that was not involved in GS-LSAMP or NNJ-B2B and thus was not as deeply involved in STEM activities. Future studies will provide this comparison.

Conclusions

Creating a program that both provides the breadth of student support recommended by the BEST model and aims to do so through the transition from community college to the four-year school requires significant resources beyond the scope of what most IHEs could provide on their own. By seeking out multiple funding sources and cooperating together, IHEs such as those in this study can create a support system for students across academic borders that utilizes proven frameworks such as the BEST model. While the use of the BEST model was opportunistic in this case, it would be wise for future support systems to be built with this framework in mind from the start.

Additionally, S-STEM as a program was too focused on tuition reimbursement to have substantial impact on the other aspects of the BEST model, meaning that had S-STEM been funded in the absence of the other programs it was unlikely to do much to impact student outcomes. This is because S-STEM at the NSF level explicitly forbids programs from requiring anything from the students in exchange for their scholarship and because it provides very limited funding to program leaders for the creation of activities. In the absence of support from other programs, the single S-STEM grant alone would have done little to change the educational experience of participants, but the addition of targeted financial support did fill some voids present in other support mechanisms.

As we continue our efforts to support our students, future decisions around funding and offerings in STEM education in northern New Jersey will be informed by what we have learned about the impact of these programs through this and other research, which has done much to improve our understanding of what outcomes of certain interventions should be anticipated and what the needs of students truly are. It is our hope that what we have learned will be of assistance to others in making similar decisions.

Limitations

This is only a preliminary study of the impact of S-STEM in northern New Jersey. As such, there are some important limitations to the broader applicability of the findings in this study. First, the sample size was small, both due to limited funding and because not all students identified for the study took part in all activities. Because of this, we did not have enough participants to make any meaningful comparisons between different schools, nor were we able to employ more sophisticated statistical models that might have allowed us to gain a more nuanced look at the outcomes of S-STEM considering other contributing factors.

Second, we only examined some of the variables that would be of interest in understanding the full impact of the S-STEM program. Of particular interest among the factors not examined are such outcomes as course performance, persistence in studies, and time to graduation. This and the first limitation will hopefully be resolved in future studies.

Third, by design this study examined the additive effect of S-STEM among students who were already engaged in GS-LSAMP and NNJ-B2B. This means that, although we have some idea of what might be predicted to happen in other S-STEM programs in the presence of other supports, we don't know what the impact of S-STEM would be on its own. Moreover, it is not clear that the impacts we saw (or lack thereof) would hold if the support structure offered by other programs was substantially different.

Local factors such as demographic makeup of students, involvement of site coordinators, and other factors may also lead to different results for programs implemented elsewhere.

And finally, the onset of the COVID-19 pandemic interrupted our study. As our data show, it impacted the number of hours that students were able to work, the activities available for students to participate in, and the ability of students to build connections and communities. While we are comfortable saying that these issues were felt by both S-STEM and Comparison students alike and with essentially the same intensity, the fact that their experience was so different from what one might expect to be the typical college experience means that we might expect some very different findings were we to run the study again entirely during a time not impacted by the pandemic.

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