Effective Strategies for Engaging Community College Students in Research via Cutting-Edge Technology

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ABSTRACT
As we train the next generation of Science, Technology, Engineering, and Math (STEM) researchers, it is imperative that we expand our recruitment to community college students. Many of these students are highly motivated and extremely talented, but they often lack exposure to cutting-edge technology found at R1 institutions, much less have the opportunities to participate in original research. The Center for Dark Energy Biosphere Investigations (C-DEBI) at the University of Southern California (USC) started a community college research internship summer program in 2013. The nonresidential and residential programs combined so far have trained 60 students in the biogeosciences, with 46 of them having transferred to 4-year institutions and 95% remaining in STEM fields. Their introduction to and acquired competence in several advanced technologies have further prepared these students to pursue graduate degrees and rewarding careers in research-based STEM fields. Keywords: community college, research, undergraduate

Introduction
Many cutting-edge instruments currently used in the marine sciences are not typically found in a community college laboratory, including liquid and gas chromatographs, electron microscopes, anaerobic cultivation chambers, and bioinformatics software packages. However, students participating in the Community College Cultivation Cohort (C4) at the University of Southern California (USC) are not only exposed to these instruments and resources, but also they become well-trained practitioners in 9 summer weeks. Community college students from across the country work in small groups; are mentored by more senior students, postdoctoral scholars, and faculty; and apply these and other laboratory techniques to fully characterize a recently isolated but yet to-be-described microorganism from marine sediments and subseafloor fluids.

C4 is a National Science Foundation (NSF)–funded Research Experience for Undergraduates (REU) developed by members of the Center for Dark Energy Biosphere Investigations (C-DEBI) staff. Its primary goals are to engage community college students in research science and subsequently to retain them in Science, Technology, Engineering, and Math (STEM) fields. Of all undergraduate students in the United States, 41% attend a community college, and the demographics of community college students not only reflect the diversity in our society but also shows an over-representation of underrepresented minority students. Note that 52% of Hispanic students, 43% of African American students, 56% of Native American students, and 40% Asian-Pacific Islander students currently attend a community college, with 36% of community college students being the first in their family to attend college (American Association of Community Colleges [AACC], 2016; National Center for Educational Statistics [NCES], 2017a, 2017b). This contrasts with only 25% of students at 4-year universities being first-generation college students (NCES, 2017a).

Program History
Based on an informal needs assessment conducted with community college instructors, C-DEBI identified a critical component for STEM-interested community college students to successfully transfer to a 4-year institution—research opportunities using state-of-the-art technologies. Such opportunities are often very limited or nonexistent at 2-year institutions. However, it is these experiences that often motivate students to pursue a career in STEM (Hunter et al., 2007; Pender et al., 2010; Stanford et al., 2017; Strawn & Livelybrooks, 2012; Thiry et al., 2011). The precursor to C4 began in 2013 at USC as
the Community College Research Internship for Scientific Engagement (CC-RISE), a nonresidential program targeting community college students in the Los Angeles area. We expanded CC-RISE to the University of California, Santa Cruz (UCSC) in 2014 and then to the Marine Biological Laboratory (MBL) in Woods Hole, MA, in 2015 (the program at MBL moved to the Woods Hole Oceanographic Institution [WHOI] in 2017).

It is well documented that community college students frequently experience transfer shock when they transition to 4-year institutions (Hills, 1965; D’Amico et al., 2014; Ivins et al., 2017). Not only must these students adapt to enhanced academic rigor, but also they must learn the cultural norms of their new institution. CC-RISE students carried out original research in their host laboratories, but they were also immersed in the research culture and participated in weekly professional development activities. To help counter or at least moderate transfer shock, we developed a seminar series, bringing in experts to discuss key steps in this transition and graduate students who began their academic career at community colleges to relate their personal pathways to success (see Figure 1 for a listing of topics). One component we have added to the REU is a community college liaison. This is a faculty member from one of the Los Angeles–based community colleges who meets with the students regularly throughout the program and is well versed on ways to minimize transfer shock and succeed in STEM at a 4-year institution.

In 2015, C-DEBI converted the USC-based CC-RISE program into the residential C4 program and began recruiting community college students at a national level. We modified the traditional undergraduate research experience where students work independently in individual laboratories into one where small groups of student researchers work on a range of tasks on the same research project—to characterize the morphology, physiology, and phylogeny of a novel marine subsurface microorganism. We found this approach to be highly beneficial as it creates a real-world setting in which the student researchers learn to work in teams and collaborate, in addition to the near-peer mentoring aspect, which we have found to be an innovative way to ease a student’s apprehension about conducting research for the first time. Students with limited or different but complementary research experiences learn from each other in a team of near-peer collaborators. Toward the end of the program, students have the option to conduct their own research by comparing the physiological function of other related species. At the end of the program, students report their findings via a poster session and a seminar symposium, with each student individually presenting a poster and a talk.

Based on student feedback from CC-RISE and C4 participants early in the program, we increased the number of professional development seminars (see Figure 1). We also added a bioinformatics component to complement the laboratory work; students were instructed on how to (1) use a state-of-the-art bioinformatic tools.
tool suite (Geneious), (2) interface with the National Center for Biotechnology Information (NCBI) Web portal, and (3) analyze and perform comparative genomic research using the Rapid Annotation using Subsystem Technology (RAST) online service. The bioinformatics module allows the students to see how the characteristics of one microbe relate to those of the community of organisms and the geochemical host environments. To date, C4 has trained 16 students from across the country from engineering to microbiology in the highly valued skill of bioinformatics.

Program Goals

The specific C4 objectives are to (1) provide a significant, integrated STEM research opportunity to research-limited, community college students from underserved and diverse socioeconomic, ethnic, and geographic backgrounds; (2) train community college students in advanced laboratory techniques; teach them to report, interpret, and present new data; and guide them to develop testable hypotheses around research questions; and (3) provide professional development resources to inform students about STEM opportunities at 4-year universities, graduate school research, and career pathways. Long term, we facilitate the transition to 4-year institutions and provide guidance, advice, and professional contacts after the C4 program ends. Students are encouraged throughout the program to talk to their mentors about their long-term goals. In addition, students are emailed periodically to check on how they are doing and if they have any questions about research, universities, internships, and so forth. Ultimately, we strive to attract and retain students in STEM majors, have them earn a degree in an STEM major, and continue on to graduate school and/or STEM careers.

Our ideal candidate is currently enrolled in a community college, planning on transferring to a 4-year institution within 2 years, and majoring in an STEM discipline. As we are funded by NSF, a federal agency, participants must be U.S. citizens or permanent residents. Applicants are required to have completed four semester-long STEM courses and have a minimum of 3.25 overall GPA. That said, we take a holistic approach to selecting candidates, look for a student’s potential and enthusiasm for embarking on research, and note if a student’s GPA increased once they started taking STEM classes. As part of the personal essay component, students are encouraged to explain any extenuating circumstances that contributed to a lower GPA or challenges they have overcome in their life.

While we are training the next generation of STEM researchers, we ensure that a scaffolding mechanism is in place where former C4 students have continued access to research opportunities. This is accomplished by tracking students, communicating frequently with them, and linking them with C-DEBI researchers in their area. We also offer funding opportunities that provide stipends for students to work in laboratories post program. C-DEBI funds a research exchange that initially was targeted at our graduate students and postdoctoral researchers, but we have since expanded it to include community college students who have participated in C-DEBI programs.

Program Accomplishments

As noted above, we track all of our students. Of 60 participants (2013–2017), 46 students have transferred to 4-year institutions (see Figure 2), eight have graduated from 4-year institutions, and two students are currently in graduate school studying microbiology and geobiology; 95% of all CC-RISE/C4 alumni remain in STEM. In addition, we strive to recruit diverse cohorts. Through 2017, more than half of the CC-RISE/C4 alumni are Hispanic/Latino, Asian, African American, or multi-racial (see Figure 3), and 56% and 50% identify as “low income” and “first generation,” respectively. The C4 program has provided several students the opportunity to present their research at national conferences. Three students from the 2016 cohort attended the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) or Association for the Sciences of Limnology and Oceanography (ASLO) meetings, and four students from this year’s class have been invited to these meetings. A few of these students were also chosen to participate in the ASLO Multicultural Program, receiving extensive mentoring and training in cohort building.

In addition to the laboratory skills gained, all 16 C4 students received training in the application of bioinformatics. All are now proficient in generating and interpreting a phylogenetic tree, a skill crucial for continuing work in microbiology. One C4 alum has received additional C-DEBI funding to continue working with bioinformatics through a project with the University of Delaware. To date, three manuscripts have resulted from the bioinformatics work, with one published (Tully et al., 2017) and two, with C4 students as first authors, in preparation for submission.
Evaluation

The CC-RISE and C4 programs are externally evaluated annually, and both student and mentor feedback is used to continually improve the various training activities. Here, we briefly highlight a couple of the specific needs identified in the student surveys and our responses in subsequent years to address these needs. For example, in the beginning of CC-RISE, students commented that the opportunity opened doors and they valued the hands-on experience, but having to commute was taxing and we needed to ensure that the mentors were trained in mentoring. As a result, the program at USC is now residential (UCSC and WHOI remain nonresidential), and the mentors are not only screened but also go through a half-day mentoring workshop to ensure that they understand what mentoring is and receive resources about effective mentoring practices. The half-day workshop focuses on discussions about what mentoring is, and participants run through case studies based on the “Enter Mentoring” seminar run by the Wisconsin Program for Scientific Teaching and originally supported by the Howard Hughes Medical Institute Professors Program (https://www.hhmi.org/sites/default/files/Educational%20Materials/Lab%20Management/entering_mentoring.pdf). Students from all 5 years (2013–2017) and both programs (CC-RISE/C4) reported that participating in CC-RISE/C4 would help them in their careers (on a 1–5 Likert scale, with 5 being “strongly agree,” 95% rated the question a 4 or 5, n = 60) and that the program introduced them to new career options (90% rated the question a 4 or 5). In addition, 30% said that the program met their expectations, and 67% of all participants (n = 60) reported that the program exceeded their expectations.

Conclusion

The C4 program seeks to engage, train, and retain community college students who are interested in
STEM fields but who have limited knowledge of relevant career paths and minimal access to research opportunities. Such opportunities at the university level are invaluable in demystifying the laboratory experience, and they help students to self-identify with STEM professions and topics. Laboratory training in microbiology and computer training in bioinformatics provide skills that are directly transferable to the STEM job market and also serve as foundations in applying to and succeeding in graduate school.

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References


National Center for Educational Statistics. 2017a. 2011-12 National Postsecondary Student Aid Study (NPSAS: 12) [American Association of Community Colleges analysis].

National Center for Educational Statistics. 2017b. IPEDS Fall 2015 Enrollment Survey [American Association of Community Colleges analysis].


