The C-MORE Scholars Program: Motivations for an Academic-Year Research Experiences for Undergraduates Program

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A C-MORE scholar processes samples in a lab.

Research Experiences for Undergraduates (REU) programs have been shown to be effective mechanisms to recruit undergraduate students into the sciences and also to retain them, especially as related to underrepresented students. Academic-year REU programs have numerous benefits, including participation in longer-term research projects that allow more time to digest material, develop skills, and draw connections with coursework. This paper describes an academic-year REU program targeted at underrepresented students within the University of Hawaii system, shows how it is aligned with best practices for broadening participation, and presents evaluation results.

Numerous studies have shown Research Experiences for Undergraduates (REU) programs to significantly and positively impact students' career paths. REU participants are more likely than nonparticipants to choose a research-oriented career (Kremer & Bringle, 1990) and attend graduate school (Hathaway, Nagda, & Gregerman, 2002). Kremer and Bringle (1990) also found that participants were more likely to be accepted at graduate schools that were highly rated in research productivity. A survey that asked students to comment on a checklist of potential gains received from their REU experience found that nearly three-quarters of all comments referenced increases in confidence (Seymour, Hunter, Laursen, & Deantoni, 2004), suggesting that increased confidence may be a key factor in pursuing graduate education. Lopatto (2004) found that 83% of participants surveyed began or continued to plan for graduate education, with no significant differences in gender or ethnicity. It is therefore not surprising that the National Science Foundation (NSF) Geoscience Education Working Group recommended that the GEO directorate expand its REU offerings, specifically citing their effectiveness in attracting minority students to science (NSF Directorate for Geosciences, 1997).

In this paper, we present a model for an academic-year REU program. The three-tiered, cohort-based program outlined is specifically targeted at underrepresented students, especially Native Hawaiians and Pacific Islanders (NHPI). An academic-year research project allows students more time to digest material, develop deeper research skills, draw connections with coursework, and build stronger networks with their peers and professors, all of which can sustain them throughout their undergraduate years. We describe how the program is aligned with best practices toward benefiting its participants (specifically cutting-edge research and professional development skills not typically shared in the classroom) and present evaluation results.

Overview of the C-MORE Scholars Program

Established in 2006, the Center for Microbial Oceanography: Research and Education (C-MORE) is a multi-institution NSF Science and Technology Center headquartered at the University of Hawaii at Manoa (UHM). C-MORE is dedicated to advancing the emerging field of microbial oceanography, and its areas of research include microbial biodiversity, metabolism, and energy flow; the role of microbes in climate variability; and ecosystem modeling. As the only Science and Technology Center based in Hawaii, C-MORE is uniquely positioned to provide cutting-edge research and educational opportunities to Hawaii's students, many of whom are ethnic minorities. Our approach is to offer a closely mentored, academic-year research experience

TABLE 1

Demographics of SOEST student majors.

Degree	Men	Women	NHPI	Filipino	Hispanic	African American	Native American
BA/BS	50%	50%	12%	3%	3%	1%	1%
MS	57%	43%	4%	2%	6%	2%	0%
PhD	54%	46%	0%	1%	6%	2%	0%
All majors	53%	47%	6%	2%	5%	1%	0%
2010 Census	51%	49%	24%	14%	9%	4%	3%

Note: Data from University of Hawaii Institutional Research Office (fall 2010) and the State of Hawaii (U.S. Census Bureau, 2011). SOEST = School of Ocean and Earth Science and Technology; NHPI = Native Hawaiians and Pacific Islanders.

with an underlying support structure to provide students with professional and academic support.

The C-MORE Scholars Program is based on the cohort model, enabling undergraduates to begin building collaborations and developing a peer-support group, which can be a critically important factor in student success. In a survey of entering freshmen, Bank, Slaving, and Biddle (1990) found that 58% rated the opinions of faculty members *very important* or *extremely important* during their first semester in college, whereas over 75% gave these two responses for peers and parents. During the second semester, students' perceptions changed such that only 45% rated the opinions of faculty members *very important* or *extremely important*, whereas over 70% still gave these two responses for peers and parents. Peer networks can be important for minority students, particularly those who lack professional role models. Several surveys of Latino college students have suggested that peer support can be even more important than family support (Rodriguez, Mira, Myers, & Cardoza, 2003).

The C-MORE Scholars Program especially aims to recruit underrepresented students into the five majors offered by the UHM's School of Ocean and Earth Science and Technology (SOEST): global environmental science, oceanography, geology and geophysics, ocean engineering, and meteorology. Table 1 compares the latest available demographic data of SOEST majors with census data of the state's overall population.

Clearly, the state's ethnic diversity is not adequately represented among students studying ocean and Earth science. The underrepresented ethnic minority groups noted in Table 1 together represent 54% of the state's population, yet only 14% of SOEST majors. Women are well represented as students within SOEST (47% SOEST vs. 49% state) but show significant attrition in the science, technology, engineering, and mathematics (STEM) pipeline following graduation. Only 17 of the 125 (14%) SOEST tenure-track faculty members are women (SOEST Dean's Office, unpublished data, 2010). Thus, women are also included in the target clientele of the C-MORE Scholars Program. Of the 26 unique students who have participated in the program to date, 16 are women and 20 are underrepresented minorities (Table 2).

After an extensive review, in August 2010 the program transitioned from a semester program to an academic year-long program. This change is intended to provide the student with a more in-depth research experience, enhanced professional development, and the opportunity to more closely bond with fellow students and lab members.

TABLE 2

Summary of demographics for C-MORE scholars (fall 2008–fall 2010).

Ethnicity	Students	Male	Female
African American	2	0	2
Asian	3	1	2
Caucasian	3	2	1
Filipino	1	1	0
Hispanic	1	0	1
Native American	4	1	3
Native Hawaiian/ Pacific Islander	12	5	7
Total	26	10	16

Note: Most scholars are of mixed ethnicity but were listed in only one category, with the underrepresented category taking precedence. Caucasian represents scholars of only Caucasian ethnicity. C-MORE = Center for Microbial Oceanography: Research and Education.

C-MORE scholars research experience

The C-MORE Scholars Program is a paid, closely mentored undergraduate research experience during the academic year. Unlike most REU programs, which are offered during the summer months, the C-MORE Scholars Program enables students to draw immediate connections between their coursework and their research and to develop relationships with their professors outside the classroom. Although C-MORE's mission is focused on microbial oceanography, the Scholars Program supports a broader group of related science, technology, engineering, and mathematics (STEM) disci-

plines, including marine biology, geology, global environmental science, natural resource and environmental management, and ocean engineering. Three levels of awards are offered, depending on the skill and knowledge level of the applicant.

Level I—trainee. Trainees are underclassmen or community college students just entering the STEM pathway. They have had little college-level science coursework and may not have declared a major. Trainees learn basic science concepts, research methods, lab protocols, and computer skills. Their mentors are patient and willing to devote significant time to teaching basic skills. Many mentors see trainees as investments, because many students choose to stay in the same lab for multiple semesters. Traineeships also allow students to "test drive" different aspects of the Earth and ocean sciences and can help students choose which majors and/or careers they want—or don't want—to pursue. Trainees work 13–15 hours/week as they are still honing their study and time-management skills.

Level II—intern. Interns, usually juniors or seniors, work 15–20 hours/week supporting a research project. Many have previously worked as a trainee and have since decided to major in an Earth or ocean science-related field. The intern experience is designed to help link the science concepts students are learning in the classroom with research and career skills (see opening photograph). Projects typically involve field or laboratory research followed by data analysis, such as statistical hypothesis testing, geospatial analysis, or sequencing genomic data. Interns may enroll in a directed research course to earn up to three academic credits for their research experience.

Level III—fellow. Fellows are seniors who have spent at least one year working as an intern. They play an active role in designing their project and are expected to work with greater independence and initiative than do trainees or interns. Their research project may serve as their senior thesis. Fellow-level projects typically require advanced skills and content knowledge and serve as a capstone for integrating undergraduate coursework with hands-on research activities and professional development.

TABLE 3

Sample themes of monthly meetings.

Meeting theme	Description of activities
Resume writing	Staff from Career Development & Student Employment (CDSE) provide a custom workshop on effective resume styles. Students submit their current resume to CDSE staff and fellow scholars for feedback and submit a revised resume to the Scholars Program manager.
Applying to graduate school	CDSE staff provide a workshop on applying to graduate school, including how to write effective personal statements and solicit letters of recommendation. Recruiters from graduate schools occasionally attend to share information about their programs and opportunities for funding of underrepresented students.
Applying to jobs and interview skills	In advance of this meeting, students submit a cover letter and resume to one of several job announcements provided. At the meeting, they are given individualized feedback on their applications. A mock interview is done with selected students to give pointers on interviewing "dos and don'ts."
Data analysis techniques	Although most program participants will take a basic course in statistics or data analysis, they may not do this until their senior year. Learning data analysis techniques before then can be beneficial to their REU experience and class projects. In this workshop led by a C-MORE graduate student, students learn how Excel can be used to analyze and graph various types of data.
Scholarships and summer internships	Information on scholarships and summer internships is shared with students and assistance is provided with application review and essays. These opportunities are also shared via e-mail and social networking (Facebook).

Note: C-MORE = Center for Microbial Oceanography: Research and Education; REU = Research Experiences for Undergraduates.

Additional program components

Meetings

At the beginning of each academic year, the scholars attend a mandatory orientation to learn about program goals and expectations. This orientation is the first step toward creating a sense of bonding, support, and camaraderie among the participants. Past activities have included a mountain-to-ocean field trip to learn Oahu's geologic history, a team debate on climate change, and oceanographic sampling using a conductivity-temperature-depth (CTD) instrument. These team-building activities underscore that the program is cohort based to avoid having students feel isolated during their undergraduate academic experience (Figure 1).

Following the orientation, the scholars meet monthly to develop and hone their professional skills, learn about upcoming scholastic and career opportunities, and share information about their classes and research with peers in a supportive environment (Table 3). The monthly meetings offer students a "value added" academic experience by providing them with life and career skills that they would not otherwise receive as part of their normal academic experience. These meetings also enable the scholars to continually enjoy the support of their emerging peer network.

Student symposium

At the end of the academic year, students present their research at a symposium that is open to the public. Interns and fellows deliver oral presentations, and trainees present their research in the more informal poster format. Prior to the symposium, the Scholars Program manager and research mentors provide guidance on preparing presentations through examples and sharing best practices. Many scholars report that this is their first time giving a presentation outside of class and that giving the presentation helps them feel more comfortable about the presentations that they have to give in their upper-division courses.

Community outreach

C-MORE scholars are required to spend 6–10 hours each semester conducting science education outreach activities. Many choose to volunteer in oceanography-related education programs, such as Ocean FEST (Families Exploring Science Together) science nights (oceanfest.soest.hawaii.edu) and science workshops for K–12 students organized by C-MORE (cmore.soest.hawaii.edu/education.htm). Sharing their knowledge with younger students helps these undergraduates to build confidence and self-esteem and enables them to start viewing themselves as the scientists they are becoming. Through these events, the scholars serve as important role models for younger students.

Optional components

C-MORE scholars enjoy a host of optional program components to help students stay on track. Free tutoring in calculus, physics, and chemistry is provided through the SOEST dean's office. Career and academic services are provided both by the university and SOEST; there is also a Native Hawaiian student services office that engages students in Native Hawaiian cultural activities and provides additional information on programs targeted at Native Hawaiians. C-MORE scholars also have the opportunity to join research cruises aboard the *R/V Kilo Moana*, where they actively participate in data collection and sampling.

Alignment with BEST practices

Building Engineering & Science Talent (BEST) Board of Directors (2004) outlined eight design principles to guide higher education programs aimed at broadening participation (Table 4). These principles are widely regarded as best practices across science and engineering fields (Pandya et al., 2007).

The C-MORE Scholars Program is aligned with these eight design principles. First, we enjoy strong institutional leadership. C-MORE has institutionalized the Scholars Program in its annual budget, which guarantees funding for at least 10 years. Second, C-MORE has formed partnerships throughout and beyond the University of Hawaii (UH) system to establish a feeder system from high schools and community colleges, including high school research experiences, summer bridge programs for incoming UH students, and ocean-themed science nights for younger students and their families. Third, the UH tenure and promotion process recognizes undergraduate student mentoring as a valuable service, and C-MORE recognizes educational outreach as a key part of its mission. Fourth, C-MORE scholars receive substantial personal attention. Each student is mentored by a faculty research supervisor and in many cases also by the faculty member's graduate students and/or postdoctoral research associates. Students also receive individualized attention from the Scholars Program manager and free tutoring in math and science courses. Fifth, C-MORE scholars enjoy extensive peer support. The students interact with each other at the program orientation, monthly meetings, and end-of-year student symposia. Sixth, an enriched research experience is the core of the program: Every student participates in closely mentored research. Seventh, the tiered nature of the program helps students see the pathway to graduation and beyond. Academic and career services are integral to the program to help keep students on track in their undergraduate programs and plan for

TABLE 4

BEST design principles.

Institutional leadership	Commitment to inclusiveness across the campus community
Targeted recruitment	Investing in and executing a feeder system, K–12
Engaged faculty	Developing student talent as a rewarded faculty outcome
Personal attention	Addressing, through mentoring and tutoring, the learning needs of each student
Peer support	Student interaction opportunities that build support across cohorts and allegiance to institution, discipline, and profession
Enriched research experience	Beyond-the-classroom hands-on opportunities and summer internships that connect to the world of work
Bridging to the next level	Institutional relationships that help students and faculty to envision pathways to milestones and career development
Continuous evaluation	Ongoing monitoring of process and outcomes that guide program adjustments to heighten impact

Note: From Building Engineering & Science Talent (BEST) Board of Directors (2004).

FIGURE 1

C-MORE scholars ready a CTD instrument for deployment during a scholars' orientation activity.

PHOTO COURTESY OF THE AUTHOR

summer internships, graduate schools, and careers. Finally, the program is continuously evaluated, both internally and externally.

The C-MORE Scholars Program also borrows strategies from four UH programs that have been successful in recruiting and retaining underrepresented students in STEM fields: Ka`Imi`Ike (http://www2.hawaii.edu/~kaimiike/); Pacific Internship Program for Exploring Science (http://www.uhh.hawaii.edu/uhintern/); Native Hawaiian Science and Engineering Mentorship Program (http://nhs-emp.eng.hawaii.edu/); and the Hawaii Space Grant Consortium Fellowship Program (http://www.spacegrant.hawaii.edu/fellowships.html).

Program goal and evaluation results

The C-MORE Scholars Program's overarching goal is to increase the number of underrepresented undergraduate students, especially those of NHPI ancestry, graduating with a degree in an Earth or ocean science field. Our progress toward this long-term goal is being assessed by an external evaluation conducted by the Social Science Research Institute at UH. The mixed-method evaluation includes written surveys from students and mentors, direct observations, and informal oral feedback from students during orientation, monthly meetings, and office visits. This paper focuses on the assessment results from the written surveys completed by students.

Program evaluation by students

This program was piloted for four semesters (fall 2008–spring 2010), during which the program continually evolved on the basis of formative evaluation results. At the beginning and end of each semester, C-MORE scholars completed online surveys consisting of multiple-choice, open-ended, and Likert scale questions. The pilot surveys have been continually refined by the external evaluators to better collect any pertinent information related to summative indicators as well as formative feedback. The surveys were finalized in summer 2011.

The presurvey collects background information on student demographics (to gauge our effectiveness in recruiting our target audience), attitudes (e.g., self-confidence and attitudes toward STEM), and skills/interests (to help formulate the monthly meeting topics). A similar postsurvey is given at the end of the semester to measure any program impact on attitudes, confidence, skills, and interests. The postsurvey also asks students to comment on various program components through open-ended questions. Because the student surveys were continually refined during the pilot period, a pre-versus-post or semester-by-semester comparison of all survey elements is precluded.

In this paper, we present evaluation results for those parts of the surveys that have remained consistent for multiple semesters. These include Likert scale quantitative responses collected in pre- and postsurveys over three semesters (spring 2009, fall 2009, and spring 2010) and qualitative responses to open-ended questions on postsurveys collected over two semesters (fall 2009 and spring 2010).

Likert scale questions (quantitative data)

Table 5 summarizes the Likert scale responses regarding research and professional development skills for spring 2009, fall 2009, and spring 2010. The survey question reads "Considering what would be expected of STEM graduate students and stem career professionals, please rate your proficiency with . . ." and is followed by a list of skills. These categorical survey items/topics are listed in Table 5, along with students' mean pre- and postsurvey ratings, standard deviations, and *t*-test results of statistical significance. In each of these three semesters, 7–11 scholars completed both the pre- and postsurvey. However, not every student answered every question, and some students answered "not applicable," which further reduced the valid *N*.

A comparison of pre-versus-post data for spring 2009 showed that students self-reported improvement in most (8 of 13) of the skill areas surveyed, with significant improvement in "making scientific charts and graphs." Students self-reported negative gains in five areas that semester. None were shown to be significant but were nevertheless a matter of concern and resulted in program revision, including restructuring the monthly meetings aimed at addressing these skill sets and discussing skill-improvement expectations with mentors.

During fall 2009, after the program was revised, students self-reported gains in virtually all (12 of 13) skill ar-

eas. Three areas showed significant improvement: "making scientific charts and graphs," "job-seeking skills," and "presentation skills." In spring 2010, students similarly self-reported gains in most (10 or 13) skill areas. It is interesting that none of these gains were significant. This insignificance may result from a large number of spring 2010 students having previously participated in the program for multiple semesters, so the material being discussed in the monthly meetings was no longer new to them.

Open-ended questions (qualitative data)

In addition to the Likert scale questions, the postsurveys administered in fall 2009 and spring 2010 included three open-ended questions:

1. Was the information provided during the monthly meetings helpful to you? If so, what was most useful?
2. If a friend asked you, "Why should I participate in the C-MORE Scholars Program?", what would you tell him/her?
3. What did you like best about your experience in the C-MORE Scholars Program?

These questions were designed to solicit feedback on how the program impacted students' research skills and professional development. All students found the monthly meetings to be useful (Question 1). The four meeting topics found to be most useful were resume/interviews, Excel data analysis, graduate school, and internships. When asked why someone should participate in the C-MORE Scholars Program (Question 2), students perceived the program as a positive opportunity in general and particularly noted the research experience and making connections with scientists. It is surprising that only one or two students each semester mentioned the stipend as a reason to participate in the program. Making connections with

TABLE 5

Means, standard deviations, and tests of significance related to scholars' research and professional skill development (spring 2009, fall 2009, spring 2010).

Survey item	Pretest mean (SD)	Postest mean (SD)	Paired *t*-test
Spring 2009			
Computer skills	4.20 (0.79)	4.29 (0.76)	$t(6) = 1.00, p = .356$
Scientific charts/graphs	3.90 (0.74)	4.43 (0.79)	$t(6) = 2.83, p = .030$
Technical writing	3.44 (0.88)	3.14 (0.90)	$t(5) = -0.79, p = .465$
Data analysis	3.70 (0.95)	3.57 (0.98)	$t(6) = -1.00, p = .356$
Job seeking skills	3.90 (0.74)	4.00 (0.82)	$t(6) = 0.00, p = 1.00$
Presentation skills	4.20 (0.92)	3.83 (1.17)	$t(5) = 0.00, p = 1.00$
Organizational skills	4.30 (0.82)	4.43 (0.53)	$t(6) = 1.55, p = .172$
Lab skills	4.13 (0.83)	4.14 (0.69)	$t(5) = 1.00, p = .363$
Fieldwork skills	3.88 (0.64)	3.50 (1.05)	$t(5) = -0.54, p = .611$
Shipboard skills	3.29 (1.60)	3.40 (1.52)	$t(4) = 1.50, p = .208$
Listening skills	4.30 (0.67)	4.00 (0.82)	$t(6) = -1.00, p = .356$
Oral communication skills	4.10 (0.99)	4.14 (1.07)	$t(6) = 0.79, p = .457$
Public speaking	N/A	N/A	N/A
Fall 2009			
Computer skills	4.11 (1.05)	4.67 (0.50)	$t(7) = 1.32, p = .227$
Scientific charts/graphs	3.78 (0.83)	4.67 (0.50)	$t(7) = 3.74, p = .007$
Technical writing	3.13 (1.13)	4.00 (0.87)	$t(6) = 1.73, p = .134$
Data analysis	3.56 (0.88)	4.22 (0.83)	$t(7) = 1.93, p = .095$
Job seeking skills	3.56 (0.53)	4.00 (0.50)	$t(7) = 2.65, p = .033$
Presentation skills	3.67 (1.12)	4.67 (0.50)	$t(7) = 2.83, p = .026$
Organizational skills	4.11 (1.05)	4.00 (1.32)	$t(7) = -0.36, p = .732$
Lab skills	4.00 (0.71)	4.22 (0.67)	$t(7) = 1.00, p = .351$
Fieldwork skills	4.00 (0.71)	4.22 (0.67)	$t(7) = 0.80, p = .451$
Shipboard skills	2.71 (1.38)	3.29 (1.11)	$t(4) = 0.78, p = .477$
Listening skills	4.13 (0.83)	4.56 (0.53)	$t(6) = 2.12, p = .078$
Oral communication skills	4.25 (0.71)	4.56 (0.53)	$t(6) = 0.79, p = .457$
Public speaking	3.50 (1.41)	4.56 (0.73)	$t(6) = 2.25, p = .066$
Spring 2010			
Computer skills	3.88 (0.83)	3.91 (0.83)	$t(7) = -0.55, p = .598$
Scientific charts/graphs	4.00 (1.07)	3.91 (1.04)	$t(7) = 0.55, p = .598$
Technical writing	3.00 (1.53)	3.18 (1.08)	$t(6) = -0.79, p = .457$
Data analysis	3.63 (1.06)	3.73 (1.01)	$t(7) = -0.80, p = .451$
Job seeking skills	3.63 (1.06)	3.45 (1.13)	$t(7) = 0, p = 1.00$
Presentation skills	4.00 (0.93)	3.82 (0.87)	$t(7) = -1.00, p = .351$
Organizational skills	4.13 (0.83)	3.73 (0.9)	$t(7) = 0.80, p = .451$
Lab skills	4.13 (0.99)	3.91 (0.7)	$t(7) = 0, p = 1.00$
Fieldwork skills	4.29 (0.76)	3.82 (0.98)	$t(6) = 1.16, p = .289$
Shipboard skills	3.75 (0.96)	3.00 (1.55)	$t(2) = 0, p = 1.00$
Listening skills	4.50 (0.76)	4.09 (0.7)	$t(7) = 1.53, p = .17$
Oral communication skills	4.25 (0.89)	4.00 (0.77)	$t(7) = 0, p = 1.00$
Public speaking	4.00 (0.93)	3.82 (0.75)	$t(7) = 0.55, p = .598$

Note: Likert Scale items ranged from 1 = *poor* to 5 = *excellent*. Responses of "not applicable" were excluded from analyses.

scientists was also the most commonly cited program highlight (Question 3); other highlights included having a new experience, completing goals, and acquiring knowledge and skills.

Program outcomes

After two years, the C-MORE Scholars Program has had several notable successes. Of the five alumni who have graduated with bachelor's degrees, two are in graduate school and three plan to enter graduate school in the upcoming year. Two scholars gave presentations at national conferences, and one scholar is a coauthor on a peer-reviewed research publication (Church, Wai, Karl, & DeLong, 2009). Through networking and participation in program events, three scholars gained the confidence to apply to highly competitive summer REU programs at Monterey Bay Aquarium Research Institute (MBARI) and the Woods Hole Oceanographic Institution (WHOI). All three students attended these programs during summer 2010 with positive results and have jointly coauthored a peer-reviewed publication on their summer research experiences (Bruno, Thomas, Frazier, & James, 2011). One of these projects will likely become a graduate thesis.

Summary

The C-MORE Scholars Program is an academic-year REU program targeting underrepresented students in the ocean and Earth sciences. During the two-year pilot, the program was continually revised, primarily on the basis of student and mentor feedback. Student evaluations, which include Likert scale data and open-ended questions, suggest that students value the skill-building monthly meetings, particularly those that focused on resume/interview skills, EXCEL data analysis, and the application process for graduate school and internships. They perceived the Scholars Program as providing rich opportunities in conducting research and making connections with research scientists. Though not specifically described in this paper, other forms of assessment, such as written surveys from mentors, direct observations by evaluators, and exit surveys have also provided us with rich and helpful data on what is working and what areas may need improvement. The C-MORE Scholars Program will continuously evolve to address the needs of its participants and mentors, and its continued success in supporting minority undergraduates in STEM is anticipated. ■

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