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# The STEM Success Program at California State University, Stanislaus

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## ABSTRACT

At many institutions, half of the undergraduates who start a STEM major leave during their first two years on campus. STEM Success at Stanislaus State counters this trend with four activities. One helps community college students select courses to facilitate their articulation. A summer academy for incoming students helps develop an undergraduate scientist community, while a third activity pairs transitioning students with STEM faculty to provide mentoring and research opportunities. STEM Success also includes a general education course that builds foundational science skills. Collectively, these activities have reduced the two-year STEM attrition rate at Stanislaus State from 49% to 28%.

## THE STEM SUCCESS PROGRAM AT CALIFORNIA STATE UNIVERSITY, STANISLAUS

In 2012, the President's Council of Advisors on Science and Technology issued a dire warning: unless colleges and universities increased the number of STEM degrees awarded to undergraduates by 34%, the United States would face a workforce shortage of 1 million STEM professionals by 2022 (Holdren & Lander, 2012, p. i). This daunting projection was made as post-secondary institutions were experiencing significant shifts in student demographics.

Enrollment of Hispanic students tripled between 1996 and 2016, fueled by increases in both the number of Hispanics in the general population and the percentage of Hispanics seeking a college degree. Hispanic students accounted for most of the enrollment growth at many institutions during the past two decades, increasing from 8% of enrolled students in 1996 to 19% in 2016 (America Counts Staff, 2017).

Clearly, one key to closing the STEM workforce gap is to increase the number of Hispanic students who graduate with a STEM degree. The U. S. Department of Education has acknowledged this challenge by offering Title III Part F grants. These grants, which are often labelled HSI-STEM grants, are designed to increase STEM degree completions by "Hispanic and low-income students" (Department of Education, 2016, p. 11532). The grants also require developing "strong articulation and transfer models" between institutions granting 2-year degrees and those offering 4-year degrees. Funding is available only to designated Hispanic-Serving Institutions (HSIs). To qualify as an HSI, an institution must be accredited and serve a student body that is at least 25% Hispanic, of whom at least half are eligible for Title IV financial aid (i.e., Pell grants).

California State University, Stanislaus (Stanislaus State) has received two HSI-STEM grants. Prior to receiving these grants, about half of all undergraduate STEM majors at Stanislaus State left the institution or switched to a different major before completing their degrees; they were not replaced by other students switching in from non-STEM majors. This mirrors trends seen nationally (Chen, 2013). However, activities that were funded by the HSI-STEM grants and designed using an intentional, evidence-based approach have cut the STEM attrition rate in half among participating students. These activities and their outcomes are detailed below.

## EVOLUTION OF STEM SUCCESS AT STANISLAUS STATE

### *Stanislaus State Characteristics*

Stanislaus State is a public institution with a Carnegie designation of Master's University: Larger Program. It is one of the 23 campuses in the California State University system and has been designated as an HSI since 2003 (*CSU Fact Book*, 2020). The university has a main campus in Turlock, California, which is located in the approximate geographic center of the state; a satellite campus in Stockton, California is an hour's drive south of Sacramento, the state capital. Students attend from around the state and the world, but the university's primary service region consists of six counties that are primarily rural: Stanislaus, San Joaquin, Merced, Calaveras, Tuolumne, and Mariposa. Collectively, these counties are among the poorest in the state, with educational attainment levels well below state and national averages.

Stanislaus State currently (as of Fall 2020) enrolls 9,643 undergraduates, of whom two-thirds (66%) are female. The majority of undergraduates identify as Hispanic (62%), are eligible for Pell grants (65%), and are the first in their family to attend college (68%); 90% belong to at least one of these three groups that have been historically underrepresented in higher education. Hispanic students have accounted for most of the enrollment growth at Stanislaus State over the past decade. In Fall 2010, Hispanic students comprised only 37% of the undergraduate student body; the Hispanic student headcount has more than doubled since then.

The most popular undergraduate programs on campus are Business (1,519 majors as of Fall 2020) and Psychology (1,334 majors). Biology is the most popular STEM program, with 673 majors. Other STEM majors are Computer Science (348 majors), Mathematics (174 majors), Chemistry (100 majors), Physics/Physical Sciences (43 majors), and Geology (24 majors).

Several STEM programs have BA/BS options or offer a choice of concentrations, so students who wish to major in STEM can choose between a large number of different programs.

### *Funding History*

Stanislaus State has received two HSI-STEM grants. The first was awarded in 2011 and funded two activities. One activity strengthened the articulation pipeline with the two community colleges that provide Stanislaus State with the second- and third-largest number of STEM transfer students. STEM faculty from all three institutions met to better understand each other's curricula and develop roadmaps that students could use to select courses at their community college to satisfy prerequisites for their Stanislaus State STEM major. Academic advisors from Stanislaus State also frequently visited the two community college partners, to answer questions from students who were considering majoring in STEM at Stanislaus State.

The 2011 grant was used as well to provide Stanislaus State STEM majors with critical resources and support services. One resource was a physical space, dubbed "The Commons," located in the campus building where most STEM courses are taught. The Commons served as a centralized meeting place for STEM majors and provided students with access to a coffee maker and microwave, as well as a generous free printing allowance. More importantly, The Commons was staffed by STEM faculty and peer mentors from a variety of STEM majors.

The Commons was open to all students, but other resources were provided to students only if they joined the "Central Valley Math and Science Alliance" (CVMSA). Membership was available to all STEM majors who were the first in their families to attend college and/or eligible for a Pell grant. CVMSA benefits included the ability to meet with a faculty mentor, receive funding to attend a professional STEM conference, be hired as a research assistant, and attend social gatherings and informal professional preparation workshops with other CVMSA students.

The 2011 grant program supported in excess of 1,400 STEM majors over a 5-year period. The grant did not specifically target Hispanic students, but 47% of activity participants identified as Hispanic, even though Hispanic students constituted only 32% of STEM majors at the start of the grant and 41% at the end. Thus, the grant was effective in serving Hispanic students.

Evaluation of the program included tracking STEM attrition. This effort revealed that about half of all students who began as STEM majors eventually switched out of STEM or left the institution entirely. Most of these losses occurred within 2 years of arriving at Stanislaus State. A survey sent to all students who changed majors indicated the most common reason for switching from STEM to a non-STEM major was that students felt they belonged more in their new major; 77% of students who left STEM cited this as contributing to their decision.

Stanislaus State received its second HSI-STEM grant in 2016. The program funded by the new grant is dubbed "Students Transitioning to Engaged and Motivated Success" (STEM Success). The design of STEM Success draws heavily upon lessons learned from the 2011 grant. Activities for STEM Success were proposed by the steering committee for the 2011 HSI-STEM grant. Since the 2011 grant highlighted belonging as critical for STEM retention, all activities in the STEM Success grant focus on helping students build a sense of belonging to Stanislaus State, to the scientific community, and to their major.

Articulation partnerships were highly successful in the 2011 grant, and so have now been expanded to include the 10 community colleges that provide the majority of Stanislaus State's STEM transfer students. This also includes the college that provides the largest number of STEM transfers, which was not a partner in the 2011 HSI-STEM grant.

Opportunities for students to attend STEM conferences and conduct research with faculty were also deemed highly successful in the 2011 grant and have been broadened in STEM Success. The emphasis on facilitating undergraduate research with faculty mirrors a national trend that has led many institutions to adopt course-based undergraduate research experiences (CUREs).

The informal CVMSA professional preparation workshops that were offered under the 2011 HSI-STEM grant were regarded as potentially providing useful information – especially for students transitioning to college – but they struggled somewhat with direction and attendance. In STEM Success, the workshops have been converted into a unit-bearing course with clear learning goals.

Finally, a new summer experience activity has been introduced to rapidly instill within students a sense of belonging and a science identity. The summer activity drew inspiration from similar programs offered at some other HSIs, including several in the California State University system. These were reported to help students rapidly develop a sense of community and a science identity, resonating with the primary focus of STEM Success.

The STEM Success activities are designed for students who are in their first two years on campus, in response to finding that most STEM attrition occurs during this period. Membership in an organization such as CVMSA is no longer required. Instead, participation in STEM Success is open to any STEM majors who are the first in their family to attend college, or eligible for Pell support, or from a group underrepresented in STEM. Examples of the latter include students who identify as members of an underrepresented minority (URM), such as Hispanic students, and females who are majoring in a discipline that is predominantly male, such as computer science.

## THE STEM SUCCESS PROGRAM

STEM Success consists of four activities: Articulation is the central focus of Warriors on the Way to STEM; STEM Discovery Academy is an intensive summer program for immersion in STEM at Stanislaus State; Natural Sciences 1000 is a first-semester course that provides foundational science skills; and Research Immersion for STEM Excellence provides students with research experience and faculty mentorship. Critical features of these activities are detailed below.

### *Warriors on the Way to STEM (WOW 2 STEM)*

Warriors on the Way to STEM derives its name from Stanislaus State's athletic teams (the Warriors) and facilitates effective and seamless transfer for STEM students by improving articulation gaps and advising with 10 partner community colleges. The core WOW 2 STEM team consists of STEM Articulation Faculty, a STEM Transfer Success Specialist, and STEM Transfer Peer Mentors.

Six Articulation Faculty from the Stanislaus State STEM majors take the lead in identifying articulation weaknesses and gaps for their designated majors. The Articulation Faculty help maintain an effective articulation model with community colleges by clearly identifying course-to-course articulation, course sequencing, pre-requisites, and major courses. The faculty also lead professional development activities for regional community college staff and coordinate major advising for incoming transfer students during summer and spring orientations.

The STEM Transfer Success Specialist serves as the lead for STEM transfer student support services and outreach by providing transfer student advising, success programming and resources, and opportunities for staff and faculty collaboration with regional community colleges. The STEM Transfer Success Specialist meets one-on-one with prospective transfer students at the community colleges to help them navigate the admission requirements and courses needed to matriculate at Stanislaus State. STEM Transfer Student Orientation is another direct student service facilitated by the Transfer Success Specialist. Orientation programming provides transfer students with an opportunity to feel connected to their STEM major through a transfer student panel, a STEM peer mentor presentation, a tour of campus labs and STEM classrooms, and major advising from STEM faculty. In collaboration with WOW 2 STEM faculty, the STEM Transfer Success Specialist facilitates the planning of community college professional development activities and supports implementation of transparent transfer credit policies. The Transfer Success Specialist also meets one-on-one with transfer students during their first semester at Stanislaus State to sustain transfer student immersion and retention in STEM. The one-on-one meetings are semi-formal; they allow a general check-in with the students to address any issues or concerns, and foster detailed conversations about campus resources and services, financial aid, and STEM major advising process and deadlines.

Three Transfer Peer Mentors, who are current upper-division STEM students at Stanislaus State, are hired as student assistants to serve as role models for prospective and incoming transfer students. The Transfer Peer Mentors conduct outreach presentations and tabling at community colleges. They also provide one-on-one advice in person and online to transfer students, to help the transfer students overcome fears and misconceptions related to the transfer process. During the STEM Transfer Student Orientation, the Transfer Peer Mentors conduct tabling and share tips and advice from their own first-hand experiences as transfer students and current STEM majors at Stanislaus State. The Transfer Peer Mentors receive training in being active listeners and engaging in supportive and respectful dialogue with the students. In collaboration with the STEM Transfer Success Specialist, the Transfer Peer Mentors conduct open office hours on campus for transfer students to answer questions and/or concerns.

Since the STEM Success grant began, the WOW 2 STEM team has connected with 219 transfer students. Over 300 students from URMs have transferred from the WOW 2 STEM community colleges, out of which more than 100 received direct WOW 2 STEM services.

The WOW 2 STEM team maintains and updates a total of 120 degree-specific articulation roadmaps in collaboration with the 10 partner community colleges. Each roadmap contains major and degree specific information to facilitate the completion of lower division STEM prerequisites by community college STEM students who are seeking to transfer to Stanislaus State. The roadmaps are published on the STEM Success website to provide seamless access for students, faculty, and staff across all institutions. A sample roadmap is shown in Table 1.

WOW 2 STEM also offers professional development and articulation training for key personnel at Stanislaus State and the partner colleges. These services support and improve transfer student articulation, retention, and graduation. The most impactful of these meetings is the annual STEM Success Summit. This is a 1-day meeting that provides a shared platform for transfer students, staff, faculty, and administrators from community colleges and Stanislaus State. The Summit's theme is to engage the participants in collective discussions on institutional and departmental challenges, solutions, best practices, and opportunities in serving STEM transfer students. The Summit consists of a data presentation and analysis session, collaborative workshops, a STEM faculty panel, and major-specific group discussions. The Summit also includes a STEM transfer

student panel so the attendees can learn from the first-hand experiences of transfer students who have navigated the articulation pathway.

**Table 1**

*A Roadmap for the Stanislaus State Biology B.A. Program*

| Prerequisites to Lower-Division Courses | Lower-Division Courses at Modesto Junior College | Major Course Requirements at Stanislaus State |
|---|---|---|
| | BIO 101*(Biological Principles) | **BIOL 3310 - Cellular and Molecular Biology (3 units)**<br><br>**BIOL 3350 - Introductory Genetics (3 units)**<br><br>**BIOL 3680 - Ecology (4 units)**<br><br>**BIOL 4400 - Evolution (3 units)**<br><br>**Genetics and Biotechnology course (2 units)**<br><br>**Structure and Function course (4 units)**<br><br>**Diversity and Systematics courses (8 units)**<br><br>**Upper Division Biology Elective courses (10 units)** |
| BIO 101 | BOT 101* (General Botany) | |
| BIO 101 | ZOOL 101*(General Zoology) | |
| MATH 90 | CHEM 101** (General Chemistry 1) | |
| CHEM 101 | CHEM 102**<br>(General Chemistry 2) | |
| | **Select 4 or more units from the following:** | |
| CHEM 102 | CHEM 112 ***<br>(Organic Chemistry 1) or<br>CHEM 122***<br>(Structure and Reactivity: Organic Chemistry 1) | |
| | **OR** | |
| MATH 161 | PHYS 142 & 143 **or**<br>PHYS 142 & 152 | |
| | **OR** | |
| MATH 171 & PHYS 165 | PHYS 101 & 121 **or**<br>PHYS 101 & 102 | |
| *Approved course articulation with Biology 1050/1150 (BIO 101 & BOT 101 & ZOOL 101) is accepted as a series only. The Lecture and Lab cannot be transferred separately for the Major.<br><br>**Students should complete CHEM 101 & 102 at MJC before transferring to Stanislaus State to ensure timely progress.<br><br>***While CHEM 112 & 122 satisfy the Organic Chemistry requirement, they do not count as upper-division units. Upon transfer, four additional units of upper-division will be required to complete the major. | | |

***STEM Discovery Academy (SDA)***

The SDA was first offered in the summer of 2017. The pilot Academy was structured as a comprehensive, 4-week program designed specifically for incoming freshmen and transfer STEM students. Remediation in mathematics and English were key components, with freshmen students participating in remedial math instruction each weekday. All students maintained a journal; for freshmen, this activity satisfied their remedial English requirement.

Significant changes in California State University policies regarding remediation, combined with student and faculty feedback from the first SDA, resulted in a substantial redesign of SDA for the summer of 2018. The Academy was offered as two separate, 2-week sessions. This model enabled SDA to serve 48 students (24 students per session), with a desired split of two-thirds freshmen and one-third transfer students. The transition to a 2-week model also made it easier to recruit students and faculty, who were more willing to commit to a 2-week summer program than a 4-week program. These changes were effective in increasing student and faculty participation. The pilot year in 2017 served 17 students, followed by 35 in 2018 and 47 in 2019 (99 total students).

There are important differences in the experiences and expectations of transfer students compared to freshmen. Accordingly, each SDA session now consists of scheduled activities under a “freshman student track” and a "transfer student research track.” The customized tracks are designed to provide more targeted and specialized programming that is better aligned to the needs of the students. Two STEM Faculty Coordinators oversee SDA, with one Coordinator responsible for each session. The Coordinators jointly assist with finalizing the programing and logistics for both SDA sessions. STEM faculty who wish to lead an SDA activity or workshop submit a formal proposal that is incorporated into the SDA schedule upon review and approval from the Faculty Coordinators and Project Director.

The current SDA format offers a diverse range of programming that includes 41 hands-on activities led by 20 STEM faculty. All activities are designed to strengthen the students’ sense of belonging to campus and increase their STEM discipline immersion. Some examples of SDA activities are a genetics laboratory, a laser lab, a robot programming workshop, “How to talk to a Professor,” and an astronomy night. Students also participate in workshops and group activities that address academic and psychological issues that can impact STEM student success and retention. Examples of such workshops include: a “hero’s journey” activity that illustrates Joseph Campbell’s (1968) notion of the monomyth with examples of heroes such as Luke Skywalker, Katniss (from *Hunger Games*), Neo (*The Matrix*), and Mulan, and encourages the students to overcome their fears and imposter syndrome through skits they create and present; a values affirmation activity based on work by Miyake et al. (2010); and a gamified version of the difference-education intervention designed by Stephens et al. (2014). SDA also includes off-campus fieldtrips to regional locations such as the California Academy of Science and Monterey Bay Aquarium. All field trips are led by STEM faulty and include an itinerary designed to expose students to data collection, group activities, and scientific exploration.

All student participants receive constant mentoring and guidance from six SDA Peer Mentors, who are experienced STEM students on campus. Each SDA Peer Mentor is assigned to a group of 4-5 student mentees, which provides the incoming students an opportunity to build a stronger connection with the SDA Peer Mentors. The SDA Peer Mentors serve as role models to help the students feel connected to campus and their STEM majors; accordingly, they are selected to mirror the STEM majors and demographics of the SDA program participants. The SDA Peer

Mentors are hired as student assistants for both SDA sessions at $14/hour and typically work for 30 to 40 hours a week. They participate in all activities alongside the participants and also serve as residential advisors. SDA Peer Mentors who are in good academic standing and eligible for student employment on campus can re-apply as SDA Peer Mentors the following summer. Over the past three years, 16 STEM majors have served as SDA Peer Mentors.

***Natural Sciences 1000 Course (NSCI 1000)***

NSCI 1000 (Information and Investigation in STEM Discipline) is a 3-unit, general education "success in STEM" course that was developed and offered in Fall 2017 to incoming STEM freshmen. The course curriculum was designed to help students have a smooth integration to college and STEM disciplines. The course provided STEM-specific study and metacognitive skills to help the students understand how to gather, analyze, and interpret scientific information and develop college-level success skills for STEM disciplines, including problem-solving and teamwork. Upon assessment and instructor input, the course was modified to include a research project component that enabled students to formulate a research question and hypothesis, identify variables to measure, create an appropriate survey, and use statistical analyses to draw conclusions regarding the research question. The update also improved alignment with Stanislaus State's general education learning outcomes, by emphasizing four course learning goals that are clearly relevant to success in any STEM major:

- Apply essential problem solving, critical thinking, and communication skills;
- Work on scientific problems using a collaborative process;
- Gather and analyze data using scientific methods, derive results from the analysis, and explain the meaning of the results from a real-world perspective;
- Articulate future academic goals and plans as a scientist or a scientific educator.

In the current course, students work in groups to construct their research methods, implement data collection, and display their data using graphs and narrative in an organized manner. The course now also includes an NSCI Peer Mentor, who participates in the course alongside the students. The NSCI Peer Mentor is a senior who is hired as a student worker for $14 per hour, with a typical weekly schedule of 8 hours a week. The NSCI Peer Mentor assists the instructor in facilitating classroom discussions and group projects. The NSCI Peer Mentor also hosts weekly open office hours to meet one-on-one with students who need additional help with class assignments or seek advice about campus life, resources, study skills, etc.

During finals week the students present their research projects and outcomes to fellow classmates, the instructor, and STEM Success staff and faculty. The course is still under revision and will incorporate research poster design and presentation in its next iteration. Over the past three years, NSCI 1000 has served 47 students, of which 79% were Biology majors, 13% Chemistry, and 9% Computer Science. These percentages reflect the popularity of each STEM major, as well as a decision to limit enrollment to Biology majors in the first year NSCI 1000 was offered. This decision was made under the assumption it would promote development of a cohesive student community, but NSCI 1000 was opened to all STEM majors in subsequent years after recognizing it could help students develop their science identity regardless of major.

***Research Immersion for STEM Excellence (RISE)***

RISE supports and expands student engagement with high impact practices that include faculty mentoring, academic support, and undergraduate research. A STEM faculty member serves as the RISE Faculty Coordinator and assists with recruitment, hiring, and placement of student

researchers with faculty mentors. To join RISE, students must submit an online application, which includes an optional section for students to list their research interest(s) and identify preferred faculty mentor(s). A list of faculty mentors is available on the project website to help the students communicate and network with potential mentors. The applications are vetted for eligibility by STEM Success staff and upon identification of a successful "match" with a faculty mentor the students are hired as RISE Research Associates. RISE Research Associates are paid $14 per hour and typically work for 10 hours each week. Both freshmen and transfer students are eligible to work as RISE Research Associates, provided they are in their first 2 years on campus.

After 2 years, the students join the RISE Emeritus group. Emeritus students can no longer receive hourly pay, but they retain access to a majority of program services. For example, they can utilize RISE funding to participate in professional conferences and present research posters if they did not do so during their first 2 years. RISE Emeritus students may also continue to work in labs with the approval of their faculty mentor.

The RISE Faculty Mentors are hired under a special consulting agreement contract, which is based on the number of student researchers they mentor. Every year, 18 to 22 STEM faculty serve as RISE Faculty Mentors for the RISE program. Each RISE Faculty Mentor receives a budget for conference travel and/or fieldwork, as well as lab supplies and research poster printing. To access the travel and supplies budget, RISE Faculty Mentors must submit an online funding request. The requests are reviewed by the RISE Faculty Coordinator and STEM Success Project Director. The STEM Success Administrative Analyst and Lab Technician support approved requests by coordinating quotes and purchases.

A RISE factsheet is posted on the STEM Success website to keep the students and faculty informed about program policies and procedures. Additionally, the RISE Faculty Coordinator conducts monthly meetings and workshops for the participants to provide updates and engage in discussions about strategies for being a successful college student and researcher. RISE Emeritus students are encouraged to attend, to help them stay connected to the RISE community and allow them to mentor current RISE participants.

RISE meetings often include 3-5 minute "lightning talks," in which students present their research projects to STEM students and faculty. These talks are designed to help students feel more confident about presenting their research and to showcase the diversity of research projects sponsored by RISE. The meetings also serve as platforms to connect students with other campus research programs and support services, including those that will help the students stay involved with STEM research beyond their 2-year RISE program eligibility window.

RISE is primarily an academic-year activity, with limited capacity during the summer. The RISE program grew from 20 undergraduate research associates in 2017 to 50 in 2018. A funding surplus in 2019 supported 67 students; 54 worked as RISE Research Associates in 2020. Faculty participation has also increased steadily since RISE began. The first year of RISE saw only 5 RISE Faculty Mentors, but currently more than 20 STEM faculty employ students in their labs.

### *Program Administration*

STEM Success employs several full-time staff: The Project Director and Principal Investigator, who oversees the program; an Administrative Analyst, who tracks expenses and processes much of the program's paperwork; an instructional support Lab Technician, who provides logistical

support for the program; the STEM Transfer Success Specialist, who oversees the WOW 2 STEM activity; and a Research Analyst, who tracks relevant institutional data and maintains databases and dashboards for the program. The STEM Success program also employs a part-time Communications Specialist, who is responsible for program marketing and social media presence. In addition to these non-academic personnel, the program employs numerous faculty on a part-time basis. These include Faculty Coordinators for WOW 2 STEM, SDA, NSCI 1000, and RISE (as described above), and the Program Evaluator, who is from an academic program not served by the grant.

Various combinations of these personnel meet regularly to review and discuss the program, with one meeting for WOW 2 STEM, another for SDA, and a third for RISE. There are also regular meetings to discuss data and evaluation; these include two faculty members who have expertise in STEM student success but are not otherwise involved in coordinating grant activities. Additionally, there are monthly meetings of the STEM Success Steering Committee.

These are attended by most of the program staff and activity coordinators, as well as the College of Science Dean and the campus coordinator for the Louis Stokes Alliances for Minority Participation (LSAMP). The LSAMP program has goals that overlap with those of the HSI-STEM grant, so the coordinator's attendance helps prevent duplication of efforts. Similarly, the STEM Success Evaluator works on two other campus programs for STEM students (both funded by the National Science Foundation) and serves as a liaison between these programs and the STEM Success program.

This administrative structure is extremely robust. Since the first HSI-STEM grant was received in 2011, there has been turnover of almost all personnel, including the university administrators who oversee the grant. Several key positions have even experienced multiple changes, creating the potential for significant disruptions to the program's operation. However, the outcomes from the grant have demonstrated consistent progress from one year to the next. The program's stability in the face of personnel turnover is a testament both to the commitment of Stanislaus State to maintaining the program's quality, and a universal belief among staff and faculty that the activities funded by the program are highly beneficial to students and worthy of continued support. These beliefs derive from outcomes data that are described below.

## OUTCOMES FROM STEM SUCCESS

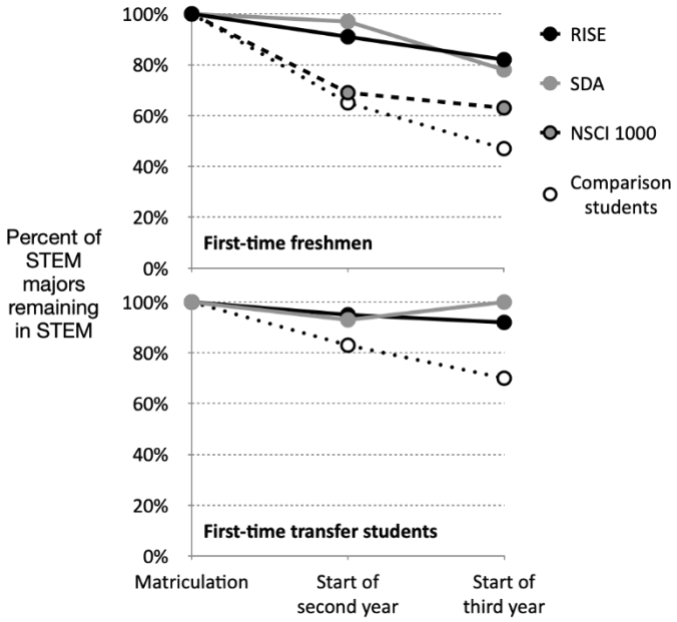
### *Number of STEM Majors*

Since Stanislaus State received its first HSI-STEM grant, the number of students majoring in STEM has increased markedly, particularly among Hispanics. Much of this increase simply reflects general enrollment trends; however, among Hispanics the growth in STEM enrollment has outpaced the overall increase in undergraduate enrollment. In Fall 2011, 109 Hispanic STEM majors matriculated at Stanislaus State; 76 were freshmen and 33 were transfer students. In Fall 2019 Stanislaus State matriculated 240 Hispanic STEM majors (192 freshmen and 48 transfer students). Thus, Hispanic enrollment in STEM increased 220% from 2011 to 2019, while Hispanic enrollment in non-STEM majors increased 174%.

The increase in STEM majors is probably largely attributable to an increased emphasis on STEM education and the perception among students and their families that earning a degree in STEM yields more benefits than earning a degree in a different major. However, positive publicity regarding STEM education and resources at Stanislaus State may also be responsible for at least some portion of the STEM enrollment growth among Hispanic students.

**Figure 1**

*STEM Retention Rates for First-Time Freshmen and Transfer Students*




***Retention within STEM***

Degree completion rates are the most important indicators of program impact, but the delay between matriculation at Stanislaus State and graduation is typically 3 or 4 years for students who enter as transfers and 5 or 6 years for students who enter as freshmen. Thus, degree completions do not provide timely feedback regarding possible avenues for program improvement. Instead, evaluation of outcomes is based upon a variety of indicators that are predictive of degree completion.

Institutional records provide one relevant source of information, but the metrics of interest here differ from those typically reported by institutions. Rather than focusing on retention within Stanislaus State, the STEM Success grant focuses on retention within STEM. Switching majors is not necessarily a negative outcome; students who move from one STEM major to another remain on track for graduation with a STEM degree (although their new major may impose additional course requirements). However, only 4% of students who switch from STEM to a non-STEM major eventually switch back. Most of those who do return are thought to have left STEM only on paper, switching out of their true major to avoid mandatory advising, which is not required for some non-STEM majors. For the vast majority of students, leaving STEM means they will not graduate with a STEM degree. This is regarded as undesirable within the context of an HSI-STEM grant, although it may well be a positive outcome for students if their new major is a better fit for their interests and life goals.

Figure 1 illustrates the STEM retention rates for SDA, RISE, and NSCI 1000. (Rates are not calculated for WOW 2 STEM, as this activity is intended to impact students before they arrive at

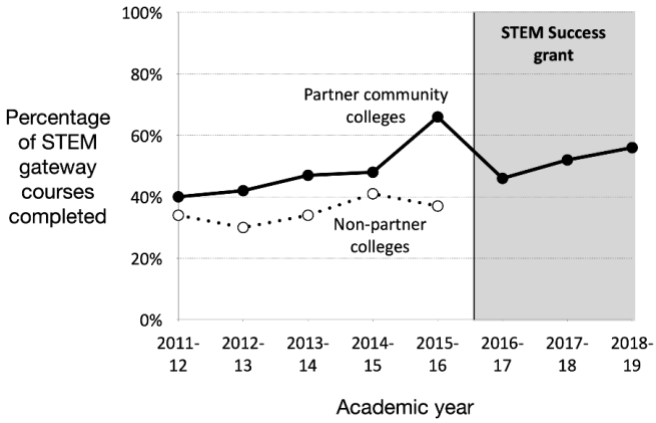
Stanislaus State, not afterwards.) Rates for freshmen are illustrated in the top panel, while rates for transfer students are shown in the bottom panel. The comparison groups are comprised of freshmen or transfer students who were eligible to participate in STEM Success activities but did not. Retention rates at the start of the second year on campus are based on students who matriculated in 2017 or 2018, while rates at the start of the third year are based only on students who entered in 2017. This explains why STEM retention among transfer students who participated in SDA *increased* from the second to the third year: One transfer student who participated in SDA in 2018 left Stanislaus State later that year. This student's departure will reduce the third year transfer retention rate for SDA when the 2018 cohort enters that year.

Combining the data across all three STEM Success activities reveals STEM attrition rates of 10% after 1 year and 28% after 2 years, which are considerably lower than the rates of 27% after 1 year and 49% after 2 years for students who were eligible for STEM Success but did not participate. An important question is whether the lower STEM attrition rates result from participation in STEM Success or simply reflect selection bias, with students who would already remain in STEM opting to participate in STEM Success. The data suggest that selection bias is not the explanation, because the STEM attrition rate for non-participants is comparable to the rate that existed before the STEM Success grant began. If selection bias were a problem, the departure of the students who were destined to remain in STEM from the comparison group would have driven down the STEM attrition rate for that group.

Figure 1 shows that retention within STEM is higher for transfer students than for freshmen, suggesting that most transfer students finalize their choice of major while they are still attending community college. The figure also shows that SDA and RISE are both highly effective at retaining students in STEM. NSCI 1000 appears less impactful. One reason for this may be that enrolling in NSCI 1000 does not require a strong commitment to STEM, as the course fulfills a general education requirement and is only one class out of four or five that students may be taking in their first semester on campus. By contrast, participating in SDA requires leaving home and sacrificing 2 weeks of summer – and possible employment during those 2 weeks. Similarly, participating in RISE requires working in a STEM lab for more hours per week than are required by NSCI 1000. Thus, some students may view NSCI 1000 more as an opportunity to learn about STEM and whether it suits their interests, than as a class they can use to hone their STEM skills.

**Figure 2**

*Percentage of Lower-Division Gateway Courses Completed by STEM Transfer Students Prior to Matriculating at Stanislaus State*



### *Prerequisites Completed*

Completion of prerequisite courses prior to transferring to Stanislaus State is of particular interest in evaluating the WOW 2 STEM activity. If students are effectively utilizing their college- and major-specific roadmaps, they should enter Stanislaus State having completed a higher percentage of the lower-division prerequisites required for their major.

Figure 2 confirms that the two HSI-STEM grants received by Stanislaus State have had this impact. When the first grant was in place, the percentage of gateway courses already completed by incoming STEM majors rose consistently every year for students who transferred from one of the two partner community colleges. No such trend is evident for the eight community colleges that were not partners during this first grant; the percentage for those colleges increased in some years but decreased in others.

All 10 community colleges became partners when the STEM Success program began in 2016. This led to an immediate reduction in the gateway completion rate, because the rates for the new partners were lower than the rates for the two pre-existing partners. However, since then, the gateway completion rate has increased every year.

Gateway completion rates have been higher for Hispanic than for non-Hispanic STEM majors. In the 2011-2012 academic year, Hispanic STEM students transferred to Stanislaus State having completed an average of 44% of their major prerequisite courses; their non-Hispanic counterparts had a completion rate of 36%. For the most recent academic year, the Hispanic completion rate increased to 65%, compared to 40% for non-Hispanic STEM majors. This is especially notable given the large number of Hispanic students who start their post-secondary journeys in community colleges (America Counts Staff, 2017).

### *Non-Cognitive Factors*

STEM Success activities are designed to facilitate the development of several non- cognitive factors integral to academic success. Sense of belonging is a critical non-cognitive factor: Students who feel they belong at Stanislaus State and in their major, and who develop a strong identity as scientists, are more likely to remain enrolled as STEM majors. Validated instruments are available to measure sense of belonging and other non-cognitive factors (e.g., Hoffman et al., 2002; Robnett et al., 2015). However, asking students to complete a lengthy survey that examines only one or a few non-cognitive factor creates challenges for assessing the impact of program activities on other key factors, such as growth mindset and the belief that a STEM education will yield important benefits. Furthermore, extant surveys do not always provide faculty with actionable data they can use to identify and address student needs.

Accordingly, an instrument to assess a variety of non-cognitive factors was developed internally in consultation with Stanislaus State STEM faculty. Most items were derived in response to current understanding of psychosocial factors impacting the academic success of STEM students as discussed at professional conferences and in the literature; other items were suggested by faculty, and some were added to serve as potential early predictors of students who were thinking of changing majors. To keep the survey short and thus improve the response rate, the instrument was designed to include 28 items that share minimal overlap in the non-cognitive factors they assess. Respondents indicate how strongly they agree with each item on a scale ranging from 1 (strongly disagree) through 7 (strongly agree). For most items a numerically higher response is more desirable, indicating stronger agreement. However, students with a growth mindset should *disagree* to the item “Succeeding in my major requires a special talent that can't just be learned.”

The item “Some students have to work harder than others to succeed in college” is another that students should reject, as it suggests some students can do well with little effort.

Psychometric analyses of the most recent responses made by each student who completed the survey at least once reveal positive manifold (Cronbach’s $\alpha = .90$, $N = 1{,}326$ STEM majors). This probably occurs because the phrasing of most items leads students to primarily use the “agree” portion of the response scale (i.e., numerical responses of 5, 6, or 7). However, correlations between the 28 psychosocial items are generally low (mean $r = .27$, range = -.05 to .62). Items are not combined when examining the impacts of each STEM Success activity on non-cognitive factors.

Students complete the instrument during the first few weeks of each semester, so it is called the Start of Semester (or SoS) Survey. In addition to asking students to self-report on their non-cognitive factors, the survey also asks students to describe, for each of their College of Science courses, what they would most like to learn in that course, what concerns them most about that course, and what grade they expect to receive. This information is anonymized and provided to the course instructors, many of whom offer extra credit for completing the survey.

Mean responses to SoS Surveys administered through Fall 2020 are summarized in Table 2, reported separately according to whether students participated in SDA, RISE, or both activities prior to completing the survey. Students who participated in NSCI 1000 are excluded due to small sample sizes. Participation in WOW 2 STEM is ignored in Table 2, as this activity was not designed to impact non-cognitive factors.

On half of the survey items, students who participated in SDA and/or RISE had significantly higher scores, on average, than students who did not participate in STEM Success (t-test $p < .05$). These items, which are indicated by an “a” superscript in the “Comparison students” column, suggest that STEM Success improves the development of important non-cognitive skills. Participating in both SDA and RISE appears to provide little benefit over participating in just one or the other activity, as only one item (indicated with a “b” superscript in the “SDA and RISE” column) yielded different average scores for students who participated in one activity compared to both activities. If students participate in only one STEM Success activity, there may be some advantage to RISE over SDA; four items (indicated by a “c” superscript in the “SDA only” column) yielded significantly higher mean scores for students who participated only in RISE than for students who participated only in SDA.

### *Qualitative Indicators*

The quantitative data provided by the SoS Survey are supplemented with a variety of qualitative data. Students in SDA maintained journals throughout the Academy, and at the conclusion of each week responded to open-ended questions regarding that week’s activities and their overall impression of SDA. NSCI students completed a survey with prompts to a variety of open-ended questions. Similarly, students and faculty participating in RISE completed surveys that included prompts for a variety of open-ended questions, and RISE students participated in focus groups.

**Table 2**

*Mean Scores on the Start of Semester Survey Through Fall 2020*

| Survey item | Comparison students (*n* = 1,191) | STEM Success participation | | |
|---|---|---|---|---|
| | | SDA and RISE (*n* = 28) | SDA only (*n* = 58) | RISE only (*n* = 53) |
| Setbacks and obstacles, I encounter as a student are opportunities for me to learn | 5.69 [a] | 6.12 | 5.88 | 6.00 |
| I'm glad I'm a student at Stan State | 5.68 [a] | 6.11 | 5.98 | 5.87 |
| I am comfortable asking my major professors questions | 5.46 [a] | 5.81 | 5.66 | 6.10 |
| It's important for undergraduates in my major to conduct research | 5.46 [a] | 6.29 | 5.68 | 6.04 |
| The faculty in my major at Stan State support me | 5.46 [a] | 6.04 | 5.68 | 6.04 |
| Professionals who work in my major have fun | 5.40 [a] | 5.96 | 5.61 | 5.62 |
| I have friends and colleagues who can help me succeed at Stan State | 5.31 [a] | 6.07 | 5.66 | 6.13 |
| I can read scholarly articles in my major | 5.26 [a] | 5.52 | 5.35 | 5.71 |
| I know how to design a scientific study to test a hypothesis | 5.12 [a] | 5.57 | 5.29 | 5.47 |
| I know where to go on campus if I need help | 5.36 [a] | 6.32 [b] | 5.33 | 5.85 |
| I know how to study for an exam at Stan State | 5.24 [a] | 5.43 | 5.12 [c] | 5.98 |
| I enjoy conducting research | 5.03 [a] | 5.85 | 5.45 [c] | 6.31 |
| I can write a scholarly paper in my major | 4.43 [a] | 4.43 | 4.43 [c] | 5.32 |
| I have at least one mentor at Stan State | 4.12 [a] | 5.33 | 4.75 [c] | 5.96 |
| Getting a college degree will help me achieve my life goals | 6.35 | 6.33 | 6.39 | 6.62 |
| Some students have to work harder than others to succeed in college | 6.23 | 6.25 | 6.18 | 6.47 |
| I am confident that I will complete an undergraduate degree in my major | 6.22 | 6.25 | 6.07 | 6.52 |
| I enjoy learning about my major | 6.21 | 6.37 | 6.28 | 6.42 |
| I would like to learn more about careers in my major | 6.15 | 6.52 | 6.16 | 6.33 |
| I am interested in pursuing a graduate degree or certificate | 5.75 | 5.68 | 5.57 | 5.81 |
| I feel like I belong in my major | 5.68 | 5.81 | 5.75 | 5.85 |
| I have the skills needed to succeed in my major | 5.52 | 5.70 | 5.57 | 5.69 |

| | | | | |
|---|---|---|---|---|
| Careers for students who major in my major pay well | 5.47 | 5.96 | 5.62 | 5.38 |
| I use an agenda, calendar, or other scheduling tool to help me manage my time | 5.38 | 5.71 | 5.45 | 5.52 |
| I am confident in my ability to solve mathematical problems | 5.29 | 5.46 | 5.28 | 5.53 |
| I can distinguish good scientific work from bad scientific work | 5.14 | 5.46 | 4.93 | 5.37 |
| My high school or community college did a good job of preparing me for Stan State | 4.69 | 4.52 | 4.98 | 4.68 |
| Succeeding in my major requires a special talent that can't just be learned | 3.60 | 3.79 | 3.14 | 3.62 |

The qualitative responses are used by staff and faculty to improve the activities delivered by the STEM Success program. However, many comments provided by participants speak to the impact of the activities on their personal or professional growth. For example, one student in SDA noted that "it helped me grow as a person & develop relationships that are going to help me continue to work on myself." Another commented that SDA "helped change my perspective towards college." A student participating in RISE stated that "the experience and push to improve to be able to conduct research definitely help me in my classes." Another RISE student wrote "I've benefited by being able to form part of a research team. I also gained team skills as well as discipline in the laboratory."

The qualitative data have not undergone a formal content analysis. However, comments from students in SDA tend to highlight the personal relationships they developed in the Academy. For example, one student described SDA as "a great program to make friends and discover a sense of family." By contrast, RISE students often focus on the professional skills they acquired by participating. One student cited learning how to use CRISPR as a benefit, while another stated "I gained many skills like writing abstracts and scientific research papers."

Overall, the qualitative data suggest participation in STEM Success facilitates development of the psychosocial skills that are important to retaining students in STEM and helping them thrive as maturing scientists. Thus, there is strong evidence that the program functions as desired. As one student noted regarding SDA, "This program was life changing … . It is among the best weeks of my life.

### *Areas for Improvement*

The outcomes for STEM Success have been strong, but areas for improvement remain. One potential challenge is a mismatch between the demographic characteristics of the students served by the program and the faculty and staff who administer it. For example, 73% of student participants in SDA, and 57% of student participants in RISE, identify as members of a URM. This meets or exceeds the percentage of STEM majors who belong to a URM (58% in Fall 2020), suggesting that STEM Success truly serves Hispanic and other historically underrepresented students. However, only 18% of RISE Faculty Mentors identify as members of a URM. The number of URM faculty who participate in STEM Success could perhaps be increased with more intentional efforts to recruit diverse faculty; recruitment efforts to date have focused instead on matching faculty with students based on their major. However, a

demographic disparity between STEM Success students and faculty is inevitable because a large proportion of STEM faculty participate in STEM Success, but only 17% of faculty at Stanislaus State belong to a URM.

To some extent this problem is ameliorated by the inclusion of peer mentors, who are themselves students. It is also important to recognize that faculty can connect with students despite differences in race or ethnicity. For example, many STEM Success faculty were the first in their families to attend college and know only too well the challenges faced by first generation students. The "How to talk to a professor" session in SDA helps students begin to acquire the academic capital they may be lacking – and may be unaware they are lacking. Similar information is provided in NSCI 1000, and discussions about academia are inherent to the mentoring provided by RISE. Furthermore, STEM Success engages students in several experiences that explicitly honor their backgrounds, including the hero's journey, values affirmation, and difference education exercises in SDA. Family members are invited to attend the poster session marking the end of SDA, and RISE poster presentations at the annual College of Science Research Celebration. Many STEM Success faculty also participate in another grant on campus, which just completed its initial year of funding from the National Science Foundation, that encourages the adoption of culturally sensitive classroom practices. Still, more could be done to help ensure that students see mirrors of themselves in the faculty with whom they interact, and engage in experiences they find particularly relevant.

This challenge is linked to another area for potential improvement: Participation in RISE is near budgetary limits, but the other STEM Success activities could serve more students. SDA has never completely filled, NSCI 1000 has had open seats every year, and more community college students could meet with WOW 2 STEM staff. All three of these underutilized STEM Success activities require students to be recruited before they matriculate at Stanislaus State (or, in the case of WOW 2 STEM, before many have even decided to attend Stanislaus State), which provides limited opportunities to connect with potential participants and make them aware of the opportunities provided by STEM Success. Marketing and outreach efforts take time to effect change and participation rates in WOW 2 STEM, SDA, and NSCI 1000 are all trending up, but further work in this area is needed.

## CONCLUSION

The STEM Success grant has greatly increased the number of students from underrepresented groups who are on track to complete a STEM degree. Program improvements have been guided by an intentional, evidence-based process. This process has required tracking outcome measures that institutions may not normally examine, including retention within STEM and completion of major prerequisites. The ability to track these novel metrics was possible only because a research analyst was included in the program's administrative staff, which is a practice that few other HSI-STEM grants seem to employ.

An important evaluation finding is that students appear to benefit just as much from participating in only SDA or only RISE as they do from participating in both activities. Thus, one mechanism for ensuring that the program serves as many students as possible is to allow eligible students to participate in only one or the other activity.

Outcomes for the NSCI 1000 course have not been as strong as for the other grant activities. This probably reflects the informal process that was used to develop the course. NSCI 1000 grew organically out of the CVMSA workshops that were offered under Stanislaus State's first HSI-

STEM grant. The workshops were not thematically organized or integrated with each other, because it was assumed that attendance by students would be sporadic. Thus, simply combining the workshops into a course did not provide students with a coherent set of learning objectives or the scaffolding essential to the development of foundational skills. These shortcomings have been recognized and the course is now being reimagined to provide students with a much more intentional learning experience.

Institutionalization of program activities can be a challenge for any grant. WOW 2 STEM and NSCI 1000 are expected to continue when the STEM Success grant ends, as most of their associated costs were experienced during startup; maintenance costs are relatively inexpensive. However, institutionalizing SDA and RISE is likely to be more challenging, as both activities in their current form have significant expenses.

An online version of SDA was offered in Summer 2020 in response to concerns regarding the novel coronavirus. This change eliminated costs associated with housing and feeding the Academy attendees. If the outcomes data are similar to those obtained for the in-person SDA, the online version of SDA may serve as a model for offering a low-cost program in future years that can be funded without grant support.

Faculty in RISE suggest that financial compensation is not essential to their participation. Students are more likely to acknowledge the important of the pay they receive, but a majority also state that would have participated in RISE if they had earned academic credits instead of dollars. These responses suggest that the RISE program may remain viable even without grant support.

An unanticipated outcome is the apparent positive impact and energy STEM Success has brought to the STEM faculty, enhancing their teaching and cross-disciplinary collaborations. Beyond articulation, the project has facilitated collaboration among Stanislaus State and partner community college faculty to share and discuss teaching strategies and student academic advising practices. It has also facilitated collaborations between faculty at Stanislaus State and partner colleges to lead joint research projects designed to help transfer students gain research experience at both institutions. Additionally, the students who have participated in STEM Success continue to display leadership qualities and a willingness to serve as role models and peer mentors to other students in formal and informal settings. These students are successful in every sense of the word, serving as productive members of their STEM disciplines and progressing towards the completion of their degrees as they help the Stanislaus State STEM community become more diverse and inclusive.

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