



## SUPPORTING STEM IN HIGHER EDUCATION

Simeon Slovacek<sup>1+</sup>

Vivian Miu<sup>2</sup>

Karibian Soto<sup>3</sup>

Hengchun Ye<sup>4</sup>

<sup>1,2,3,4</sup> California State University, Los Angeles; 5151 State University Drive,  
Los Angeles, California, USA.

<sup>1</sup>Email: [sslovac@calstatela.edu](mailto:sslovac@calstatela.edu) Tel: (323)343-5622

<sup>2</sup>Email: [vmiu@calstatela.edu](mailto:vmiu@calstatela.edu) Tel: (323)343-5622

<sup>3</sup>Email: [ksoto23@calstatela.edu](mailto:ksoto23@calstatela.edu) Tel: (323)343-5622

<sup>4</sup>Email: [hye2@calstatela.edu](mailto:hye2@calstatela.edu) Tel: (323)343-2000



(+ Corresponding author)

### ABSTRACT

#### Article History

Received: 20 August 2019

Revised: 23 September 2019

Accepted: 25 October 2019

Published: 11 December 2019

#### Keywords

Undergraduate programs

Mathematics workshops

STEM

Underrepresented minorities

Student retention

Research.

Although there is much interest in pursuing a STEM career, many students choose not to or drop out prior to completing their STEM degrees for numerous reasons. In this research study, the focus is on supports that may increase overall STEM retention as well as underrepresented minority (URM) retention in STEM degrees consequently leading to a more robust and diverse pool of researchers and scientists within the US. The purpose of the current research was to assess the benefits of extra-curricular (outside traditional coursework) student workshops and other strategies provided by DIRECT-STEM, a university program emphasizing STEM-related career pursuits. Results indicate that program participation increased students' interest level in graduate school and a career in STEM. Student confidence in succeeding and completing their current degrees also increased and students developed a sense of community through exposure to research culture within the university. Differences between funded, partially-funded, and non-participant groups are noted.

**Contribution/Originality:** The study contributes to the existing literature by demonstrating how student research activities and workshop components beyond traditional academic courses can increase student interest in STEM-related graduate school programs and/or careers as well as increase student confidence levels in succeeding and completing their degrees.

## 1. INTRODUCTION

Although there has been growth in employment in the fields of Science, Technology, Engineering and Mathematics (STEM), in order for the US to remain competitive, the pool of qualified researchers and scientists must continue to be expanded and diversified to meet labor force demands. While there is much interest in pursuing a STEM career or job, many students do not pursue a STEM degree or they dropout prior to completing their STEM degrees.

In 2015-2016, only 18% of the bachelor degrees awarded were in STEM fields (National Center for Education Statistics, 2019). Furthermore, many students who enter college as STEM majors will inevitably transfer to a non-STEM major or dropout from college altogether (Chen and Soldner, 2013) thus demonstrating the need to increase student retention rates to foster more researchers and scientists.

Studies have investigated the cause of attrition in STEM students concluding that the causes are factors such as weak academic support, lack of encouragement from family and friends as well as scant advisement regarding

education and/or careers (College Atlas, 2018; McWhirter, 2019). Appropriate focus addressing these factors has the potential to relieve dropout rates.

Another contributing factor is the time and money needed to complete their degrees. In fact, a survey asking individuals why they chose not to pursue a STEM career revealed that the time and money required for education was the most cited reason (Funk and Parker, 2018).

In addition, research shows a disproportionate underrepresentation of ethnicities and race of those in STEM jobs. According to results from the 2014 – 2016 American Community Survey conducted by the Pew Research Center, employed adults in STEM jobs were 69% white, 13% Asian, 9% African American and 7% Hispanic (2018). Although termed “Underrepresented Minorities” (URMs), it has been predicted that by the year 2060 the “minority” population in the United States is expected to rise to 56% from 38% in 2014, with not one racial group above 50% (United States Census Bureau, 2015). To prepare for this, universities must do more to increase interest, college enrollment, retention, graduation with STEM degrees, and ultimately support more employment of underrepresented minorities (URM) within their careers.

One of the emerging disciplines within STEM is Data Science. With the immense amount of data available, companies are focused on hiring data scientists to analyze data that could be used as a competitive advantage. Many academic programs have been developed in response to this, but effective programs distinguish themselves by addressing the interdisciplinary nature of data science (West, 2018). They do so by incorporating statistics, computer science, engineering and other discipline sciences. Analyses in a multitude of fields have already led to breakthrough findings ranging from genomics to astronomy to physics (National Research Council, 2013).

In this research study, the investigators focused on supporting tactics that may increase overall STEM retention as well as URM retention in STEM degrees consequently leading to a more robust and diverse pool of researchers and scientists within the US. We focused on a Data Science Center located at California State University, Los Angeles (Cal State LA) to identify the key components that have led to student success within the university and its scientific community.

### *1.1. Program*

The Data Intensive Research and Education Center for Science, Technology, Engineering, and Mathematics (DIRECT-STEM) program housed at Cal State LA was funded by NASA in 2015 for five years. It was created to conduct advanced collaborative research with the Jet Propulsion Laboratory (JPL) in the areas of hydrology and climate change, computational physics, and cloud computing areas that directly contribute to NASA’s mission goals.

DIRECT-STEM’s overarching goal is to recruit and train highly competitive racially and ethnically diverse students, give them first-hand experience in data mining and modeling, and inspire them to become future leaders in STEM-related professions. Through the grant, students have opportunities to strengthen math skills, develop computational and modeling aptitude, conduct hands-on research through JPL internships, interact with faculty mentors at Cal State LA and UCI, and participate in multi-disciplinary seminars and research symposia with experts in NASA-related research. Faculty from three colleges at Cal State LA (College of Natural and Social Sciences (NSS), College of Engineering, Computer Science and Technology (ECST), and Charter College of Education (CCOE)) are supported by their Deans and administrators and are involved with DIRECT-STEM to ensure a multidisciplinary approach to program components.

## **2. CONTEXT**

There have been many efforts made to encourage diversity in the STEM fields for years, yet there still remains a deficit in underrepresented minorities. Based on government statistics there are obvious gaps between the proportion of certain racial/ethnic groups in the country and those in these fields. For instance, Hispanics aged 21 and older make up 15% of the total U.S. population, yet account for only 6% in science and engineering occupations

(National Science Board, 2018). In comparison, 67% of whites in these same fields are comparable to the 66% of whites in the total U.S. population (NSB, 2018). In California specifically, the gap is even more pronounced as Hispanics make up 39% of the population (USCB, 2018) but only 7% of the STEM workforce (Landivar, 2013). As the nationally ranked #1 institution for upward mobility (Ruble, 2018) Cal State LA has positioned itself as a leader in helping to bridge the gap between underrepresented minorities and the STEM fields.

A seminal article by Chickering and Ganson (1987) outlined the “Seven Principles for Good Practice in Undergraduate Education”, which continue to be referenced and hold merit after over thirty years of being published. The seven principles focus on various features that can improve undergraduate education based on research to guide educators in supporting their students (Chickering and Ganson, 1987).

This is particularly important when dealing with underprepared or underrepresented minority students who seek to pursue a career in STEM. The seven principles are: 1) encouraging contact between students and faculty; 2) developing reciprocity and cooperation among students; 3) encouraging active learning; 4) giving prompt feedback; 5) emphasizing time on task; 6) communicating high expectations; and lastly, 7) respecting diverse talents and ways of learning. Programs following these principles have resulted in positive outcomes for students including higher retention rates, higher grade point averages (GPAs), and higher graduation rates among many others (Congos, 2002). Presently, DIRECT-STEM encompasses components that incorporate all seven principles in some form. It follows that such a higher education program should yield positive outcomes for its participants – funded or not.

Students often require social support to help them ease into a scientific research community, as students must discover their identity as a scientist while learning the culture of science research (Richmond and Kurth, 1999). Much of modern research requires a collaborative team effort as opposed to independent work. Peers in the same research labs can provide comfort and empathy during hardships or frustrations relating to research work (Gardner *et al.*, 2015). In addition, the use of support groups emphasizing academic and social support is necessary to create an inclusive environment (Wilson *et al.*, 2018) as well as provide a sense of comradery in regards to academic support.

### 2.1. Similar Undergraduate Programs

A variety of programs have been developed over the years to encourage and support students who are interested in pursuing a career in the STEM fields. Although the structure varies from program to program, many programs like DIRECT-STEM incorporate student activities and workshop components to offer added support for students related to their fields. Programs such as these are important since research has shown that typical undergraduate student interest in science-related fields declines steadily throughout their time in college (Schultz *et al.*, 2011). Participation in these programs can help students develop their identity as a scientist (Hurtado *et al.*, 2009) in order to offset attrition rates.

One such program is the Mathematics Workshop Program developed with Uri Treisman at the University of California, Berkeley after identifying a difference in academic performance between African American and Chinese American students (Duncan and Dick, 2000). During the workshops, students were able to receive supplemental support in math and collaborate with peers to practice problem-solving strategies. These math workshops developed into a program to help African American and Latino students succeed in math courses while increasing their representation in math majors. Treisman’s model was so beneficial to students that it was adapted and implemented at many universities with a variety of disciplines (Duncan and Dick, 2000).

A study by Duncan and Dick (2000) analyzed one adaptation of Treisman’s model in-depth at Oregon State University where students were enrolled voluntarily in a separate one-unit course led by a graduate student and student assistant(s). Analysis of the program showed that workshop participants attained higher GPAs than non-participants; specifically over half a grade point (0.671) higher. Students completed an evaluation survey following their experience with the program. Results showed that more than 90% of participants perceived that they would

not have otherwise earned the grade they did and viewed cooperative peer groups as highly effective (Duncan and Dick, 2000). This is just one example of a seemingly effective program model, however, there are others that yield just as good if not better results with only a few tweaks in program structure.

The Mathematics, Engineering, and Science Achievement (MESA) program at Hartnell Community College in Salinas, CA provided facilities, activities, and support for underrepresented and disadvantaged students in these fields (Kane *et al.*, 2004). Similar to Cal State LA students who face financial hardships and must work to cover educational and living expenses, students at Hartnell College required support to overcome these obstacles inhibiting them from persisting and succeeding in their majors. A main component of the MESA program was the academic excellence workshops, which was noted to have a significant impact on student grades, specifically students averaged a full letter grade increase when compared to students who did not participate in the workshops (Kane *et al.*, 2004). Overall positive outcomes impacted not only students who participated in the program, but also the university itself by increasing retention through completion to 42% compared to a state baseline retention of 33%. In addition, about 90% of MESA participants successfully transferred to a four-year university and continued in STEM-related majors (Kane *et al.*, 2004). Clearly programs such as MESA are essential to student success.

At Cal State LA, the decades long Minority Opportunities in Research (MORE) programs have been implemented to address the issue of underrepresentation of minorities in STEM-related majors and subsequent careers using many of the same strategies. They do this by supporting underrepresented minority students in their pursuit of higher education through various externally (NIH) funded pathway programs such as the Bridges to the Future, Minority Access to Research Careers (MARC), and Minority Biomedical Research Support (MBRS) programs to name a few (Slovacek *et al.*, 2012). These programs provide students with academic support, research experience, targeted advisement, mentoring, and financial assistance to ensure their persistence and success in STEM-related fields. In addition, the programs offer workshops and seminars on a variety of STEM topics actually offered by more senior URM scientists to enhance students' knowledge and continued interest in their field. According to previous studies, the MORE programs have produced positive outcomes for students over time. These studies showed that program participants graduated at higher rates, were more likely to persist in science majors, and in one instance were seven times more likely to pursue graduate studies compared to students who did not participate in the program (Slovacek *et al.*, 2008; Slovacek *et al.*, 2012). These results further support the effectiveness of such university programs.

### 3. PURPOSE

The purpose of the current research was to assess the benefits of extra-curricular (outside traditional coursework) student workshops and other strategies provided by DIRECT-STEM, a university program emphasizing STEM-related career pursuits. Because minority students are greatly underrepresented in the STEM fields, this was also another challenge the program sought to combat. Existing research has examined various aspects of this issue including racial/ethnic identity and gender differences, yet the issue still persists, thus there continues to be a need for further research.

In the present study, various aspects of the DIRECT-STEM program were explored to gauge their impact on student outcomes. The program allows the participation of both fully-funded and partially-funded students in countless program components that encourage students to persist in STEM-related majors. The main goal of this research was to answer the research questions that follow.

#### 3.1. Research Questions

1. Did students' interest level in graduate school and careers in STEM change as a result of enhanced academic support?

2. Did partially-funded comparison student interest in working with NASA centers change after attending STEM-related workshops?
3. Were funded research students' GPAs affected by workshop participation?
4. Were partially-funded comparison student GPAs affected by workshop participation?
5. Did partially-funded comparison student confidence levels in succeeding and completing their current degrees change?
6. Did program-related activities such as workshops and research opportunities create an inclusive scientific community for students or sense of belonging?
7. Did DIRECT-STEM workshop enrollment increase over the years of this program grant?

## 4. METHODS

### 4.1. Participants

Participants for this study included the NASA DIRECT-STEM funded research students and the partially-funded comparison students. Both groups consisted of students who were pursuing a bachelor's degree or a master's in STEM majors focusing on data science such as engineering, geography/geology, physics etc. Funded research students were committed to a research lab overseen by a DIRECT-STEM faculty mentor, multi-disciplinary seminars and mathematics and coding/programming workshops. Funded research students also received advisement from the DIRECT-STEM program director and a faculty mentor as well as stipends.

Undergraduate research students received a stipend up to \$2000 during their first year and \$4000 for the subsequent year. If selected for an internship at NASA's Jet Propulsion Laboratory (JPL) they would receive an additional \$6000. Graduate research students can receive a stipend of up to \$8000 during their first year with the program and up to \$12,000 for the subsequent year. If selected for the JPL summer internship, graduate research students would receive an additional \$8000.

Comparison students were committed to attending the mathematics and coding/programming workshops and were also invited to attend multi-disciplinary seminars from the program. As funding was limited, the comparison students could not be included in the program as funded research students although they were still invited to participate in the mathematics and coding workshops. The comparison students could receive a stipend ranging from \$225 to \$300 per semester depending on the number of workshops they attended (approximately \$75 per workshop attended). The comparison students were used in this research study as they are similar in content interests, academic level, GPA as well as declared major(s) with the funded research students.

### 4.2. Data Collection and Analysis

Program files, institutional records and student applications to the program were used to collect student demographics, academic background, declared major(s) and student GPAs for each semester. In addition, quantitative and qualitative data for this study data was gathered by monitoring the implementation of the project's activities. This included: pre- and post-survey questionnaires, observations, focus groups and interviews.

Questions such as "*Was the workshop level too basic or too advanced for you?*", "*Please rate your overall impression of today's workshop*" and "*Please rate the helpfulness/usefulness of the following sections of the workshop*", were used to understand student's perception of the overall workshops as well as the different components of the program workshops and seminars. Funded and partially-funded student post-graduation plans were gathered using the National Student Clearinghouse database and online research. Data collected were analyzed by combining results of cohorts beginning with the 2015-16 school year and ending with the 2018-19 school year. Qualitative data was coded for general themes in the participant responses to open-ended questions.

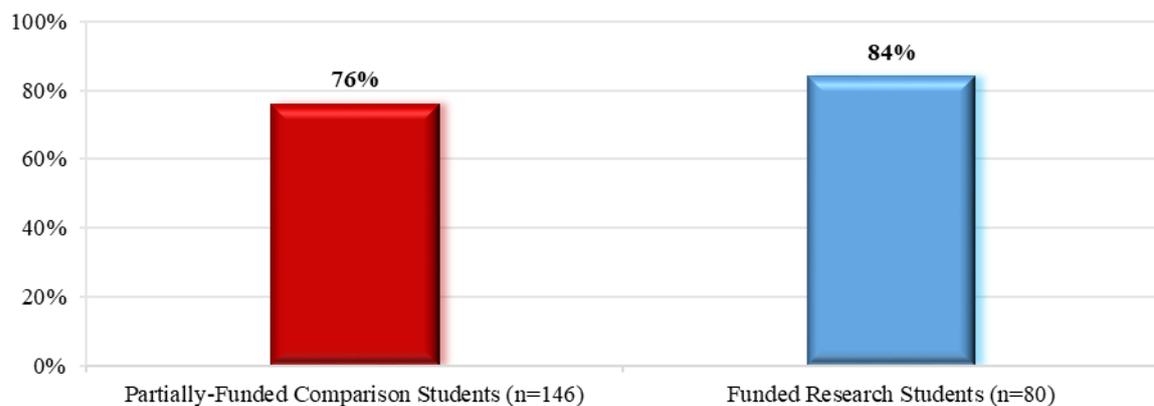
## 5. FINDINGS

### 5.1. Did Students' Interest Level in Pursuing Graduate School and Careers in STEM Change as a Result of the Enhanced Academic Support?

Prior to acceptance into NASA DIRECT-STEM, funded research students must be committed to completing program activities such as research lab hours, multidisciplinary seminars, mathematics and coding/programming workshops and receiving advisement to qualify for stipends. Comparison students did not receive stipends or advisement but were invited to attend the mathematics and coding/programming workshops as well as the multidisciplinary seminars. Both groups consisted of students who were either pursuing a bachelor's degree or a master's degree in STEM Data Science.

At the end of each academic year, a year-end student survey was administered to the funded research students where they were asked for their highest educational goal. Similarly, the comparison students were asked regarding their interest in pursuing a Master's or a PhD degree during the last session of the mathematics and coding/programming workshops. As shown in Figure 1, 84% of the funded research students stated that they were planning to continue their studies and obtain a Master's or a PhD, whereas 76% of the comparison students stated that they were "very interested" in graduate school (Master's or PhD).

The difference between both groups was statistically significant ( $t = -1.415$ ,  $n = 226$ ,  $sig = .005$ ) as the results may have been due to self-selection into the program or participation in the workshops and other activities. Both groups were pursuing STEM degrees with the expectation that graduate school may help their chances of securing a career in STEM. One might argue that the support from the mathematics and coding/programming workshop had boosted interest in graduate school for both groups. However, further investigation needs to be conducted regarding their interest before attending and participating in the workshops and after to assess change or growth. Regardless, based on a weighted average these results, the researchers concluded that about 78% of students planned to continue on to graduate school after they had participated in the program whether or not they received funding.



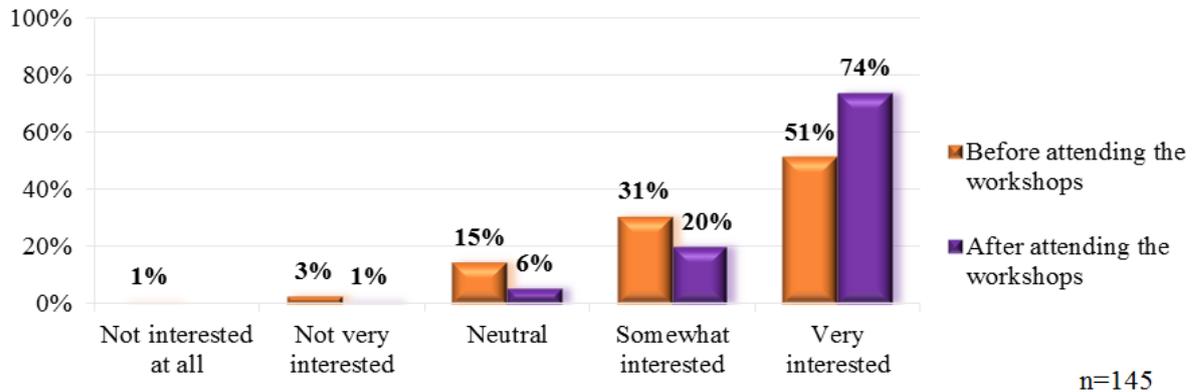
**Figure-1.** Percentage of students (cohorts 2015-16, 2016-17, 2017-18, 2018-19) planning to go on to graduate school.  
 Source: Program evaluation and research collaborative (PERC) at California State University, Los Angeles.

### 5.2. Did Partially-Funded Comparison Student Interest in Working with NASA Centers Change after Attending STEM-Related Workshops?

As DIRECT-STEM is a NASA funded program, the partially-funded students' interest in working at one of the NASA centers was measured pre- and post-program activities. Figure 2 shows the combined results from three previous cohorts (2016-17, 2017-18 and 2018-19).

While only approximately half of the students (51%) stated that they were "very interested" in working at one of the NASA centers prior to attending the workshops, student interest increased to 74% after attending the program

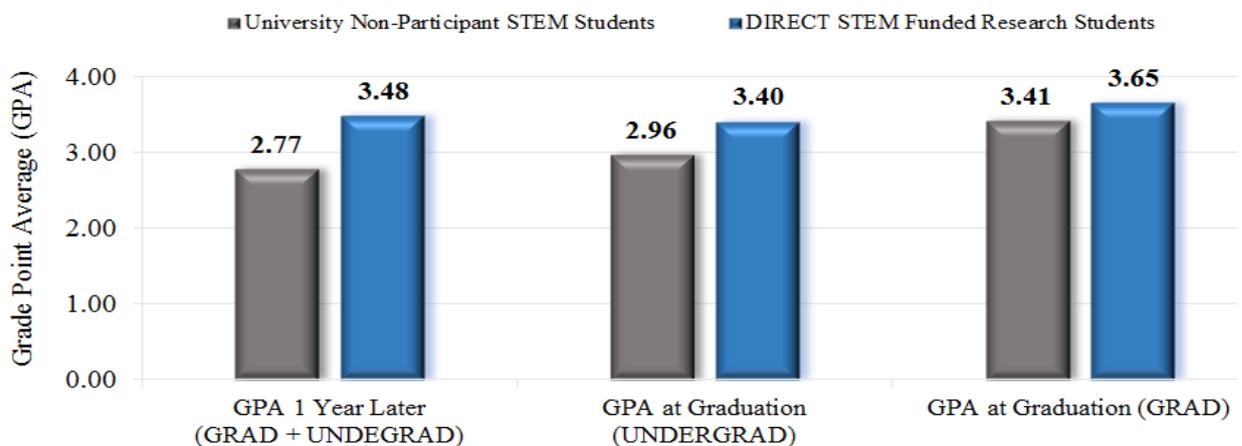
workshops and paid internships at a NASA center. After performing a paired samples t-test, we concluded that the results were significant ( $t=6.026$ ,  $n=144$ ,  $\text{sig } p=.000$ ). This provided strong evidence to affirmatively support the research question above. Student interest in working at one of the NASA centers may have increased due to more exposure to research and scientists as well as doing hands-on research in labs. There are many factors contributing to this, but one of the reasons this may be the case is due to students being able to visualize themselves in a scientific career other than through textbooks.



**Figure-2.** Partially-funded students' (cohorts 2016-17, 2017-18, 2018-19) interest level of working at one of the NASA centers. Source: Program evaluation and research collaborative (PERC) at California State University, Los Angeles.

**5.3. Were Funded Research Students' GPAs Affected by Workshop Participation?**

To identify program success, we looked at student grade point averages after they had participated in the program. Figure 3 and Figure 4 below illustrate student grade point averages at two different intervals: 1) GPA one-year after program entry and completion and 2) GPA upon graduation for both undergraduates and graduates. A comparison between the STEM, non-participant group and the DIRECT-STEM funded research students' grade point average was made, one year after program participation and GPA at graduation. Although the GPAs of DIRECT-STEM funded research students was impressive throughout their academic career, we were unable to see a significant increase in GPA for the undergraduate students. One could however, argue that the GPAs were calculated throughout their 4+ years of education, not one semester or one year. The GPAs at graduation were still an impressive feat given the difficult and challenging courses STEM students are required to take to obtain their degree.



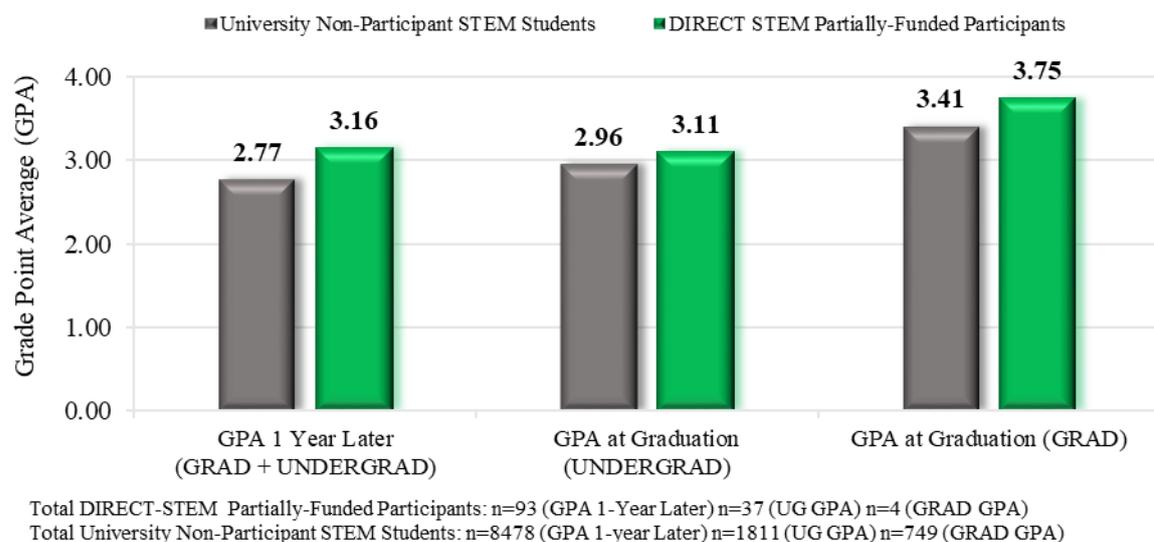
Total DIRECT-STEM Funded Research Students: n=48 (GPA 1-Year Later) n=22 (UG GPA) n=26 (GRAD GPA)  
 Total University Non-Participant STEM Students: n=8478 (GPA 1-year Later) n=1811 (UG GPA) n=749 (GRAD GPA)

**Figure-3.** Funded research students (Cohorts 2015-16, 2016-17, 2017-18) GPA compared to university non-participant GPA a year after starting the program and at graduation.

Source: Office of institutional effectiveness at California State University, Los Angeles.

#### 5.4. Were Partially-Funded Comparison Students' GPA Affected by Workshop Participation?

Figure 4 compares the pre-trainee grade point average after their participation in the program with the non-participants. As you can see, GPA was sustained throughout their degree until graduation. However, when compared to the STEM non-Pre-Trainee group, there was not much of a difference in the increase of GPA. This was attributed to the fact that the mathematics and coding/programming workshops (also known as the Pre-Trainee Mathematics Workshops) were offered twice a month for six hours, which roughly equates to one college course. Therefore, one can argue that narrowly focusing on short-term GPA may not show the entire picture of the impact of these workshops and program activities. As mentioned previously, one might also look at qualitative data to observe the effects on student interest, and perseverance within their degree as well as the student's identity within the scientific community.



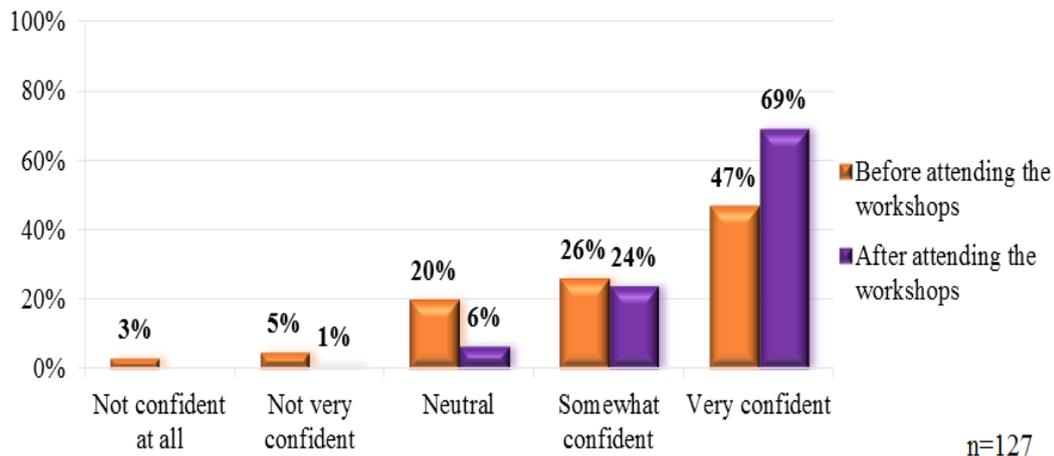
**Figure-4.** Partially-funded participants (Cohorts 2015-'6, 2016-17, 2017-18) GPA compared to university non-participant GPA a year after starting the program and at graduation.

Source: Office of institutional effectiveness at California State University, Los Angeles.

#### 5.5. Will Partially-Funded Comparison Students' Confidence Levels in Succeeding and Completing their Current Degrees Change?

An objective of providing student assistance and support for students in STEM-related majors was to bolster student confidence in their relative fields. Many students who attend Cal State LA come from underserved communities and under-resourced high schools that leave students unprepared for university study. In addition, the transition to university itself is challenging. The DIRECT-STEM program hoped to boost student confidence and prevent students from changing majors or dropping out.

Students were asked to describe how confident they felt about succeeding and completing their degree before and after attending workshops. Prior to attending program workshops, student responses ranged from "not confident at all" to "very confident" as can be seen in Figure 5. The combined responses of three cohorts revealed an increase in confidence levels. Before attending the workshop only 47% of students indicated that they were "very confident" that they could succeed and complete their current degree. Following the end of the workshops a survey was administered. The original percentage saw a 22-point increase to 69%. We performed a t-test and we concluded that the results showed significance ( $t=6.894$ ,  $n=126$ ,  $\text{sig } p=.000$ ). These results indicated that the workshops directly affected students' self-efficacy and did in fact increase students' confidence levels. This could be useful information for other programs as workshops are inexpensive ways to impact student outcomes. One reason for the low cost was that these workshops were non-credit bearing. Therefore, they did not have a tuition or credit unit fee attached.



**Figure-5.** Partially-funded student (combined cohorts 2016-17, 2017-18, 2018-19) confidence level in succeeding and completing their degree before and after attending program workshops.

Source: Program evaluation and research collaborative (PERC) at California State University, Los Angeles.

### 5.6. Did Program-Related Activities Such as Workshops and Research Opportunities Create an Inclusive Scientific Community for Students or Sense of Belonging?

Although there has been a push to increase the performance of research at California's state universities, the faculty (and research labs available) to student ratio simply does not allow most students to participate in research laboratories during their undergraduate career. Because of this, placing students in research labs is an essential part of the funded DIRECT-STEM program.

These students make up the research student group, who work in a lab setting up to 25 hours a week either at Cal State LA or UCI. In previous surveys, research students stated that one of their expectations about the DIRECT-STEM program was to "build connections", referring to networking with peers and faculty. This expectation was realized as research students stated throughout the year that their best-liked aspects were research opportunities and networking in the science community. Both aspects remained in the top four most cited student responses every year in the year-end student survey.

One student stated, "I greatly valued the opportunities to talk with other students with similar interest and goals, who I would not have encountered otherwise." This student's response speaks about the ability to interact with students from various majors since DIRECT-STEM incorporated a multidisciplinary perspective by including faculty and students from different fields. The chance to interact with not only their own cohort, but other cohorts as well from different fields through workshops and program events, was planned deliberately so that students would gain confidence in themselves by being exposed to knowledge of their own field and other fields as well. One student commented, "I liked the access to researchers and the sense of community with fellow cohort members." These sentiments were felt across all cohorts as evidenced by the students' comments on community described every year.

Students who were partially-funded also wrote similar comments in the surveys after various program events. Since the inception of the program, at least one student each year has expressed that their best-liked aspect was having the opportunity to work with others or meet new people. After the first few workshops held by DIRECT-STEM, multiple students said they enjoyed "working in groups to solve difficult problems", "enjoyed the group activities", and "group presentations". These comments have appeared every year since the program began hosting workshops.

Students not only enjoyed interacting with other students, but also conveyed an appreciation for the faculty involved. One student early on in the project stated, "I also liked that the professors asked for feedback and were very welcoming." Other comments about professors included "excellent teachers", "the [teacher assistants] and

professors were all extremely friendly and helpful”, and “presenters were funny, engaging, very approachable”. Students’ remarks about faculty and peers speaks to the type of environment the program fostered.

### 5.7. Did DIRECT-STEM Workshop Enrollment Increase Over the Years of this Program Grant?

Partially-funded students were allowed to participate in certain program activities, such as the bi-monthly math workshops. However, their participation was not mandatory and so students who participated were self-selected. A final hypothesis of this research study was that enrollment of the DIRECT-STEM workshops would increase over the years if the students found them helpful. Based on program records, workshop attendance increased each year. As depicted in Figure 6, attendance was relatively consistent the first two years. However, during the third and fourth years there were significant spikes in attendance. Over the course of four years, attendance increased from 31 to 78, which was a 40% increase overall. These results speak highly of the program as students who participated did so for sheer academic benefit. In addition, the increased participation of these students further confirmed that the program workshops are valuable components of the program.



Figure-6. Partially-funded student enrollment in fall workshops over time.

Source: Program evaluation and research collaborative (PERC) at California State University, Los Angeles.

## 6. DISCUSSION

This study provided evidence for several of the research questions. The NASA DIRECT-STEM participating students’ interest in pursuing STEM careers through further study in graduate school increased regardless of the funding level. Student interest in working with NASA centers in the future also increased after participation in the program. Students felt their confidence levels in succeeding and completing their current degree programs had increased as well.

As word got around the student STEM major community about the success of DIRECT-STEM, more students enrolled in the Saturday day-long (non-credit bearing) workshops related to STEM courses over the first four years of the study of this five-year grant program. Although Cal State LA is a moderately large university with over 28,000 students and a graduation rate of under 50%, there was evidence through interviewing participating students that a research culture within the university had emerged. It created an inclusive sense of a scientific community, in other words, a sense of belonging – something often missing in a large university where many students’ only connection is their coursework. We can say that the impact of the funding for the DIRECT-STEM program will extend beyond the funding period especially since the partially-funded student participant outcomes were comparable to the fully funded students which shows that low cost research and academic support can improve STEM metrics. This grant program has introduced the idea of research amongst many students who did not previously know of such opportunities at Cal State LA.

The research team did not find an improvement in participating students' GPAs unlike previous research studies cited in this work (Duncan and Dick, 2000; Congos, 2002). The absence can be explained by the inadequate assessment used by this research team which lacked power to detect changes the program may have effected. Instead of using cumulative GPAs for study which are based on three to five years of coursework including non-STEM coursework, it would have been preferable to examine STEM course grades earned during the period of student participation (typically one to two years) in the program. Examining cumulative GPAs diluted the finding with irrelevant coursework and coursework conducted at times different to the time frame of the program. This limitation will be addressed in the future by the research team.

Another area for improving the assessment of potential outcomes would be developing and using more quantitative measures of a 'sense of belonging' to a scientific community. Again, the research team plans this expansion for future efforts. Perhaps the limitation of focusing on a funded program at a single university could be addressed by future research efforts focusing on similar programs at multiple institutions of higher education.

The importance of pursuing these lines of investigation is two-fold. The first is that this research provides evidence for a lower cost partially-funded option to improve STEM outcomes. The second is that the growth in STEM degree preparation is not keeping up with the changing or increasing growth of underrepresented minorities (races and ethnicities) in the demographic in the United States. This study provides some direction for other institutions of higher education to address this inequity.

**Funding:** This study received no specific financial support.

**Competing Interests:** The authors declare that they have no competing interests.

**Acknowledgement:** All authors contributed equally to the conception and design of the study.

## REFERENCES

- Chen, X. and M. Soldner, 2013. STEM attrition: College students' paths into and out of STEM fields, 2013. Retrieved from the U.S. Department of Education, National Center for Education Statistics. Available from <https://nces.ed.gov/pubs2014/2014001rev.pdf>.
- Chickering, A.W. and Z.F. Ganson, 1987. Seven principles for good practice in undergraduate education. *American Association of Higher Education Bulletin*, 39(7): 3-7.
- College Atlas, 2018. US college dropout rate and dropout statistics. Available from <https://www.collegeatlas.org/college-dropout.html>.
- Congos, D.H., 2002. How supplemental instruction stacks up against Arthur Chickering's 7 principles for good practice in undergraduate education. *Research and Teaching in Developmental Education*, 19(1): 75-83.
- Duncan, H. and T. Dick, 2000. Collaborative workshops and student academic performance in introductory college mathematics courses: A study of a Treisman model math excel program. *School Science and Mathematics*, 100(7): 365-373. Available at: <https://doi.org/10.1111/j.1949-8594.2000.tb18178.x>.
- Funk, C. and K. Parker, 2018. Women and men in STEM often at odds over workplace equity. Washington, DC, US: Pew Research Center.
- Gardner, G.E., J.H. Forrester, P.S. Jeffrey, M. Ferzli and D. Shea, 2015. Authentic science research opportunities: How do undergraduate students begin integration into a science community of practice? *Journal of College Science Teaching*, 44(4): 61-65. Available at: [https://doi.org/10.2505/4/jcst15\\_044\\_04\\_61](https://doi.org/10.2505/4/jcst15_044_04_61).
- Hurtado, S., N.L. Cabrera, M.H. Lin, L. Arellano and L.L. Espinosa, 2009. Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education*, 50(2): 189-214. Available at: <https://doi.org/10.1007/s11162-008-9114-7>.
- Kane, M.A., C. Beals, E.J. Valeau and M. Johnson, 2004. Fostering success among traditionally underrepresented student groups: Hartnell College's approach to implementation of the math, engineering, and science achievement (MESA)

- program. Community College Journal of Research and Practice, 28(1): 17-26. Available at: <https://doi.org/10.1080/10668920490251944>.
- Landivar, L.C., 2013. Disparities in STEM employment by sex, race, and Hispanic origin. Education Review, 29(6): 911-922.
- McWhirter, K., 2019. How to prevent students from dropping out. Available from <https://www.accreditedschoolsonline.org/resources/preventing-students-dropping-out/>.
- National Center for Education Statistics, 2019. Status and trends in the education of racial and ethnic groups. Available from [https://nces.ed.gov/programs/raceindicators/indicator\\_REG.asp](https://nces.ed.gov/programs/raceindicators/indicator_REG.asp).
- National Research Council, 2013. Frontiers in massive data analysis. Washington, DC: The National Academies Press.
- National Science Board, 2018. Science & engineering indicators 2018. National Science Foundation [data file]. Available from <https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-engineering-labor-force/women-and-minorities-in-the-s-e-workforce#minorities-in-the-s-e-workforce>.
- Richmond, G. and L.A. Kurth, 1999. Moving from outside to inside: High school students' use of apprenticeships as vehicles for entering the culture and practice of science. Journal of Research in Science Teaching, 36(6): 677-697.
- Ruble, A., 2018. CSU campuses among the best in the nation for upward mobility. The CSU System News. Available from <https://www2.calstate.edu/csu-system/news/Pages/CSU-Campuses-Among-the-Best-in-the-Nation-for-Upward-Mobility.aspx>.
- Schultz, P.W., P.R. Hernandez, A. Woodcock, M. Estrada, R.C. Chance, M. Aguilar and R.T. Serpe, 2011. Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. Educational Evaluation and Policy Analysis, 33(1): 95-114. Available at: <https://doi.org/10.3102/0162373710392371>.
- Slovacek, S., S. Tucker and J. Whittinghill, 2008. Modeling minority opportunity programs: Key interventions and success indicators. Journal of Education and Human Development, 2(1): 1-14.
- Slovacek, S., J. Whittinghill, L. Flenoury and D. Wiseman, 2012. Promoting minority success in the sciences: The minority opportunities in research programs at CSULA. Journal of Research in Science Teaching, 49(2): 199-217. Available at: <https://doi.org/10.1002/tea.20451>.
- United States Census Bureau, 2015. New census bureau report analyzes U.S. population projections. Available from <https://www.census.gov/newsroom/press-releases/2015/cb15-tps16.html>.
- USCB, 2018. California quick facts. Available from <https://www.census.gov/quickfacts/fact/table/CA/PST045218>.
- West, J., 2018. Teaching data science: An objective approach to curriculum validation. Computer Science Education, 28(2): 136-157. Available at: <https://doi.org/10.1080/08993408.2018.1486120>.
- Wilson, M., A. DePass and A. Bean, 2018. Institutional interventions that remove barriers to recruit and retain diverse biomedical PhD students. Life Sciences Education, 17(2): ar27-ar27. Available at: <https://doi.org/10.1187/cbe.17-09-0210>.

*Views and opinions expressed in this article are the views and opinions of the author(s), International Journal of Education and Practice shall not be responsible or answerable for any loss, damage or liability etc. caused in relation to/arising out of the use of the content.*