Improving Persistence and Success for At-Risk STEM Students through a Summer Intervention Program at a Hispanic-Serving Institution

Dr. Melissa Danforth, California State University, Bakersfield

Melissa Danforth is a Professor and the Chair of the Department of Computer and Electrical Engineering and Computer Science at California State University, Bakersfield (CSUB). Dr. Danforth was the PI for a NSF Federal Cyber Service grant (NSF-DUE1241636) to create models for information assurance education and outreach. Dr. Danforth was the Project Director for a U.S. Department of Education grant (P031S100081) to create engineering pathways for students in the CSUB service area. She was also the co-PI for an NSF IUSE grant for STEM retention (NSF-DUE 1430398) and the co-PD for multiple U.S. Department of Education grants related to engineering education and outreach. Her research interests are focused on network and system security, particularly with respects to protecting mission-critical resources and services. She is also conducting research in applying biological concepts to cybersecurity, such as artificial immune systems.

Dr. Charles Lam, California State University, Bakersfield

Dr. Charles C.Y. Lam is a Professor in the Department of Mathematics. Dr. Lam received his Ph.D. in Combinatorics and Optimization from the University of Waterloo. His research areas are in cryptography, digital watermarking, and combinatorics. He is the PI for the NSF IUSE grant (NSF-DUE 1430398) for STEM retention, and the co-PI for the NSF Federal Cyber Service grant (NSF-DUE1241636) to create models for information assurance education and outreach. He is also the Project Director for Department of Education HSI-STEM Award P031C160080 (A Guided Pathway Solution to STEM Degree Completion), and two MSEIP awards. He has mentored various undergraduate student researchers as a faculty mentor for the LSAMP and McNair Scholars Program. He has extensive experience in curriculum assessment, undergraduate curriculum development, and student mentoring.

Dr. Ronald Hughes, CSU, Bakersfield

ACADEMIC RESPONSIBILITIES: (2017-Present) Associate Professor for the STEM Affinity Group, School of Natural Sciences and Mathematics, California State University, Bakersfield. Duties included teaching responsibilities in Undergraduate Biology. Additional duties included grant writing, management, and evaluation.

RESEARCH INTERESTS: Include teaching and learning cognition skills, informal learning environments and strategies, and science/technology curriculum design/implementation/evaluation.

Improving Persistence and Success for At-Risk STEM Students through a Summer Intervention Program at a Hispanic-Serving Institution

Abstract

This Complete Evidence-Based Practice paper describes a four-year summer intervention program for at-risk STEM students at California State University, Bakersfield (CSUB) that was supported by an NSF IUSE grant*. CSUB is a Hispanic Serving Institution (HSI) and Minority Serving Institution (MSI) located in a service region with historically low educational achievement. Students from the region lag behind their statewide peers in mathematical readiness for college, which affects their persistence and success in STEM fields at CSUB. The summer program paired small groups of students with faculty mentors to complete STEM projects designed to create a connection between mathematics and STEM disciplines. Analysis of retention and graduation rates, participant survey data, and interviews of participants and faculty mentors show that the program had a positive impact on the participants' persistence and success in STEM fields.

Introduction

California State University, Bakersfield (CSUB) is a public, comprehensive university located in an ethnically diverse service region and has an enrollment headcount of about 11,000 students. Current demographic estimates for the region are 54% Hispanic / Latinx, 6.3% Black / African American, 2.6% American Indian / Alaskan Native, 0.3% Pacific Islander / Native Hawaiian, 3.1% Two or More Races, 5.4% Asian, and 33.5% White (Not Hispanic / Latinx). CSUB reflects the demographics of its service region and currently carries designations as both a Hispanic Serving Institution (HSI) and Minority Serving Institution (MSI). The service region is also marked by low educational achievement and low socioeconomic status. Only 16.1% of residents in the region have college degrees, compared to 31.5% nationwide. The percentage of people in poverty in the service region is 20.5%, which is 1.5 times that of the state and national rates [1].

Students from local high school districts lag behind their statewide peers in mathematics testing and readiness for college. In the past five years of assessment, only 22.0% of the region's high school students met or exceeded the state standard for mathematics, compared to the 31.6% rate statewide [2]. In Fall 2016 at CSUB, more than one-fourth of all entering freshmen and 37% of freshmen with declared STEM majors were not ready for college-level mathematics. As a consequence, many STEM majors at CSUB enter their programs at either the remedial or pre-calculus level. This increases their time to graduation and lowers their persistence in calculus-based STEM majors such as engineering.

To investigate strategies to address this issue, CSUB received an NSF IUSE grant which had multiple activities to improve persistence and success in STEM. One of the activities was this summer intervention program, which was intended to provide a connection between mathematics and STEM disciplines to encourage persistence and success. The research question was if a

* National Science Foundation Improving Undergraduate STEM Education grant number 1430398.

short-term summer intervention program would be effective in improving retention and academic performance in STEM fields. The program ran for all four summers during the grant activity period, from Summer 2015 to Summer 2018. The program paired small groups of students with faculty mentors to complete a STEM project for two weeks (one week in Summer 2015). Students also participated in a career workshop on the last half-day of the program.

Students were considered “at-risk” if they were still in pre-calculus or earlier mathematics courses at the end of the academic year. Grant personnel went to pre-calculus courses in Spring term to recruit participants. Faculty members teaching pre-calculus courses also sent emails about the program to their students and CSUB sent emails and social media blasts to lower-division students to advertise the program. In addition to this recruitment, faculty and staff advisors could refer a student to the program for another reason beyond their current mathematics placement, such as having a low GPA or showing signs of struggling in major or mathematics coursework. Students were not told that the program was for at-risk students, but rather that it was for students still at the pre-calculus or earlier level.

The recruited participants were primarily first-year students, although participants could also be second-year students or transfer students in their first year at CSUB after transfer if they were also considered at-risk. There was a small stipend for completion of the program, to encourage students to participate. Students who participated the prior summer were also allowed to return for a second summer, regardless of their mathematics progress.

Persistence and success were measured through multiple parameters. In [3] and [4], the first year and first two years of the summer program were presented respectively. This paper analyzes the full four years of the program, including retention and graduation data, surveys administered during the program, interviews conducting during and after the program, and a follow-up survey administered in Spring 2019.

Related Works

In designing the summer intervention program for the grant proposal, the grant team looked at prior works to find promising techniques for encouraging persistence and success in STEM, particularly for underrepresented minorities [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16]. The grant team conducted updated literature surveys during the grant activity [17], [18].

In [13], active and collaborative learning environments were identified as a key factor in attracting underrepresented minority and female students to STEM fields and to encouraging their academic success. Actively engaging students was also identified by [14] as a key strategy for retaining STEM students. In [15], they found that persistence in STEM is not related to the students’ innate abilities, but rather related to their perceptions about STEM careers and to classroom/activity experiences. This is supported by [5] and [7], which found that persistence in STEM is related to perceptions of STEM fields and students’ confidence in their abilities.

The first year was identified as a critical intervention period in several prior works. Research at any point in the first year was identified by [5] as a critical component to improve retention in

STEM. In [18], they found that research seminars and collaborative-learning workshops for first- and second-year STEM students, particularly URM students, resulted in higher grades in mathematics and chemistry courses and in significantly higher persistence rates.

Summer research and activities were also identified specifically by many prior works as an effective technique to encourage persistence and success in STEM fields, particularly for URM students [7], [8], [10], [11], [12], [16], [17]. Exposure to real-world activities such as a summer research experience was identified by [7] as a critical component to success. Additional previous works were surveyed in [16], which found that key factors in success were research activities and faculty mentorship. In [11] and [12], summer research experiences were evaluated through surveys and it was found that the experience helped students gain independence, increased their academic motivation, and increased their participation in courses after the summer research experience. URM students reported higher positive effects in [11] and [12].

Project Approach

Each summer, a small set of focus areas were available, and students could express a preference for focus areas on the application form. The focus areas were generally classified as "Science", "Engineering", and "Mathematics / Computer Science". Specific focus areas for each summer are noted in Table 1.

Table 1: Summary of Focus Areas Offered in Each Summer

Year	Focus Areas Offered
2015	Chemistry: Analyzing Chemical Solutions with a Photospectrometer Materials Science/Engineering: Wettability of Natural Surfaces and Plant Leaves Mathematics: Investigating Nonlinear Dynamic Systems and Chaos Theory
2016	Biology: DNA Extraction to Detect Coccidioides immitis Using PCR Engineering: Designing a Residential House – Construction and Cost Estimates Electrical and Computer Eng.: Using Arduino to Build a Door Knock Detector Mathematics: Investigating Nonlinear Dynamic Systems and Chaos Theory
2017	Materials Sci./Eng.: Experimenting with Liquid Repelling Surfaces Engineering: Designing a Residential House – Construction and Cost Estimates Electrical and Computer Eng.: Smart Electronics for Everyday Applications Mathematics: Explore the World of Chaos
2018	Biochemistry: Math is in Your Genes Electrical and Computer Eng.: Application of Basic Algebra and Linear Functions in a Tracking Sys. Computer Science: Math is Everywhere in System and Application Software Design Mathematics: Statistical Analysis of Breast Cancer Research

In the first summer, 2015, the program was only one week long and offered just three focus areas. In response to student and faculty feedback, as described in [3], grant personnel received permission from NSF to allocate more funding to extend the program to two weeks in length and to add another focus area each summer.

Faculty mentors were selected for the program based on abstracts submitted to grant personnel. Projects which incorporated mathematics into their respective fields through hands-on, team-based activities were preferred for the program. The proposed activities also had to be feasible to complete in just under two weeks of work by students who were at the pre-calculus level. The goal was to create a fun and encouraging environment to engage the students with each other and with their faculty mentor, as this has been shown by prior works to be a good way to improve persistence and success [7], [12], [16]. Faculty mentors also selected an upper-division undergraduate student to serve as a teaching assistant and peer mentor during the activity. The faculty mentor, peer mentor, and participants received a stipend for participating in the program.

The last half-day of the program was a career skills workshop organized by CSUB's career education center. Students learned skills related to resume writing, job searching, and interviews from career counselors. Students were also introduced to CSUB's job portal.

Assessment Tools

Academic progress of all participants was monitored through CSUB's enrollment management system. Grant personnel recorded each student's major, GPA, mathematical preparation, and class level at the time of application, then tracked those metrics over time. The students' current academic standing (graduated, good standing, academic probation, academic disqualification, no longer enrolled) was also tracked. Comparison data to all STEM students and the university as a whole was gathered from the faculty portal provided by CSUB.

Assessment data was also gathered through surveys and interviews developed by grant personnel and the internal and external evaluators. Pre-surveys (Table 2) were administered at the start of the first day and post-surveys (Table 3) were administered at the end of the last day. Both surveys contained matched attitudinal questions using a 5-pt Likert scale. The post-survey also had a set of questions to gauge participants' self-rated change of interest using a 3-pt Likert scale, as previous survey experiences from the grant personnel noted many students tend to circle "Strongly Agree" on the pre-survey, making it impossible to gauge change in interest purely from comparing responses on the matched pre- and post-survey questions.

Table 2: Pre-Survey Questions

Pre-Survey Question	Question Type
Participant identification (Student ID Number, Year, Faculty Mentor)	Text boxes and Lists
Participant academic information (Major, Class level, GPA, Last math course taken, When last math course was taken)	Text boxes and Lists
Participant demographic information (Gender, Race / Ethnicity)	Select from lists
Q: What interested you about this summer program?	Open-ended comment
Q: What do you expect to learn and experience in this summer program?	Open-ended comment
Q: How do you expect this program to help your academic career?	Open-ended comment
Q: Rate your agreement with the following statements: • I am interested in the field that I am studying. • I am interested in a career in STEM. • I am confident that I am prepared for this program. • I am aware of the academic knowledge required for a career in STEM. • I understand what skills are required for a career in STEM. • I understand what "research" in STEM means. • I am interested in research in STEM.	5-point Likert scale (strongly agree = 5, agree = 4, neutral = 3, disagree = 2, strongly disagree = 1)

Table 3: Post-Survey Questions

Post-Survey Question	Question Type
Participant identification (Student ID Number, Year, Faculty Mentor)	Text boxes and Lists
Q: Rate your agreement with the following statements: • My faculty facilitator has been supportive. • I am interested in the field that I am studying. • I am interested in a career in STEM. • I was prepared for this program. • I am aware of the academic knowledge required for a career in STEM. • I understand what skills are required for a career in STEM. • I understand what "research" in STEM means. • I am interested in research in STEM. • The career workshop helped me to understand what is needed to be successful in STEM fields.	5-point Likert scale (same scale as pre-survey)
Q: What did you like about this activity?	Open-ended comment
Q: What specific knowledge and/or experiences did you gain from this activity?	Open-ended comment
Q: If anything, what would you change about this activity?	Open-ended comment
Q: Rate your change of interest in the following areas: • The field that I am studying. • A career in STEM. • Research in STEM.	3-point Likert scale (increased = 3, no change = 2, decreased = 1)
Q: If you indicated a decrease in interest in any of the above areas, please give a brief reason why.	Open-ended comment
Q: Would you recommend this program to your friends?	Yes/No/Uncertain
Q: If you have additional comments, please leave them here.	Open-ended comment

Interviews with faculty and students were conducted by the internal and external evaluators during and after the summer program, using a framework derived from [19].

A follow-up survey was also conducted with participants in Spring 2019. The follow-up survey was an online survey and was sent via email to the last known email address for the participants. It asked the students what their current academic standing was and to describe the benefits they received from participating in the program in terms of focusing their attention on STEM careers and providing motivation to complete a STEM degree.

Results and Discussion

In total, 89 students participated in the program over the four summers, with 18 of those students returning to participate for a second summer. Mathematics preparation matches the target audience, with 76% in pre-calculus or earlier mathematics courses at time of application to the program. The majority of students at the pre-calculus or earlier level were first-year students. The most common mathematics course placement in the Spring term before participation was Pre-calculus I (41.6%), followed closely by Pre-calculus II (22.5%).

At time of application to the program, 38.2% of the students were in an engineering major, 42.7% were in a science major, 15.7% were in a mathematics or computer science major, and 3.4% were in other majors (including undeclared).

Self-identified demographics on the pre-survey for the participants were similar to the demographics of CSUB and the region as a whole. A majority of the participants were Hispanic / Latinx and two-thirds were underrepresented minority students (Figure 1). 52.8% of the participants identified as female, 38.2% identified as male, and 9% selected declined to state or did not answer the question on the pre-survey.

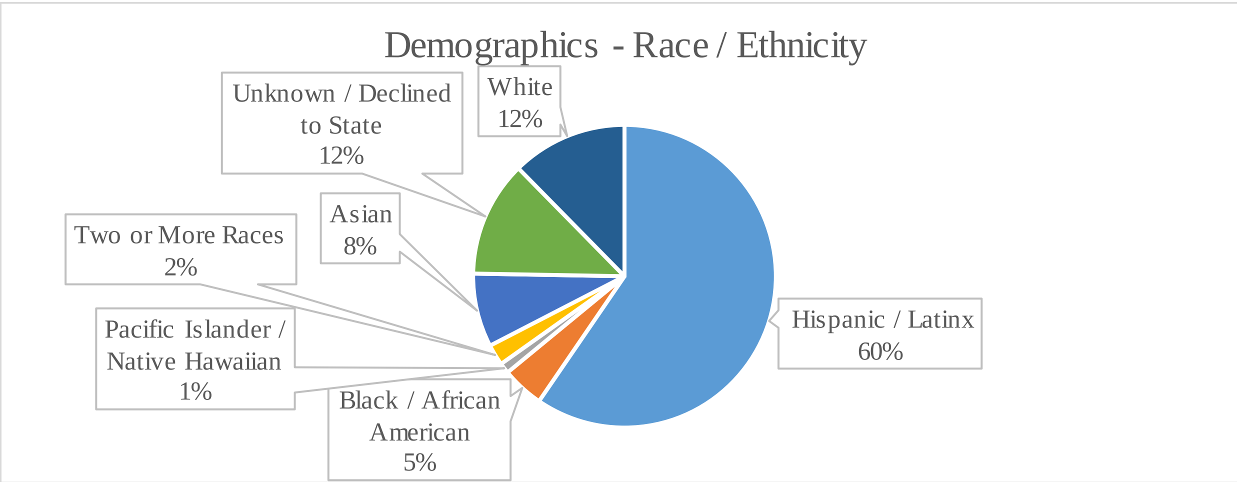

Figure 1: Self-identified race / ethnicity demographics of the summer participants.

Looking at the demographics in each major area (Math/Computer Science, Science, and Engineering), the percentage of URM students in science and engineering majors is higher than in mathematics and computer science majors, although the percentage of unknown / decline to state students is higher in mathematics and computer science majors (Figure 2).

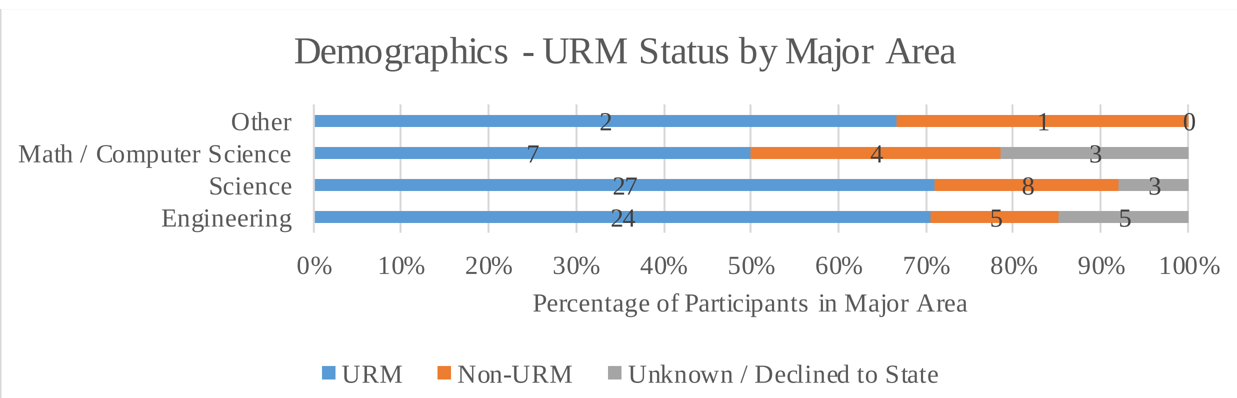

Figure 2: Self-identified underrepresented minority status by the students' major area.

Gender breakdown by major area shows that the majority of the engineering majors participating in the program were male, while the majority of science majors were female. Identified gender for the mathematics and computer science majors was evenly split (Figure 3).

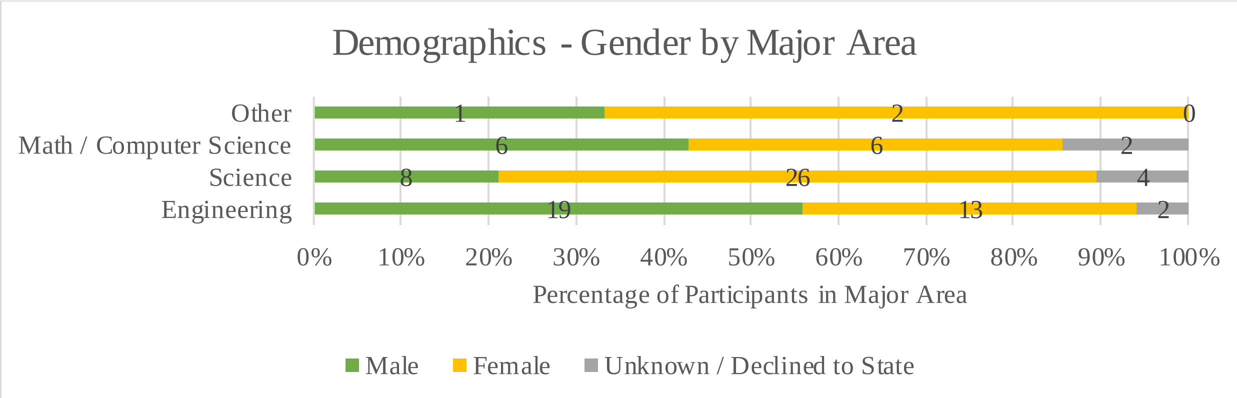

Figure 3: Gender of participants by the students' major area at time of participation.

Retention, Graduation, and Academic Success

The current declared majors and academic status of students were tracked through CSUB's enrollment management system. After participation in the program, 17 students changed their major to another STEM major and 14 changed their major to a non-STEM major. For purposes of this analysis, students were considered "retained in STEM" if they still had a major within STEM and were actively attending CSUB during the past academic year and were considered "graduated in STEM" if they had graduated in a STEM major.

The participant retention/graduation rate in STEM for each summer of the program exceeds the comparison STEM persistence rates at CSUB, although the margin is slim for the Summer 2017 participants. The percentage of students retained or graduated at CSUB in any major is also higher than the comparison persistence rate for CSUB (Figure 4).

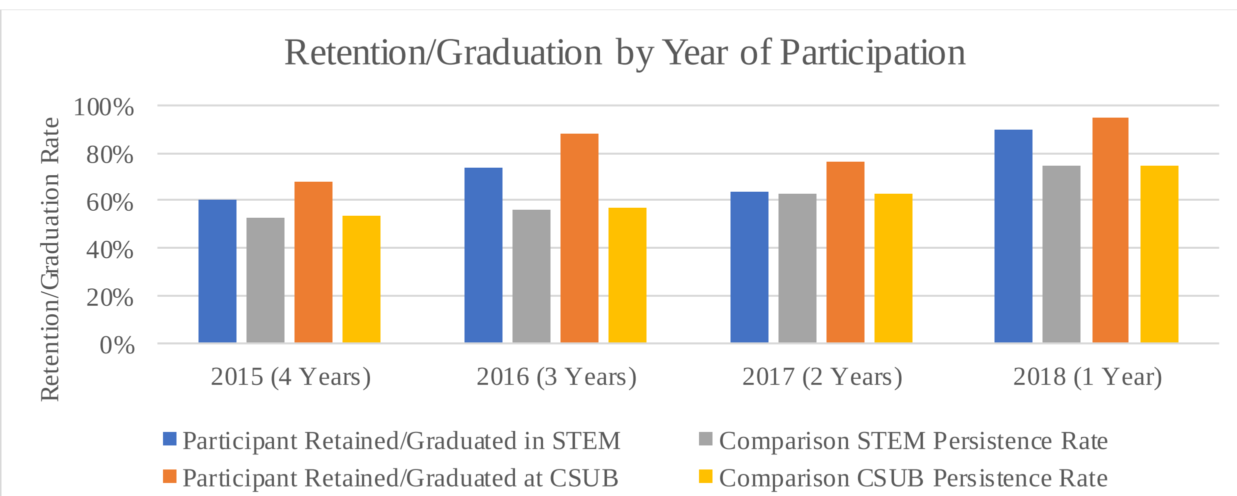

Figure 4: One-, two-, three-, and four-year retention/graduation rates for participants, with institutional and STEM comparison persistence rates.

Overall, 66.3% of the participants were retained or graduated in STEM and 79.8% were retained or graduated in any major at CSUB. The majority of non-retained students stopped enrolling at CSUB, which is defined as not being enrolled for two or more semesters. Only 4 participants were academically disqualified due to poor academic performance.

Within each major area, engineering students had the highest STEM retention and graduation rate, with 73.5% retained or graduated in STEM. Science students were 68.4% retained or graduated in STEM, while mathematics and computer science students were only 57.1% retained or graduated in STEM (Figure 5).

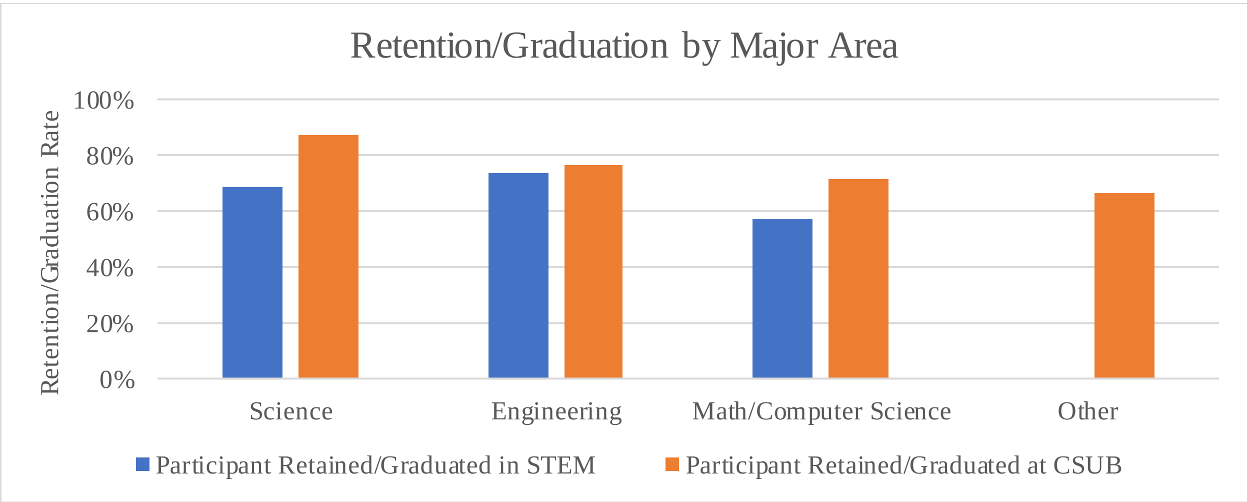

Figure 5: Retention/graduate rate by students' major at time of application.

Mathematics progression was also monitored. For the participants who stayed in a STEM major, all science majors have completed their pre-calculus or calculus sequence (depending on specific science major), 91.7% of the mathematics and computer science majors have completed their calculus sequence, and 76.2% of the engineering students have complete their calculus sequence. For the 6 students who have not completed their calculus sequence, they all have just one more calculus course to complete. Three (3) of those students were Summer 2018 participants, so they are still within the expected time frame to complete the calculus sequence. The remaining 3 students are engineering students from the Summer 2015 and Summer 2016 cohorts, so they are significantly behind in the major even given the interventions of this program.

The average GPA for each population of participants in Fall 2019 was analyzed (Figure 6). The comparison institutional average GPA in Fall 2019 was 2.757 and the comparison STEM average GPA for Fall 2019 was 2.702. There is no significant difference in overall GPA for participants who were enrolled (2.783 ± 0.489) or graduated (2.776 ± 0.468) in STEM from the comparison institutional and STEM average GPAs. Even though the participants were originally at risk, they have improved their academic performance to the institutional average. There is also no significant difference between the enrolled/graduated in STEM participants and participants in STEM majors who stopped enrolling at CSUB (2.713 ± 0.431). This suggests those participants stopped enrolling for non-academic reasons or they transferred to another institution.

Participants who switched to non-STEM majors had slightly higher overall average GPAs (enrolled 2.763 ± 0.30, graduated 2.993 ± 0.371), but this was also not statistically significant from either the institutional comparison or the participants who were retained in STEM. The most popular non-STEM majors that participants switched to were business and liberal studies.

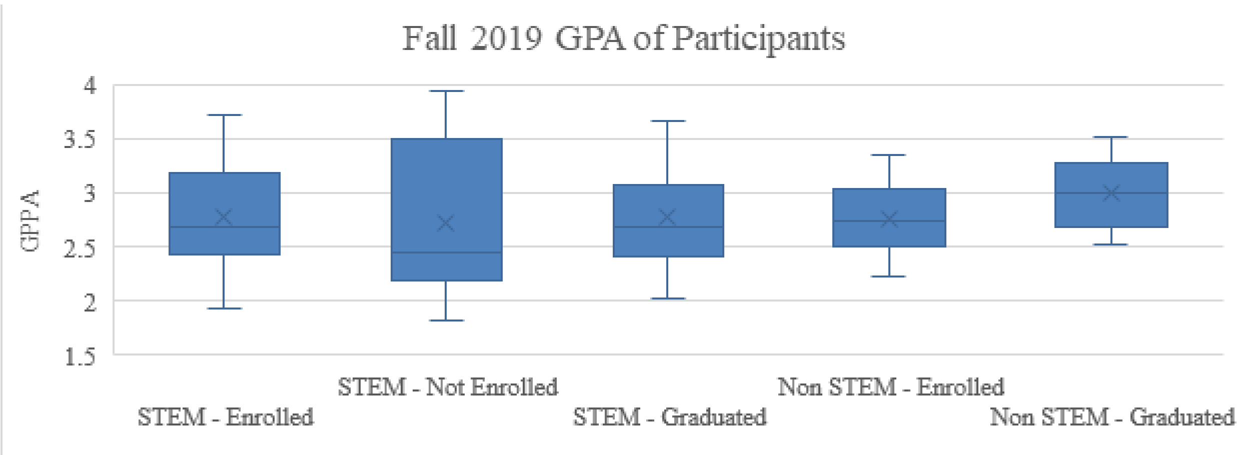

Figure 6: Average GPA for each population of participants in Fall 2019.

Findings from Pre- and Post-Surveys

The matched questions on the pre-survey and post-survey were analyzed to see if there was any significant increase in agreement with the statements on the post-survey. The most significant increases were in understanding the skills needed for a career in STEM, understanding what research in STEM means, and interest in research in STEM. There were also significant increases for awareness of the academic knowledge needed for a career in STEM and interest in a career in STEM. There was an increase, but it was not significant, for participants' confidence in their preparedness and interest in their field of study. While over 30% of the participants had an increase in confidence, nearly 20% had a decrease in confidence. Prior research conducted at CSUB has noted that students become more aware of what they don't know as a result of participating in research activities, which decreases feelings of preparedness on the post-survey [20]. Interest in their field of study was already high on the pre-survey, with 67% answering "Strongly Agree" (Table 4, Figure 7).

Table 4: Average and paired t-test p-value for the matched pre- and post-survey questions.

Matched Question	Pre Avg	Post Avg	P-Value
I am interested in research in STEM.	4.352	4.648	<0.0001
I understand what research in STEM means.	4.170	4.716	<0.0001
I understand what skills are required for a career in STEM.	4.318	4.659	0.0001
I am aware of the academic knowledge required for a career in STEM.	4.466	4.659	0.0235
I am confident that I am prepared for this program. (pre-survey) I was prepared for this program. (post-survey)	4.057	4.227	0.1041
I am interested in a career in STEM.	4.636	4.784	0.0271
I am interested in the field that I am studying.	4.591	4.670	0.2768

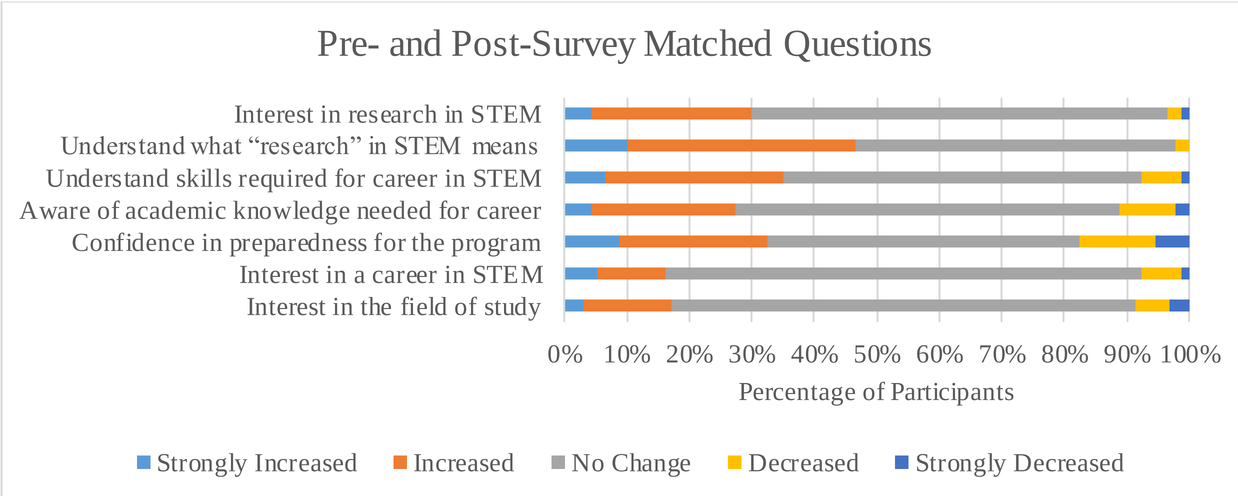

Figure 7: Change in participant responses for the matched pre- and post-survey questions.

The post-survey also contained questions that asked the participants to self-rate their change of interest in the field they are studying, research in STEM, and a career in STEM. For all of these questions, none of the participants indicated a decrease in interest. All participants indicated that their interest had increased or remained unchanged (Figure 8).

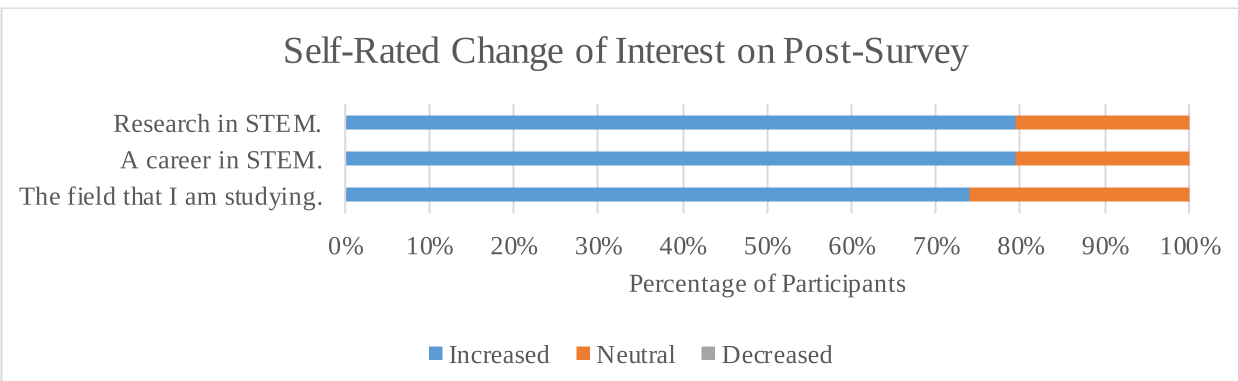

Figure 8: Participants self-rate change of interest on the post-survey.

Open-ended questions on the post-survey were also analyzed to determine trends in participant responses. On the question "What did you like about this activity?", the most prevalent response indicated that they enjoyed gaining new skills and knowledge, followed by working on real-world, hands-on projects and working with other students / teamwork (Figure 9). Selected participant comments include:

- It was a positive learning experience, and I gained new knowledge on a subject that was new to me. The career workshop at the end was very helpful.
- What I liked about this activity was that we had to apply an educational skill for the project we built, and also the support and advice of our mentor.

- I liked that I got to learn more mathematics that I otherwise would not have learned. I also liked seeing different ways that mathematics could be used in the real world.

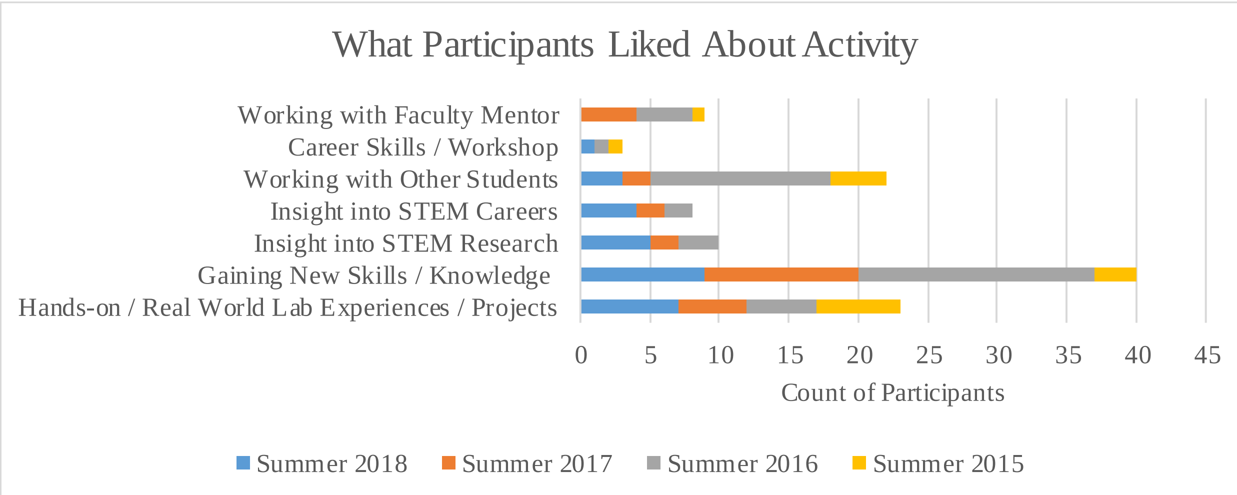

Figure 9: Responses to question asking what participants liked about the summer activity.

On the question "What specific knowledge and/or experiences did you gain from this activity?", the two most prevalent responses were about gaining general knowledge / learning general concepts and about learning specific tools, equipment, and skills needed for their major (Figure 10). Comments included:

- I learned how to work in a group to conduct research and analyze results on our own without the professor doing it for us.
- I learned that even though the project may seem simple, once you break it down it gets very complex and there is a lot of math involved.
- Working with a group, and learning some very cool math concepts not usually taught in the curriculum.

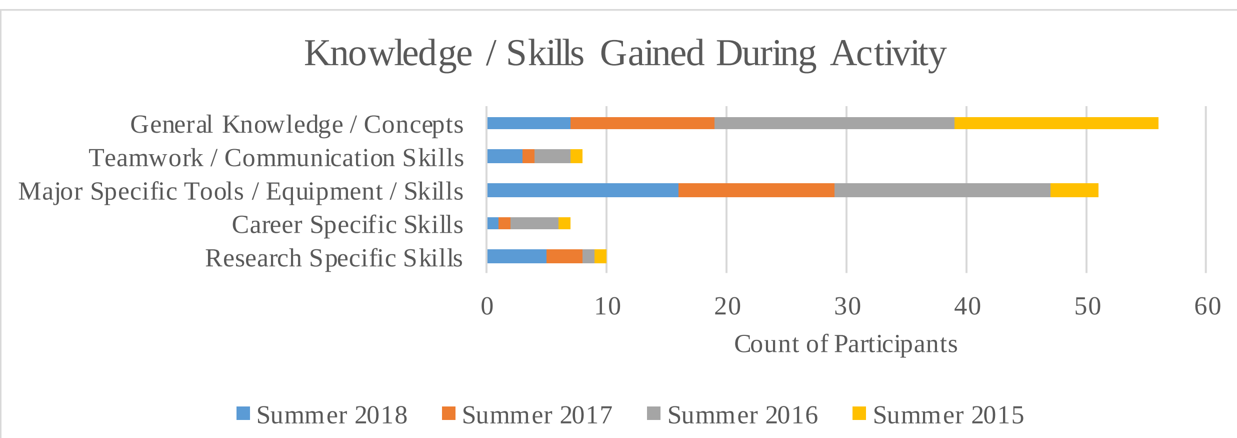

Figure 10: Specific knowledge and skills participants gained during the activity.

Students could also leave additional comments at the end of the post-survey. Most of these comments were positive feedback about the program and the faculty mentor. Comments include:

- I love this program, everyone does such a great job and I'm very appreciative that I was chosen to participate.
- Please continue to offer this excellent program to students! It allows us to get a taste of the field we're studying.
- I loved this program and I enjoyed the research that we conducted.
- Loved the program! Dr. [redacted] was a wonderful instructor and her passion for the field kept my interest in the group topic.
- Dr. [redacted] is extremely motivating.
- Great program, thank-you so much for the opportunity.

These results show that the short summer intervention does have an immediate positive effect on participants' attitudes towards STEM academics, research, and careers.

Interview Data

Several participants and upper-division teaching assistants (peer mentors) were interviewed by the internal and external evaluators during the program. Faculty mentors were interviewed either during the program or shortly after the program. The evaluators also gathered additional written reflection statements from some activities, where the faculty mentors opted to gather that feedback from the participants. A qualitative analysis of the interview data and reflection statements was performed by the grant personnel and by the internal and external evaluators using the triangulation method from [19].

Three themes emerged from this qualitative analysis of interview data. First, the program expanded the students' perspectives of their chosen career objective through fun and creative hands-on STEM projects, instead of the stress associated with graded coursework during the academic year. Second, the program allowed students to connect with faculty mentors and other students, which helped students be more comfortable asking questions and helped them to understand that struggling with topics is a normal part of STEM education. Faculty mentors also appreciated the opportunity to encourage the students to persist. Third, the program helped students develop their teamwork and communication skills, which are valuable tools for success. These themes mirror the themes that emerged in the post-survey open-ended comments.

Interview data in support of expanding the students' perspectives through fun projects:

- Student: It feels a little less like work, and more like fun. Because, everything that we are doing is more like what we are interested in--like programming and workshops, and things we can see being done.
- Student: Our perspective is different. In the Fall Semester, our focus is grades: passing our classes. We focus on facts. Here (in the summer workshop) we learn on a different perspective. Here we have hands-on with chemicals. In the regular academic-year classes we learn primarily from books. Here, the instructor takes the time to explain things. He takes everybody's questions, and he takes his time. When we are in a regular class it is more rushed and we make more mistakes.

- Students: With this one, there are a lot of different aspects. I code in different languages – and it is fun. It's like you are not even learning half the time. And for people that haven't even started circuit building, or do not have the degrees to know how to do circuit building, you have to learn it. It's not a whole lot of pressure. It's like, I want to do this. It doesn't feel like research. You want to do this. Exactly (by another student). Building upon what he said, he is absolutely right, I love programming, and these workshops give me a taste of what it is to build a breadboard. It is really interesting to see it. To answer your question, I think, in my opinion, when I exit this workshop, I got a hint of what it is to be in the field for which I study.
- Faculty: I think a major challenge for us (faculty members), in our courses, especially engineering courses, in my areas and my area is probably one of the toughest ones, electrical engineering, the challenges that we do a lot of theory, and as you said, it's grade space, they will be rated, they are under pressure, they have other courses. Sometimes you want to tell them that's there's more to this; there are lots of applications. Not all of it is rigorous theory that presents you. There are things, that, if you see, you're going to enjoy. To show them this application (this workshop) is a window to into that world. No pressure, its summer.
- Faculty: The biggest thing that they (students) are exposed to is the research aspect. A lot of them ask me "What happens next?" I say, I don't know! That's what we are here to find out. It may be that nothing happens. It may be that something really exciting happens. You never know until you actually get in and do the experiment. I am guiding you through this, but that doesn't mean that I have all the answers.

Interview data in support of forming connections with faculty mentors and other students:

- Student: It gives us more experience. We have more time with the professor. If we were in a regular bio-chemistry class, we would not have the time to do half of the things we do here. Today, we are here for five hours. We are able to interact with our peers. We can ask as many questions as we want. In the regular bio-chemistry class we are graded for everything, we are under stress. Here we have the time, we are stress free. We are able to learn everything and take our time doing it.
- Student: We show each other how to do it (project). It gives us more of a background to it. So, later on in the academic year, when we have to do something on our own, we are able to perform it more thoroughly. The background and the basics. This program focuses on this one thing. In the school (academic) year - smaller workshops. This one (IUSE activity) is the whole program – it is dedicated to the one task, objective.
- Faculty: I think they (students) are doing some kind of bonding. They have common ground. The other day I was talking with them, and (explaining that) I was first generation college student. Not all of them, just informally to some of them. And they were saying, "I am also – first-generation college student." Some of their parents only finished elementary, or high school, or something like that. They (students) say that they see somebody here "like me."
- Faculty: One of the nice things about this is that some of my students, and the teaching assistant, were in the same peer group. The teaching assistant was a peer mentor throughout the year, so they already know how to work together.

- Faculty: I am an advisor and I have more time to talk with the students, but unfortunately, I only have a few students to advise. This program gives me an opportunity to teach them what is really important: how to graduate, how to be successful. For example, how to think mathematically. That is really important. The students (in the IUSE Summer Program) can notice that. Also, I ask them to use every second, every minute, while you are walking from class to class, that you think about mathematics. Always thinking. Practice a lot. I tell them (students) that you have to think like a mathematician - practice like a basketball player. That is what I tell them to do before they come to the classroom, and after they leave.

Interview data in support of developing teamwork and communication skills:

- Student: It really helps, as a female, to be able to get together with other females - and males - to work in groups in what is otherwise a male dominated field. It is easier to ask questions, see role-models.
- Student reflection statement: What I will remember about this workshop is the workshop/experiment we did as a whole class rather than individual because it made it more fun.
- Teaching Assistant: As a student assistant, first of all, I would have liked to have had a program like this when I was learning about it (math and science). Fortunately, for our generation there is Google for a lot of things. There are a lot of questions that you can just look at it over and over again, and not realize what your mistakes are. And another set of eyes in that same category will help you get through the problem. For example, yesterday, we were trying to get the code to work on Raspberry Pie. It is meant for Arduino for the one we were working, but we are, collectively, getting it to work. We were there 90% of the way, but there was a 10% we were all stuck on, including myself, so it was nice to be able to have not only the students, interact and get stuck at that part, but us together collectively figure out what is going on.
- Faculty: I think that the fact that we put them (students) in this environment, and that they can work with their peers, and they discuss it, that helps a lot. As you mentioned, the other faculty members pointed that out. I agree with that. That's important. It's not, like, an assignment. It's not like you have to do that. I don't do it that way. On the first day, they came back to me and said, "Can we take these home to play with, to continue?" so that was it very positive. That already shows that they are so interested. I've never seen a student in class (academic year) come up and say, "Oh, can you assign me some more homework? I want to play." There is a fundamental difference.

Follow-up Survey Data

A follow-up survey was sent to participants in Spring 2019. Only 11 of the original 89 participants responded to the survey. Two (2) of those students had graduated and the remaining 9 were still students at CSUB. The most prevalent theme in the open-ended question about how they benefited from the program was that it gave them insight into STEM research and careers (4 of 11). Selected responses include:

- You get more knowledge about projects and how to work with others in a group.

- I was able to see some aspects of the Engineering sciences and although it was interesting it showed me that it wasn't for me. [Student switched to Electrical engineering]
- Good experience and got to know new friends and gave me an idea of what research is really about.
- Getting an idea of how research will be conducted in a lab setting.
- Allows you to practice your major career or other major careers and see how things work. It also teaches you how to research in STEM and what you need to get a STEM degree.

Conclusions

The summer intervention experience had a positive effect on at-risk students' attitudes, persistence, and success in STEM majors. Retention and graduation rates within STEM and in any major exceeded the comparison persistence rates at CSUB. Only 4.5% of the participants were dismissed from CSUB due to poor academic performance. 89.9% of the participants who have persisted in STEM have completed the appropriate pre-calculus or calculus mathematics sequence for their STEM major. The average GPAs of participants are statistically indistinguishable from the institutional average in Fall 2019, showing that the participants are at parity with the institutional academic performance.

Comparison of matched questions on the pre- and post-surveys show significant increases in understanding the skills needed for a career in STEM, understanding what research in STEM means, awareness of the academic knowledge needed for a career in STEM, interest in research in STEM, and interest in a career in STEM. Interview data also showed that the program had a positive impact on participants' attitudes, knowledge, and skills, and that the program helped students forge connections with one another and their faculty mentors.

Future Work

The summer program requires adequate funding to support the activities and to provide funding to participants and mentors. A sustainable funding source has not been secured for the summer program after the conclusion of the IUSE grant. However, a similar two-week intervention program for at-risk students during winter break has been authorized on another CSUB grant from the U.S. Department of Education. Comparisons of the data and outcomes from that activity to the data and outcomes from this summer activity will help determine if the winter break is a more effective intervention period than the summer, since it happens earlier in the students' academic career.

Acknowledgment

This paper is based upon work supported by the National Science Foundation under Grant No. 1430398. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] US Census Bureau, *Census Data for Kern County and Bakersfield, California,* 2010 census and 2019 estimates.

[2] California Assessment of Student Performance and Progress, *Kern High School District and California Mathematics Assessment*, 2014-15 through 2018-19.

[3] C. Lam, M. Danforth and R. Hughes, "Short-term Exploratory Summer Program for At-Risk First Year Students (work in progress)," in *American Society for Engineering Education Annual Conference*, New Orleans, LA, 2016.

[4] M. Danforth and C. Lam, "Work in Progress: Increasing Interest in STEM and Improving Retention for At-Risk Students - A Two-Year Study," in *American Society for Engineering Education Annual Conference*, Columbus, Ohio, 2017.

[5] C. Alvarado and Z. Dodds, "Women in CS: An Evaluation of Three Promising Practices," in *ACM Technical Symposium on Computer Science Education*, Milwaukee, WI, 2010.

[6] L. Fleming, K. Engerman and D. Williams, "Why Students Leave Engineering: The Unexpected Bond," in *American Society for Engineering Education Annual Conference*, Chicago, IL, 2006.

[7] S. Garcia-Otero and E. O. Sheybani, "Retaining Minority Students in Engineering: Undergraduate Research in Partnership with NASA," in *American Society for Engineering Education Annual Conference*, San Antonio, TX, 2012.

[8] M. J. Graham, J. Frederick, A. Byars-Winston, A.-B. Hunter and J. Handelsman, "Increasing Persistence of College Students in STEM," *Science,* vol. 341, no. 6153, pp. 1455-1456, 27 Sep 2013.

[9] K. Grindstaff and G. Richmond, "Learners' Perceptions of the Role of Peers in a Research Experience - Implication for the Apprenticeship Process, Scientific Inquiry, and Collaborative Work," *Journal of Research in Science Teaching,* vol. 45, no. 2, pp. 251-271, 2008.

[10] D. M. Hammond and M. M. Lalor, "Promoting STEM Careers Among Undergraduates Through Interdisciplinary Engineering Research," *Council on Undergraduate Research Quarterly,* vol. 30, no. 2, pp. 26-33, 2009.

[11] D. Lopatto, "Undergraduate research experiences support science career decisions and active learning," *CBE-Life Sciences Education,* vol. 6, no. 4, pp. 297-306, 2007.

[12] D. Lopatto, "Undergraduate Research as a High-Impact Student Experience," *Peer Review,* vol. 12, no. 2, 2010.

[13] National Academies of Science, "Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads," National Academies Press, Washington, D.C., 2010.

[14] C. Rasmussen and J. Ellis, "Who is Switching out of Calculus and Why?," in *Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education*, 2013.

[15] E. Seymour and N. Hewitt, Talking About Leaving: Why Undergraduates Leave the Sciences, Boulder, CO: Westview Press, 1996.

[16] L. Tsui, "Effective strategies to increase diversity in STEM fields: a review of the research literature," *The Journal of Negro Education,* pp. 555-581, 2007.

[17] M. Estrada, M. Burnett, A. G. Campbell, P. B. Campbell, W. F. Denetclaw, C. G. Gutierrez, S. Hurtado, G. H. John, J. Matsui, R. McGee, C. Moses Okpodu, T. J. Robinson, M. F. Summers, M. Werner-Washburne and M. Zavala, "Improving Underrepresented Minority Student Persistence in STEM," *CBE Life Sciences Education,* vol. 15, no. 3, p. es5, Fall 2016.

[18] B. Toven-Lindsey, M. Levis-Fitzgerald and P. Barber, "Increasing Persistence in Undergraduate Science Majors: A Model for Institutional Support of Underrepresented Students," *CBE Life Science Education,* vol. 14, no. 2, 2015.

[19] Y. Lincoln and E. Guba, Naturalistic Inquiry, Beverly Hills: Sage Publications, 1985.

[20] M. Danforth, C. Lam, R. Hughes and S. Salomon, "Enhancing Research Pipelines for Underserved Students through a Lower-Division Research Experience at a Minority-Serving Institution (Experience)," in *American Society for Engineering Education Annual Conference,* Tampa, FL, 2019.