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UNDERGRADUATE RESEARCH AT COMMUNITY COLLEGES

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Undergraduate Research at Community Colleges

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Introduction

James Hewlett, *guest editor*

Undergraduate Research at Community Colleges

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Community colleges serve close to half of all US undergraduates. Their role in this diverse higher education landscape may have evolved since their inception more than a century ago, but it is clear that any national educational reform effort must include these institutions so that the impact of reform can be maximized, and access and equity for all students can be ensured. This is especially true for the many students from underrepresented backgrounds who, more than any other demographic group, attend community colleges to obtain their degrees. Undergraduate research experiences (UREs) have been studied extensively for their contribution to student outcomes, and the positive results of those studies support the designation of a URE as a high-impact educational practice (Kuh 2008). The development and implementation of successful undergraduate research programs have presented, until recently, significant challenges for community colleges, because of issues such as the lack of an institutional research culture, high faculty teaching loads, competitiveness in establishing external funding streams, and limitations of space for some disciplines.

Several recent initiatives have focused on finding ways to address these issues. In 2006, the Council on Undergraduate Research and the National Council on Instructional Administrators initiated six regional conversations with community colleges. A 2009 effort funded by the National Science Foundation (NSF) engaged faculty from 95 colleges to support the development of undergraduate research opportunities at US community colleges. Around the same time, the Community College Undergraduate Research Initiative (CCURI) was established at Finger Lakes Community College in Canandaigua, NY. Initially focused on supporting the development of UREs at six regional partner institutions, CCURI has grown into a network of 124 community colleges in 38 states and two countries. The rapid expansion of undergraduate research opportunities for community college students that occurred during this time is evidenced by the 2019 Community College Undergraduate Research Experience Summit in Washington, DC, that was sponsored by the American Association of Community Colleges and NSF. The meeting brought together 120 thought leaders in a think-tank approach to gain insights and plan for future expansions of this high-impact practice at community colleges (Patton and Hause 2020).

This issue of SPUR highlights some innovative approaches of community college faculty and staff to broaden participation in undergraduate research at community colleges. It opens with three articles that offer strategies for measuring the impact of a URE on students in a variety of institutional settings and classroom formats. These assessment articles reflect the widely adopted strategy of embedding UREs into the curriculum as course-based undergraduate research experiences (CUREs) or as summer undergraduate research experiences (SUREs). Infusing or embedding the experience also helps to address issues of faculty teaching loads and space limitations. Virginia Balke and colleagues (Delaware Technical Community College) report on their effort to measure a diverse suite of student impacts in a bioscience/biotechnology program, which employed institutional research data to examine the effect of the program on student enrollment, completion, and graduation rates. Retrospective qualitative data from participant interviews provided insights into the achievement of gains in student persistence. Kristen Genet (Anoka-Ramsey Community College) describes a URE offered as both a face-to-face (seated) and asynchronous online experience in a large introductory course in environmental sciences. Online solutions have increased in popularity not only as a result of the COVID-19 pandemic but also as a strategy to address issues of access and equity in communities served by the institution. Student impact data were collected via the validated Undergraduate Research Student Self-Assessment (URSSA) instrument. As the author describes, the URSSA data uncovered inequities that were addressed in an iterative process of program development and improvement. Matthew Loeser (Yakima Valley College) and colleagues profile the development and assessment of UREs at a rural, Hispanic-serving institution. The authors argue for partnerships in scaling and sustaining an undergraduate research program at a community college. They also employed the URSSA instrument to measure student impact and used a comparison group of STEM students to report gains for SURE participants on their campus. Taken together, these three articles emphasize the importance of using validated data sources and offer suggestions for sustainability and adaptability of an undergraduate research program.

The next three articles represent a snapshot of known best practices in delivering UREs in diverse settings and feature strategies for utilizing partnerships with high schools, four-year institutions, and public university systems. Joan

Petersen (Queensborough Community College, CUNY) and colleagues detail an effort to employ a comprehensive suite of tools and strategies to institutionalize undergraduate research across multiple academic departments. The authors underscore the need for strong internal supports as well as external and "top-down" support structures to sustain an undergraduate research program at a community college. In offering suggestions for nurturing successful UREs, the article continues the themes of establishing partnerships and embedding the experiences into the curriculum. Ardi Kveven (Everett Community College) describes a unique dual-enrollment program where students engage in undergraduate research beginning in their third year of high school. More than 500 students have participated in the Ocean Research College Academy (ORCA) program over the past 17 years. This unique partnership features an undergraduate research experience scaffolded across multiple courses as part of a larger academic program. The author offers a comprehensive list of suggestions for individuals and institutions interested in replicating the model. Jared Ashcroft (Pasadena City College) and colleagues then revisit the critical importance of partnerships in highlighting a program in California with a focus on enhancing equity and diversity in undergraduate research experiences. Critical race theory forms the foundation of this unique program that was adapted from the 2014 National Institutes of Health initiative Building Infrastructure Leading to Diversity (BUILD). In addition to discussing the various student, faculty, and institutional outcomes of the program, the authors detail some best practices in forming partnerships involving community colleges and universities.

The eight vignettes in this issue show the diversity of undergraduate research at community colleges and offer a variety of practices and strategies that have been employed to scale the experience and broaden participation in UREs. Kaatje van der Hoeven Kraft (Whatcom Community College) and Karen M. Kortz (Community College of Rhode Island) present an example of the integration of a service-learning experience into a CURE that not only provides a research experience for students but also establishes meaningful and lasting connections to the local community. Amiko Matsuo (South Seattle College) describes a unique service-learning URE in which fine arts students at Allan Hancock College participate in a cooperative work-experience project with a community partner. Angelo Kolokithas (Northeast Wisconsin Technical College) provides an example of the adoption and adaptation of established, large-scale, multisite research programs to accelerate the scaling of an undergraduate research experience at a community college. The Tiny Earth Initiative has global reach and involves a crowdsourcing approach to antibiotic discovery. A well-established and time-tested curriculum and supportive network of practitioners help to overcome barriers associated with establishing a novel student research program. Todd Pagano (Rochester Institute of Technology) and colleagues highlight the importance of access and equity in undergraduate research experiences with their vignette describing the CUREs developed for Deaf and Hard-of-Hearing students in a Laboratory Science Technology program at the National Technical Institute for the Deaf (NTID). Naomi Stubbs (LaGuardia Community College, CUNY) describes the implementation of a URE in a humanities program where participants in a collaborative faculty-led project reported gains across a variety of critical skills. Beatriz Villar-Fernandez (Northampton Community College) and colleagues address an often overlooked challenge to ensuring equity and access to the undergraduate research experience with their focus on developing and sustaining UREs at branch campuses. Scott L. Walker (Northwest Vista College) showcases an undergraduate research agenda that aligns with well-established "marketable skills" that are highly valued by employers. Finally, Madeline Patton and Ellen Hause discuss the 2019 Community College Undergraduate Research Experience Summit, describing the structure of the meeting and some key recommendations produced as part of the conference activities.

This collection of articles and vignettes capture the diverse nature of the undergraduate research experience at US community colleges as well as the continued growth and scaling of UREs. Broadening participation in undergraduate research for *all* students has become an educational priority, and the increasing role played by community colleges in addressing this priority is evident throughout this issue.

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ASSESSMENT

Long-Term Outcomes of Biotechnology Student Participation in Undergraduate Research Experiences at Delaware Technical Community College

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Abstract

Engagement in undergraduate research experiences (UREs) has a positive impact on student skill development, scientific identity, and retention in STEM. Incorporating UREs into two-year programs would greatly benefit the diverse, nontraditional student populations enrolled at community colleges. This article describes the infusion of the bioscience/biotechnology program at Delaware Technical Community College with course-based and mentored research experiences, which may serve as a model for other institutions. Studies done with the Office of Institutional Research revealed a concurrent increase in enrollment and graduation rates. Retrospective interviews with graduates from the program highlight the critical influence of research, the mentor-student relationship, a sense of community, the development of transferable skills and self-efficacy, and subsequent successes in pursuing higher education and employment.

Keywords: *biotechnology education, community college alumni, community college graduation rates, course-based undergraduate research, mentoring, student outcomes*

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Undergraduate research experiences (UREs) have a positive impact on STEM students, particularly female, underrepresented minority (URM), and first-generation students (Espinosa 2011; Gentile, Brenner, and Stephens 2017; Haeger and Fresquez 2016; Hurtado et al. 2009; Jones, Barlow, and Villarejo 2010). Increasing numbers of community colleges have adopted both classroom-based and mentored models of undergraduate research experiences (Hensel and Cedja 2014; Hewlett 2018). This movement holds promise for greater access to STEM fields through wider student participation (Bangera and Brownell 2014) given that almost half of all URM students in the US are enrolled in community colleges (American Association of Community Colleges 2020), and more than half of all students receiving STEM bachelor's degrees complete some part of their education at community colleges (NCSES 2010). With lower costs, open-access policies, and support for nontraditional students, community colleges serve populations who benefit greatly from exposure to these opportunities (Olson and Labov 2012).

Many publications on UREs report on perceived gains in skills, confidence, and career plans gathered from student surveys and interviews (Lopatto 2010; McIntee et al. 2018; Mraz-Craig et al. 2018), whereas others use institutional data to investigate student retention and graduation rates (Rodenbusch et al. 2016). Several studies delve deeper into nuanced dynamics, such as whether mentoring relationships influence retention, how scaffolding across multiple courses affects skill development, and how multi-semester research experiences influence development and identity as a scientist (Adedokun et al. 2014; Linn et al. 2015; Nagda et al. 1998; Thiry et al. 2012). Because UREs are relatively new to community colleges, there are few studies that examine their impacts on community college students or ask alumni to take a retrospective look at the impact of UREs on their career trajectories or pursuit of advanced degrees (Nerio et al. 2019). This article examines the long-term education and career outcomes for alumni who participated in a URE-infused program over a five-year period in the Bioscience/Biotechnology Program at Delaware Technical

TABLE 1. BIS-BIT Program Biology and Chemistry Courses

Year 1	
Fall	Spring
Biology I Chemical Principles I	Biology II *Principles of Microbiology* Chemical Principles II
Year 2	
Fall	Spring
Biotechnology I Organic Chemistry I Analytical Chemistry I	*Biotechnology II* Organic Chemistry II Analytical Chemistry II

Note: Italicized courses have embedded undergraduate research experiences.

Community College (DTCC). Working with data from the National Student Clearinghouse and the college's Office of Institutional Research, the authors have shown that infusion of the program with multiple opportunities for UREs corresponded with increased program enrollment, higher graduation rates, and continuation of higher education. Interviews with graduates provided more detailed insights into the program's influence on student success after graduation, whether students continued their education or entered the workforce.

The Research-Infused Program

DTCC is an open-access college serving a diverse population of approximately 15,000 students. It is both a technical and a community college with three campuses across the state, each addressing the needs of local industry and preparing students to enter directly into the workforce upon graduation or to transfer to a four-year institution. The Biotechnology/Bioscience (BIS-BIT) Program described in this article, which is housed in the Department of Biology and Chemistry on DTCC's Stanton campus, has an average enrollment of 200 students and graduates about 12 students per year. The program is rigorous, requiring students to take five biology courses and six chemistry courses (see Table 1); all science courses include a laboratory section. Lack of college readiness, financial issues, and family obligations extend the time to degree completion from two years to an average of four years. Responding to current industry needs, the college has created articulation agreements with local four-year institutions to which most students transfer upon graduation.

Course-Based Undergraduate Research Experiences

To provide research experiences for the maximum number of students, laboratory activities were modified to provide scaffolded experiences that emphasized scientific and transferable skills through a sequence of three biology courses (see Table 1). The laboratories consisted of instructor-designed research-based projects in which students took ownership of the project, had opportunities for reiteration to complete the project, and were vested in the outcome. Scientific literacy was explicitly emphasized through laboratory reports in which students were expected to use scientific terminology and style when analyzing data and communicating results. New in-class activities were introduced to strengthen critical thinking, reinforce group work, and encourage development of a deeper understanding of the primary literature and the ethical conduct of research.

Mentored Undergraduate Research Experiences

Students also had the opportunity to work on a research project in a traditional mentored model. Many of the research projects were related to course-embedded projects, building on several of the same technical skills, thus lowering the threshold to entry. Each semester, including summers, up to 12 students worked with two to four faculty members on a variety of long-term projects. Because faculty recruited students from their courses and any interested students were encouraged regardless of where they were in the course sequence or of their grade point average, demographics of mentored students reflected those of the program and the college (see Table 2). The length of student participation in mentored research ranged from one semester to three years. Participating students developed their research skills through multiple semesters, with an initial focus on techniques and reading scientific literature, followed later by troubleshooting and data analysis. Eventually students were able to postulate hypotheses and design their own experiments. Since multiple students were working on the same projects, there was an opportunity for peer mentoring, with more experienced students aiding newer ones.

Several of the research projects were developed in partnership with research faculty at the University of Delaware and Delaware State University, contextualizing students' contributions to the larger scientific community. As these relationships grew, the reputation of the DTCC students improved, leading to more opportunities for summer internships and transfers.

Students working on mentored research received grant-funded stipends, easing some of the financial burdens that frequently required them to work outside of the college. As the program evolved, credit-bearing research courses were created to provide compensation for faculty mentors, with each mentor receiving the registration fees for his or her section.

Biannually, students presented their research at a campus research poster session, which helped garner support for the undergraduate research program and expand it to other departments. Grant funds also supported student travel for presentations at regional and national conferences, for

TABLE 2. Academic Metrics and Demographics of DTCC's Stanton Campus and Program Students (2008–2014)

	Campus-wide	CUREs only	CUREs plus mentored research
Graduation rate	N/A	34.5% (41/119)	46.8% (22/47)
Average time to completion of AAS (years)	3.25	5.3	3.9
Average GPA	3.03	3.25	3.4
Percentage of female participants	57%	55.2%	56%
Percentage of URM participants	32.5%	38.6%	42.7%

Note: DTCC = Delaware Technical Community College; CUREs = course-based undergraduate research experiences; AAS = associate of applied science degree; URM = underrepresented minority. Time range includes the students who participated in mentored research in 2008 before CURE implementation.

TABLE 3. Summary of Study Questions, Data Sources, and Analysis

Study question	Data source	Analysis
To what extent have the DTCC BIS-BIT program's rates of enrollment and completion changed since implementation of research opportunities?	Enrollment and completion data for five years prior to and following research infusion	Comparison of descriptive data
How do graduates fare in employment and further education following participation in the URE-infused BIS-BIT program?	Interviews with a random sample of graduates regarding current employment and education status	Descriptive data regarding career and education attainment for sample of alumni
How do graduates of the URE-infused BIS-BIT program describe the program's influences, supports, and/or deficits in their own subsequent education and employment?	Interviews with a random sample of graduates regarding reflections and evaluation of undergraduate research opportunities at DTCC	Identification of important program features in view of students' graduation, further education, and employment

example, the biannual research symposium of the Community College Undergraduate Research Initiative, the National Conference on Undergraduate Research (2013, 2017), and the Council on Undergraduate Research–sponsored Posters on the Hill in Washington, DC.

Impact Studies

The research presented uses institutional and interview data to gain a broad picture of the impacts of the URE-infused program and to identify aspects that alumni found most beneficial to furthering their education and STEM careers (see Table 3). Recognizing that instructional practices and research experiences may only partially influence student outcomes, methods were intentionally combined to gather different types of information. First, existing institutional data were compared for changes in enrollment and graduation rates between two five-year periods, pre- and post-implementation of UREs. In the second phase, long-term student outcomes of URE participation were examined by interviewing a random sample of alumni, encouraging them to reflect on their research experiences and assess their impact in light of their current education or employment.

Institutional Data Analysis

Annually 200 students enrolled in the BIS-BIT program, with fewer than 20 completing their degrees. Because high numbers of students struggled with developmental courses or first-year biology and chemistry and dropped out or transferred before the research-infused courses, program growth and graduation rates were calculated using only students who had declared a BIS-BIT major and passed Biology I and Chemical Principles I. This was the student population prepared to enroll in Principles of Microbiology, the first biology course with embedded research.

Comparing the 2004–2009 (prior to URE infusion) students with the 2009–2014 (post-URE infusion) group, there was a meaningful increase in both program enrollment and graduation rates (see Table 4), without a similar increase in campus-wide enrollment or number of graduates (DTCC 2020; see Table 5). Comparison also was performed between populations participating in course-related undergraduate research experiences (CUREs) alone and those with both CUREs and mentored research, finding meaningful but not significant differences in GPA, graduation rate, and time to completion between the two (see Table 2). The

TABLE 4. BIS-BIT Program Metrics before and after Infusion of Undergraduate Research Experiences (UREs)

	Enrollment	Graduation rate
2004–2009 (pre-URE)	74	24.3% (18)
2009–2014 (post-URE)	148	36.5% (54)

Note: BIS-BIT major students who passed first-semester chemistry and biology courses (*χ^2, $p < 0.05$, $df = 1$)

TABLE 5. DTCC's Stanton Campus Metrics for 2008–2009 and 2013–2014 Academic Years

	Fall enrollment	Number of graduates
2008–2009	3,857	544
2013–2014	3,572	330

National Student Clearinghouse (2015) tracked all DTCC students who had participated in mentored research from 2009–2014, regardless of major. Of 90 students, 26 (29 percent) were continuing their education at DTCC and 47 (52 percent) had transferred to a four-year institution.

Interviews

Sampling Strategy

From the pool of BIS-BIT graduates from 2012–2016, 25 were randomly selected and invited to participate in interviews. Twelve graduates agreed to be interviewed for this study. Demographically, the sampled group was similar to all BIS-BIT graduates and differed slightly from DTCC's Stanton graduates at that time (see Table 6).

Instrumentation

A semi-structured interview protocol, adapted from the Accreditation Board of Engineering Education (ABET) student survey instrument (Volkwein et al. 2004), guided collection of new data. Although the DTCC BIS-BIT program is not accredited by ABET, the survey's focus on the impact of learning authentic problem solving in context aligns well with the goals of the DTCC BIS-BIT program and its focus on UREs.

Interview questions were reviewed and selected by program faculty to align with program goals and practices, as well as with research on typical components and outcomes of URE. To estimate timing and ensure that items were clear, relevant, and well-ordered, the protocol was piloted with a recent graduate who was not part of the sample. Interviews lasted approximately 30 minutes and were held either face-to-face or by phone. The second author, who had no previous experience with the program or alumni, administered and initially coded all interview data.

An introductory statement encouraged interviewees to think back to a specific time, and Likert-type questions served to focus memory and standardize some statements of evaluation. The interview was conversational in nature, and alumni were encouraged to elaborate on their ratings and describe their experiences. In addition, open-ended questions were designed to elicit additional context and depth. All interviewees gave a verbal or written statement of informed consent, and none asked to skip or omit any part. Interviews were recorded and transcribed.

A coding scheme was jointly developed and refined by the authors to capture statements regarding important features and benefits identified in earlier studies of URE. Transcripts were first read as a whole and coded by one researcher. If any additional impacts or insights were noted at this phase, they were coded. As the process continued, patterns and relationships developed within the data. The authors met again to clarify new understandings, insights, and themes, including multidimensional learning, real-world applications, the value of learning in a community, and perceived benefits and obstacles to further education and career (see Table 7). Most frequently, interviewees mentioned the benefits of interpersonal relationships with peers, faculty, and members of the greater scientific community, particularly in gaining information critical to their research projects and career pathways. The respondents did not discuss learning specific skills but rather recognized their increased confidence and understanding of the scientific process and the importance of their work to society.

Alumni Outcomes

STEM Degrees and Careers

Interviewees provided information regarding current education—that is, whether they were currently working (or if they ever had worked) toward a four-year degree, the degree major, full- vs. part-time status, and anticipated graduation date. All also were asked about current full- or part-time employment, job title, and typical responsibilities. Following graduation from DTCC, most students continued with STEM education and/or employment in STEM-related fields.

Of the nine students then currently enrolled in bachelor's programs ($n = 6$) or pursuing advanced degrees ($n = 3$), all anticipated finishing their degree programs within two years and continuing to work in research labs or professional placements or moving into graduate training. All nine were employed either full time ($n = 1$) or part time ($n = 8$) in STEM fields ($n = 5$) or non-STEM jobs, including IT, retail, restaurants, and child care. The three who were not enrolled in school at that time were working full time, two in bioscience careers and one in computer sciences. One of the three had completed a BS in biology. The other two indicated that they might consider earning a four-year degree in the future.

TABLE 6. Demographics of DTCC's Stanton Campus Graduates, BIS-BIT Graduates, and Interview Participants, 2012–2016

	Campus-wide	All BIS-BIT	Interview sample
Percentage of female participants	55.4%	49%	42%
Percentage of URM participants	36.9%	49%	58%
Percentage of mentored research participants	N/A	50.9%	67%
Average age	25	27	26.25
Average GPA	3.06	3.23	3.25

Note: DTCC = Delaware Technical Community College; URM = underrepresented minority

TABLE 7. Key Analytic Themes, Subordinate Codes, and Number of Coded Instances

	Instances (*n*)
UREs are multidimensional learning experiences	
Learn/apply lab skills	11
Master course content; incorporate writing, math skills	7
Learn professionalism and teamwork	17
UREs yield positive outcomes	
Confidence	22
Career advice, including transfer advice	20
Job readiness, including new technologies	11
Open doors to new opportunities	10
UREs address real-world problems	
Useful, important scientific or social implications	24
Science is iterative, collaborative, and open to inquiry (scientific process)	10
Benefits of UREs occur within a community (benefits attributed to—)	
Peers: unspecified	7
Faculty	17
Peers: project or research team	47
Other professionals: off-campus REUs or professional experiences	21
Concerns when deciding to further education	
Information gap	5
Funding, including credit transfers	5
Time commitment, including credit transfers	10
Question level of preparedness	2

Note: UREs = undergraduate research experiences; REU = Research Experiences for Undergraduates program, National Science Foundation

Program Impact

Alumni highly valued their research experiences in the BIS-BIT program, describing a multidimensional learning environment focused on researching real-world problems and situated in relationships with generous, caring faculty and smart and supportive peers.

Recalling their research projects, graduates communicated a sense of participating in scientifically relevant projects with broad implications, for instance, "bats with white-nose disease," "testing soil bacteria from a farm to see the impact of fertilizers and pesticides on soil microbes," and "what proportion of ticks in New Castle County had

markers for Lyme disease." One compared this work to lab activities at another college where "they were very simple. At Del Tech we were like real scientists. We were doing important work."

Faculty members were characterized as warm, open, caring, and motivating. Students remembered instructors sharing their own research during lectures, advising students on career paths, and preparing them for "real world work-place." They held high standards for student professionalism and competence but offered support for reaching these goals.

Alumni recognized that written and oral communication and sharp math skills were vital to long-term success. Some offered insights into the scientific process. All recognized the power of learning new concepts in a problem-focused setting that required critical thinking, deep understanding of text and lecture material, and technical skill:

> Every lab was new. You couldn't rely on the same techniques. You were constantly learning. And what the book says does not always appear that way in the lab. You have to think and see differences.

Long-term research experiences fostered confidence, enabled growth, and opened doors to more challenges, as two alumni commented:

> We had to understand lab processes and equipment to get correct results and to know when they aren't [correct]. It was a year-long process and if we made mistakes we had to start over. It taught us patience and to be careful, and to have pride because MY name was on it. It reinforced classroom learning, which was the best part for me. (emphasis in original)

> Improved leadership skills come from the long term [ongoing research projects.] You take over from someone and then pass the project on to someone else.

In course-based research experiences, all students worked in formal, assigned peer groups, whose members were shuffled during the semester. As one alumnus commented, "It was really annoying at first." Teams, however, provided students with additional opportunities for teaching and learning from each other. Faculty members held an expectation that together students could work out some of their own solutions. One respondent noted, "We were expected to work as a team. We had to work and plan for ourselves, solve problems ourselves." Looking back, alumni recognized their classmates were "sharp," and "smart people from diverse backgrounds, but equally important" who they "could depend on."

Even if a student had not participated in mentored research projects, they benefited indirectly through peer relationships. A network of informal peer mentoring grew. Upper-level students who helped with lab techniques and equipment problems also shared information about educational opportunities and credit transfer agreements to the area's four-year institutions and graduate programs. For some, this was a primary source for transfer advice.

Overwhelmingly, alumni realized they were confident and well-prepared for the next career challenge. Several recalled a point when they understood their own high level of preparedness relative to others, whether working on lab assignments at their new higher education institution or employed in industry, government research facilities, or university research laboratories. A few wondered if more DTCC BIS-BIT students realized how well trained they were they also would consider graduate degrees. As one respondent commented,"Biotech students here are ready for it, if they knew how [to access graduate programs]."

Discussion

This study has a few potential limitations. There was an attempt to address generalizability by providing both qualitative and quantitative data, but program numbers were small, as was the pool of alumni from which the interviewees were drawn. It was hoped that the unaffiliated interviewer might overcome the reluctance of some to participate regardless of further employment or education, and it was encouraging to note that the interviewees' demographic and academic performances were similar to those of the pool of recent graduates. However, questions remain about how the experiences of nonrespondents might differ. Finally, this study does not investigate the experiences of those who did not complete the program. Understanding the experiences and concerns of program alumni offers a foundation for future research to examine this important question.

The BIS-BIT program at DTCC provided students with multiple opportunities for undergraduate research, both in courses and through mentored research. Analysis of institutional data reveals a corresponding increase in the number of students who continued after their first-semester core courses as well as a significant increase in graduation rates. Although the data do not prove a direct correlation, retrospective comments by alumni indicate the importance of the mentor-student relationship, skill development over multiple semesters, and opportunities for teamwork to their growth as scientists and increased self-confidence. This echoes findings from studies at other institutions (Adedokun et al. 2014; Linn et al. 2015; Nagda et al. 1998; Nerio et al. 2019; Thiry et al. 2012). Of note, the graduates' discussions focused on the transferable skills they gained, considering this more important to their success than the course content itself.

Taken together, these reflections offer insight into how program components may have worked together to support their success. Although they detailed many features and benefits of UREs identified in this study's preliminary research, they also highlighted the importance of other factors potentially overlooked for their simplicity, specifically, the precious commodities of time and money when pursuing higher education today, the central organizing role of relationships, and the power of competence and confidence to sustain those in transition.

This interview group represented all the diversities of nontraditional community college students. Five of the twelve were older than 21 years when they first entered. Six attended at least one other college before DTCC. Half were first-generation college attendees. Five were from immigrant families. Four needed more than four years to complete their AAS degree. It is recognized that none of these factors limit a student to attending community colleges, and the study did not directly address the decision to enroll in community college. Nevertheless, respondents revealed its importance in their statements of concern about graduation and decisions to continue on education or career paths. It was in evidence when they recalled earlier academic struggles, inability to enroll elsewhere, and aimlessness. It was reflected in the high premiums they placed on time; money; proximity to home; and, for some, the flexibility to drop in and out by semester as needed. The journeys of these alumni could have been undertaken only at a community college such as DTCC.

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ASSESSMENT

The CURE for Introductory, Large Enrollment, and Online Courses

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Abstract

Increasing undergraduate research opportunities for introductory and non-STEM students benefits large numbers of students from diverse backgrounds. This article assesses a course-based undergraduate research experience (CURE) in a large, introductory course offered both online and in person at an open-door community college. Seated students collaborated during class, and online students collaborated asynchronously at the same pace over eight weeks. Changes in scientific literacy and attitudes toward science varied; seated students showed greater gains and rated their abilities higher upon completion of the CURE. Although online students did show gains, additional interventions improved their experience. This study demonstrates how reflective and iterative evaluation and improvement in CURE integration for introductory courses and non-STEM majors across delivery formats develops best practices for broadening participation in undergraduate research.

Keywords: *broadening participation, course-based undergraduate research, CURE, curriculum development, online education, undergraduate research*

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Undergraduate research (UR) is widely accepted as a high-impact education practice that facilitates deep learning and retention (e.g., Bhattacharyya, Chan, and Waraczynski 2018; Laursen et al. 2010; Lopatto 2007; NRC 2003). The benefits of UR for students from a wide variety of backgrounds—including Black, Indigenous, and people of color (BIPOC), as well as underresourced and first-generation students—have been well documented and established (e.g., Bhattacharyya, Chan, and Waraczynski 2018; Hunter, Laursen, and Seymour 2006; Seymour et al. 2004), and benefits of UR also extend to faculty (Osborne and Karukstis 2009). Engaging in UR allows students to actively participate in scientific discovery and construct knowledge through experiences. Students participating in research early in their educational programs are allowed to explore ideas and develop passions, which motivates them to succeed as they continue in higher education (e.g., Hartline and Poston 2009).

Traditionally, undergraduate research experiences (UREs) in STEM are geared toward high-achieving students who are majors in those fields and are most often offered in upper level, advanced, and specialty courses. Increasing opportunities and broadening participation in undergraduate research for introductory courses, non-STEM majors, and students who are typically overlooked in STEM allow the benefits of UR to be extended to a far greater number of students (Awong-Taylor et al. 2016; Ballen et al. 2017; Linn et al. 2015). In addition to the often cited benefits of UR for STEM majors (e.g., increased retention, deep learning, increased interest in career path), involving non-STEM majors who are taking introductory courses also has the potential to increase science literacy, positive attitudes about science, and evidence-based decision-making, which are extremely important regardless of major or intended career path (Ballen et al. 2017). However, large classrooms and online course environments present practical challenges to implementation of UREs in introductory courses and with nonmajors. Involving students from both seated and online course delivery methods will increase understanding and knowledge of the impact of UREs on students interacting with course material in multiple ways. Literature on implementing undergraduate research experiences in an online course delivery environment is

just emerging, yet with the recent growth and necessity of online course offerings innovative strategies of including online students in UREs need to be developed and piloted. This study fills that gap in current knowledge by providing a comparison between online and seated CUREs as well as evaluating the effectiveness of methods to bring UR into the online environment, particularly for non-STEM major students in introductory courses with large enrollments.

A significant number of students obtaining college degrees enroll in community colleges as they are working to complete degree requirements, and there is great potential for including these students in UREs at community colleges, thereby facilitating student success in transfer to and degree completion at a four-year institution (Cejda 2009; Hensel and Cejda 2014; Higgins et al. 2011). Approximately 50 percent of students completing bachelor's degrees in academic year 2015–2016 had credits transferred from a community college, and in more than 20 states more than half of students earning bachelor's degrees had been enrolled in community colleges during the previous 10 years (NSC Research Center 2017). Community colleges and other two-year institutions traditionally are not well poised to play a significant role in UR, as faculty have demanding teaching schedules, and infrastructure and funding for UR are limited. However, designing, implementing, and sustaining CUREs represents one of the ways that two-year institutions can broaden participation in UR by students at the beginning of their undergraduate education (Hensel and Cejda 2014; Patton and Hause 2020). Embedding research as part of the course curriculum—using research as a way of teaching and learning—provides community college faculty and students opportunities to be engaged with and contribute to the scientific community. Additionally, this study is a significant contribution to current biology education research literature, as only 3 percent of articles published in the last eight years have been authored by community college faculty (Schinske et al. 2017). CUREs have been formally defined as experiences "in which students address a research question or problem that is of interest to the broader community with an outcome that is unknown both to the students and to the instructor" (Auchincloss et al. 2014, 31).

The Scholarship of Teaching and Learning (SoTL) initiative is a faculty learning community centered on teaching and learning across a variety of disciplines and experience. SoTL has a systematic approach to teaching and learning, in which faculty investigate pedagogical questions pertinent to their own practice and classroom experiences, and outcomes are evaluated and shared with others to enhance the teaching experience and students' learning experiences (McKinney 2006). Participation in this faculty network allowed for design and implementation of a pedagogical study to determine the impact of a CURE over a two-year period, as well as collection and evaluation of data on student outcomes, perceptions, and gains in skills and confidence in a large-enrollment, introductory course for non-STEM majors offered in both seated and online delivery formats, using the Undergraduate Research Student Self-Assessment, or URSSA (Weston and Laursen 2015). The ultimate goal was to develop a meaningful and impactful CURE accessible to introductory students that could be integrated into a large (greater than 50 students) introductory course for non-STEM majors and effective in both seated and online delivery formats. Preliminary work was completed during spring semester 2019, which led to modifications and interventions that were implemented and evaluated during spring semester 2020 (the CURE was completed by midsemester in spring 2020, so it was not affected by the COVID-19 pandemic). The reflective and iterative process of assessment and revision is ongoing and will provide insight into the challenges and strategies of providing an equitable CURE for students to be offered in future terms, including the summer term via an accelerated online format.

CURE Design and Implementation

This study was conducted at an open-door, two-year public institution that is part of a statewide college and university system. Enrolling more than 12,000 students annually with an average student-to-faculty ratio of 33:1, this institution has two campuses that serve suburban and rural student populations, respectively. Approximately two-thirds of students are under age 25, and 21 percent of students are BIPOC. A variety of UREs are offered in multiple disciplines, both integrated into course curricula and as independent research opportunities mentored by faculty. As a member of the Council on Undergraduate Research, the college adheres to the organization's statement that "faculty members enhance their teaching and contribution to society by remaining active in research and by involving undergraduates in research, and students succeed in their studies and professional advancement through participation in undergraduate research" (CUR n.d.).

The focal course was an introductory environmental science course that introduces basic characteristics and dynamics of ecosystems and explores effects of increasing and changing human demands on the environment. There are no prerequisites for this course, and it fulfills two goal areas within the state transfer curriculum. It is a popular course among students of all backgrounds, abilities, and academic pathways. Multiple sections are offered each term, and several faculty in the Biology Department have experience teaching this course. The course is offered both fully seated and fully online, and the author teaches both content delivery formats. Maximum enrollment for the seated course is 60 students, and each section of the online course has up to 35 students.

TABLE 1. Summary of Classroom Implementation for WildCam Gorongosa CURE

Week	Task/Assignment	Brief description
1	WildCam Gorongosa introduction and data collection	Students practice identifying African animals from camera trap images and submitting data on the WildCam Gorongosa platform on Zooniverse.
2	History of Gorongosa National Park	Students learn about the history and ongoing restoration effort through an online interactive tool, readings, and videos (HHMI BioInteractive n.d.).
3	Ecosystems of Gorongosa National Park	Students explore factors that may influence populations of individual species or entire communities. They explore potential independent variables and brainstorm about how those factors influence potential dependent variables.
4	Scientific inquiry: questions, hypotheses, predictions, and variables	Students work collaboratively once they have identified variables to ask an original question and formulate a hypothesis and prediction that will become the basis of their research projects.
5	Data analysis: data summaries	Students learn to manipulate spreadsheets with a large amount of data.
6	Data analysis: figures and tables	Students use data summaries to produce tables and figures for presentation. Extension: Students may do inference testing using statistical methods.
7	Data interpretation and conclusions	Students create a scientific research poster. Patterns in the data are explained using ecological mechanisms and concepts that are course core content.
8	Peer review of posters	Students peer review posters from other groups to critically evaluate writing, data analysis, and visual display. They revise their own posters using peer review comments.
9	Poster session/ symposium	In a class poster session or virtual symposium online, student researchers answer questions from students and faculty. Students submit feedback for other groups' posters and peer evaluations of group members' contributions to the entire CURE.
	College-wide presentation at student OSCARS event (optional)	Extension: students revise posters based on feedback from the symposium and present their work at the college-wide Outstanding Scholarship, Creative Activities, and Research Symposium (OSCARS) recognizing significant student work in all disciplines.

The embedded CURE uses the WildCam Gorongosa platform (Zooniverse n.d.) and associated resources that are freely available online (HHMI BioInteractive n.d.). Those resources have been significantly modified, and additional classroom activities also were designed. Students work in long-term collaborative groups (four to six students) that are formed and assigned at the beginning of the term. Throughout the first half of the semester, they accomplish tasks each week that guide them through investigating an original research question using the scientific process (see Table 1). Students in the seated section have one dedicated class period of 50 minutes per week ("research day") to work on project tasks. They receive handouts, verbal explanations, demonstrations, and guidance from the instructor during class as they work together in collaborative groups during this class period. Online students work together to complete the same tasks asynchronously each week; these online students receive detailed written instructions with embedded links, and their collaborative space is a discussion forum within the institution's online course learning management system. Upon completion, undergraduate research projects are presented as formal scientific research posters in a classroom symposium: an in-person poster session for the seated course and a virtual symposium for online students. Students also have the opportunity to take peer and faculty feedback and prepare for a college-wide undergraduate research symposium near the end of the semester.

SoTL Design and Methods

This SoTL project used a cyclical design, evaluation, and redesign method that allowed thoughtful and thorough investigation of the impact of a CURE for introductory-level undergraduates from the perspectives of improving both teaching and students' learning. The SoTL project was explained to all students, and student participation in the SoTL study was voluntary, although all components of the CURE were required and graded components of the environmental science course.

At the beginning of the term, students completed a pre-project survey using the URSSA (Weston and Laursen 2015). The URSSA is a tested and validated web-based survey instrument for evaluating student learning outcomes of UR. The survey questions focus on comfort or confidence with scientific skills and data literacy, as well as attitudes and behaviors associated with scientists and scientific research (survey questions are presented in Table 2). Students then worked through the CURE over the first half of the semester. Upon completion of the CURE, students completed a post-project URSSA. Changes in scientific literacy, attitudes, and behaviors over the duration of the CURE as well as self-assessed proficiency in these areas were then evaluated after the CURE.

Changes in comfort/confidence and abilities/attitudes evaluated in the URSSA were assessed for students

TABLE 2. Changes in Responses to Pre- and Post-Project URSSA in Spring 2019 and Spring 2020

	Spring 2019		Spring 2020	
	Online (n = 7)	Seated (n = 6)	Online (n = 11)	Seated (n = 21)
Thinking and working like a scientist[a]				
Figuring out the next step in a research project	0.14	0.83*	0.55	0.29
Formulating a research question that can be answered with data	0.29	0.83*	0.36	0.43
Identifying limitations of research methods and designs	0.57	0.50	0.55	0.62***
Understanding the theory and concepts about population and community ecology	0.29	1.33*	0.73	0.67***
Understanding the connections among scientific disciplines	0.14	1.17*	0.55	0.76**
Personal views related to research[a]				
Confidence in my ability to contribute to science	0	0.83*	0.27	0.14
Comfort in discussing scientific concepts with others	0.86*	0.83	0.73	0.05
Scientific skills and literacy[a]				
Making oral presentations	0.71***	1.00**	0.55	0.19
Explaining my project to people outside my class	0.29	0.50*	0.36	0.48**
Preparing a scientific poster	0.86	1.67**	0.36	0.14
Using statistics to analyze data	-0.14	0.33	0.27	0.57***
Formulating a testable hypothesis and prediction	0.29	0.83*	0.45	0.41
Organizing, analyzing, and interpreting quantitative data and scientific information	0.14	0.67	0.82	0.40*
Creating graphical representations of data	0.29	0.83*	0.64	0.43*
Reading and interpreting graphical representations of data	0.29	0.33	0.55	0.76****
Justifying inferences, predictions, and conclusions based on quantitative data	0.43*	0.83*	0.73*	0.43*
Research experience and attitudes[a]				
Engaging in real-world science research	0.29	0.83*	0.27	0.33
Feeling like a scientist	0.29	0.17	0.64	0.43*
Trying out new ideas or procedures on my own	0.286	0.500*	0.636	0.238
Future role of scientific research[b]				
Doing research clarified for me which field of study I want to pursue	-1.143	-0.667	-1.091*	0.286
My research experience prepared me to transfer from a two-year to a four-year institution	-1.714*	0	-0.727	0.571
My research experience prepared me for a job	-0.857	0.333	-0.363	0.667*
Future education and career plans[c]				
Completing my associate's degree	-0.571	-0.500*	0.091	0

Note: Student responses were provided on a Likert scale on both pre- and post-project surveys; positive changes indicate gains over the duration of the CURE. Pre- and post-project survey responses were evaluated using a one-tailed paired t-test, $\alpha = 0.05$. Only survey items with significant change were included. All data are available and can be obtained from the author. URSSA = Undergraduate Research Student Self-Assessment.

[a]How confident or comfortable do you feel about each of the following items (please rate each on a scale from 1 = very uncomfortable/lack confidence to 5 = very comfortable/confident).

[b]How much do you agree or disagree with the following statements (please rate each item on a scale from 1 = strongly disagree, 3 = neutral/no opinion, to 5 = strongly agree).

[c]How likely do you think you are to (please rate each item on a scale where 1 = not more likely, 3 = extremely more likely).

*$p < 0.05$, **$p < 0.01$, ***$p < 0.005$, ****$p < 0.0001$

who completed both the pre-project survey and post-project survey in spring 2019 (online $n = 7$, seated $n = 6$) and spring 2020 (online $n = 11$, seated $n = 21$) using a one-tailed paired t-test ($\alpha = 0.05$). Post-project URSSA responses were evaluated separately for students in spring 2019 (online $n = 14$, seated $n = 16$) and spring 2020 (online $n = 23$, seated $n = 16$) using a two-sample t-test ($\alpha = 0.05$). Analysis of outcomes from spring 2019 guided the development and implementation of interventions in spring 2020, with the goal of achieving equitable CUREs for students, independent of course delivery format.

Iterative Evaluation

In spring 2019, changes in scientific literacy, attitudes toward science and research, and evidence-based decision-making varied between treatment groups, with seated students generally showing greater gains in literacy (see Table 2) and rating their abilities and confidence after project completion higher in several different areas evaluated by the URSSA (see Figure 1A). Although online students did learn and gain confidence and proficiency over the duration of the CURE, there were clear disparities, and additional interventions needed to be implemented to make the CURE equitable for online students. Instructor demonstrations, in-person assistance, and synchronous student collaboration are very important in the research process, and those components were not well represented in the online section in spring 2019. As a result of student comments and reflection on the differences seen in spring 2019, it became clear that components that increased both individual engagement and group collaboration were lacking in the online environment, hindering the ability of online students to actively understand and participate in the steps of the scientific process. The interventions that were subsequently developed and implemented included video tutorials, synchronous instructor demonstrations, and group conferences. These tools were implemented in the online section for spring 2020. Although gains in scientific literacy, attitudes toward science and research, and evidence-based decision-making still varied and were more prevalent for seated than online students in spring 2020 (see Table 2), the significant differences in post-project self-assessment seen between the two groups in spring 2019 were not evident in spring 2020, after the additional interventions were implemented for the online group (see Figure 1B). Although significant changes in pre- and post-project assessment scores are valuable for informing decisions about interventions to enhance students' experiences, student participation in the surveys was voluntary and resulted in a small sample size. Additional, more comprehensive evaluations of students' experiences in CUREs in both online and seated courses will be conducted in future semesters.

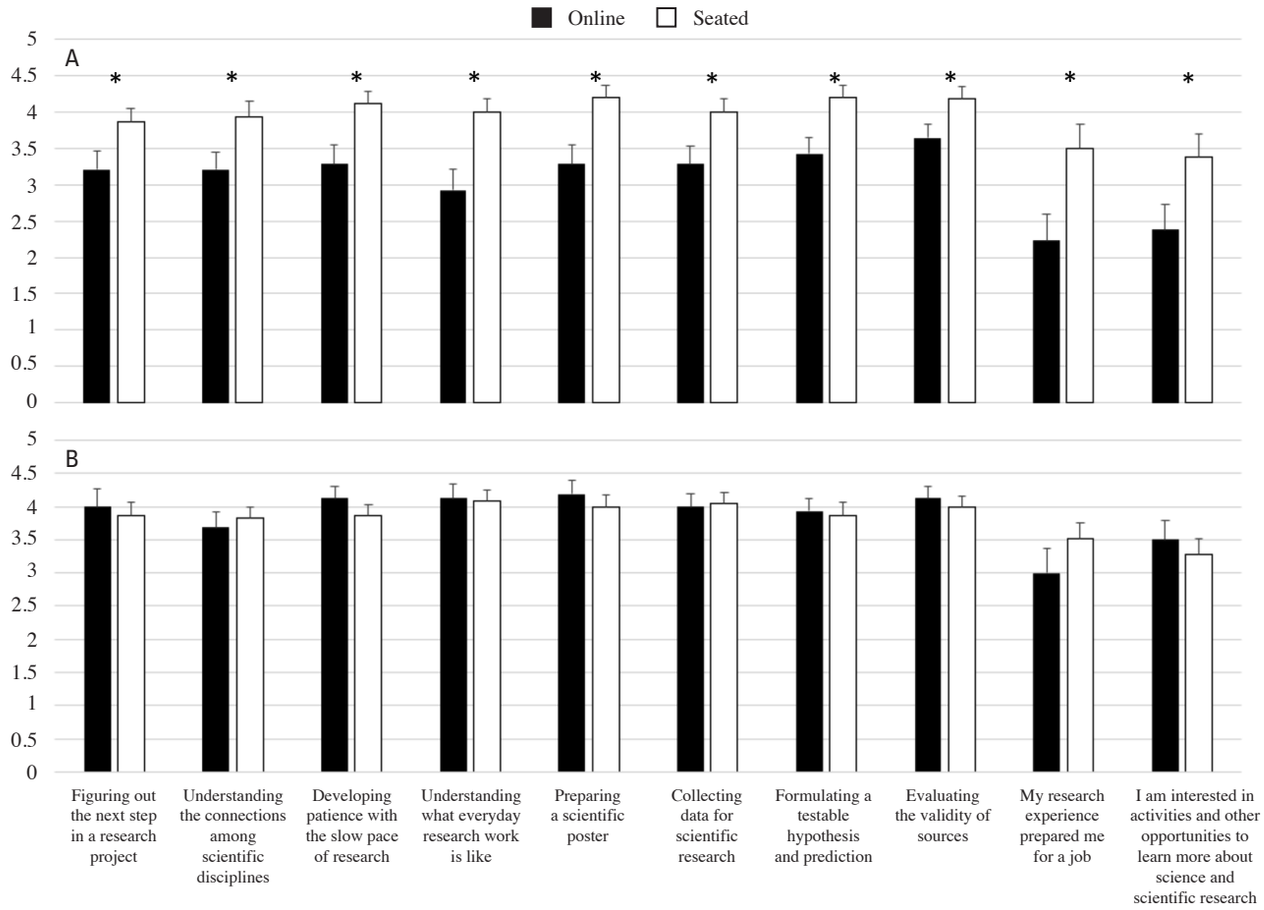
Impact

The overall goal of this project was to provide an impactful and meaningful CURE for a large and diverse group of students enrolled in an introductory biology course for mostly non-STEM majors and for the CURE to be accessible and equitable for students, whether they elected to enroll in a seated or online section of the course. Providing a CURE is different from more individual-based mentored UR (e.g., Auchincloss et al. 2014), and although the scope of research is limited due to time constraints and the range of student backgrounds, the benefits for providing these opportunities significantly outweigh the challenges in planning and implementation of the CURE (e.g., Alkaher and Dolan 2014; Corwin, Graham, and Dolan 2015). Broadening participation in UR can increase mentoring and collaboration opportunities, promote students' identities as scientists and researchers, reinforce science as a process, and increase students' conceptual understanding and communication of science. Expansion of UR opportunities to introductory courses and two-year colleges will result in a much greater number of students learning crucial critical thinking and scientific process skills earlier in their educational programs, which will build their confidence and set them up for long-term success as they pursue their degrees and careers (Brandt and Hayes 2012).

The process of designing a highly scaffolded CURE that is accessible to introductory students in both online and seated courses is challenging; however, it offers tremendous potential for increased student engagement and success (Grabowski, Heely, and Brindley 2008). Introductory students benefited from working collaboratively in long-term groups; after the first iteration and assessment in spring 2019, the importance of the verbal explanations, demonstrations, and synchronous discussions to the success of the CURE and student achievement became clear. Overall, both seated and online students worked through the CURE using similar protocols with the same goals and benefits inherent in the scientific process but differed in their means of collaboration. Online students consistently reported communication as a challenge during spring 2019. Students found working asynchronously difficult, identified scheduling conflicts as obstacles, and recognized the value of synchronous collaboration.

Providing opportunities for all students both to listen to and watch instructor explanations and demonstrations (either live or recorded) and to collaborate synchronously with other students were important components for reducing disparities in students' post-project URSSA responses. Communication in an online environment continues to be a challenge, yet providing opportunities and structure for collaborative spaces and synchronous discussions helped students feel connected and successful. After these interventions were implemented, students were more positive about communication and collaborative work and recognized positive outcomes of the CURE.

FIGURE 1. Mean (± Standard Error) Post-Project URSSA Responses for CURE Implemented in (A) Spring 2019 and (B) Spring 2020



Note: URSSA = Undergraduate Research Student Self-Assessment; CURE = course-based undergraduate research experience. URSSA responses were based on a Likert scale (0 = low, 5 = high). Sample sizes were the following: spring 2019 (online n = 14, seated n = 16), spring 2020 (online n = 23, seated n = 16). Spring 2020 included the additional interventions integrated for online students.
*Significant differences between sections (two-sample t-test, $\alpha = 0.05$). Complete post-project survey results can be obtained from the author.

As assessed by changes in student URSSA responses before and after the CURE, improvements in science literacy and evidence-based decision-making, attitudes toward science and research, and understanding of the role of research in education and career were present, yet not consistent. Gains were more prevalent for seated than online students in both 2019 and 2020. This is interesting, as there were no significant differences between seated and online students in their self-assessed confidence and proficiency at the end of the CURE in spring 2020. Students self-selected to enroll in the seated or online section of the course, and online students may already have had skills and experiences that were relevant and beneficial, such that gains over the duration of the CURE were lower than for the seated students. This leads to the next iteration of revisions and modifications to the CURE; assignment instructions and tasks will be modified to increase their effectiveness in improving outcomes for both seated and online students. All students consistently reported positive experiences with the CURE as well as the inherent complexity and value of the scientific process. When asked about the greatest benefit provided by the CURE, student responses were thoughtful and insightful. Several students recognized the relevance and value of the scientific process and its application to problem solving in other fields and reported an increased appreciation for environmental issues. Another theme that emerged from student responses was preparation for future courses and careers, and non-STEM majors gained confidence and felt much less intimidated by science.

Because the sample size for students who participated in this SoTL study was small (participation was voluntary), there is limited statistical power in the quantitative results. However, the greatest value of the results is that they qualitatively demonstrate that UR provides a meaningful experience that contributes to student engagement and success and that it is perceived as important for future educational and career goals. As such, it accomplishes the overall goal of the CURE, although the reflective and iterative process of evaluation and improvement will be

continued in future terms. A limitation of this study is that the impact of the CURE on BIPOC, underresourced, and first-generation students cannot be parsed out; these data will be collected and analyzed in future studies. In a question integrated into the final exam at the end of each semester, students are asked for their views on the most memorable and impactful component of the course. The majority of students respond with a statement that references the CURE, what they learned, or how much they enjoyed participating as a citizen scientist for WildCam Gorongosa. Students clearly enjoy identifying pictures and investigating questions about African animals in an ecosystem unfamiliar and exotic to them.

Although WildCam Gorongosa represents one citizen science project available on Zooniverse, the structure for this CURE may easily be adapted and modified for other Zooniverse projects (e.g., Snapshot Safari, Eyes on the Wild) or a wide variety of other data sets that also are publicly available. Students in introductory, nonmajor courses with large class sizes and multiple delivery formats are very capable of learning and following the scientific process, but they benefit greatly when that process is thoroughly scaffolded and provides opportunities for assessment and feedback along the way. This "learning by doing" pedagogical model also can help reduce performance gaps between students from diverse backgrounds and experiences (e.g., Freeman et al. 2014) in addition to providing students with the opportunity to learn science actively by actually *doing* science. Guiding students through the CURE also offered the instructor the opportunity to work with students in small groups, which influenced and developed rapport and a positive learning environment in the classroom, even when that classroom was in a virtual space. In addition to small-group (rather than individual) mentoring by faculty, collaborative student-student interactions are another important component of CUREs (Bhattacharyya et al. 2020).

Conclusions

Iterative evaluation and improvement in how UR is integrated into the learning experiences of non-STEM majors in introductory courses across multiple delivery formats will contribute to the development of best practices for broadening participation in UR in a wider variety of courses and institutions and provide an inclusive and equitable experience for all students (Bangera and Brownell 2014; Staub et al. 2016). Although there are extensive examples of UR opportunities in STEM fields, introductory courses and non-STEM students also can benefit from these experiences (e.g., Bhattacharyya et al. 2020; Schuster 2018). Projects integrated into course curricula that are supported by institutional commitments to UR will ensure that UR continues to be a part of students' learning experiences. It is imperative that there is additional work focused on implementing and assessing UR experiences as well as sharing that information broadly, such that innovative solutions and best practices can be established for providing increased UR opportunities (Crowe and Brakke 2008). This study provides evidence that a CURE can be effectively implemented in large introductory courses offered both in person and online. Institutional structures that encourage and support the development and implementation of similar efforts will have a significant impact on broadening participation in UR by large numbers of students early in their undergraduate experiences.

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ASSESSMENT

Development and Assessment of an Undergraduate Research Program at a Two-Year, Rural, Hispanic-Serving Institution: The Essential Role of Partnerships

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Abstract

Yakima Valley College—a two-year, Hispanic-serving institution in south-central Washington state—partnered with four-year universities, agricultural centers, businesses, and federal and state agencies to develop a streamlined undergraduate research experience in which students work closely with a faculty mentor in a science, technology, engineering, or mathematics (STEM) field on summer projects of 120 hours each. Assessment metrics reveal high transfer, graduation, and/or continued enrollment rates for research participants as well as increased student perceptions in thinking and working like a scientist, personal gains related to research work, and skills. Faculty also benefited as indicated by high rates of return to the program. This article reviews the importance of multiple stakeholders in program development, including the essential role of university and community partnerships.

Keywords: *community colleges, student outcomes, undergraduate research, university partnerships*

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Community colleges play an essential role in the rate of bachelor's degree attainment, as 52 percent of the graduates who earned their first bachelor's degree between 2008 and 2017 had attended a community college at some point in their college career (Foley, Milan, and Hamrick 2020). Community colleges have an even stronger role in serving traditionally underrepresented minority (URM) groups (Dinh and Zhang 2020). URMs (including Hispanics or Latinos, Blacks or African Americans, Native Hawaiian or other Pacific Islander, and those reporting more than one ethnicity) were all more likely than whites to have attended a community college in the 2008–2017 period (Foley, Milan, and Hamrick 2020). Thus, community colleges are poised to offer opportunities for URMs in science, technology, engineering, and mathematic (STEM) fields (Cohen and Brawer 2014; Van Noy and Zeidenberg 2017), with the community college transfer pathway providing an affordable education avenue for students who otherwise may not have access to STEM degree programs (Dinh and Zhang 2020; Mooney and Foley 2011).

Community colleges are already essential in producing STEM graduates, and the number of students choosing a community college STEM pathway is growing. From 1999 to 2008, the percentage of recent STEM graduates at the bachelor's and master's levels who had attended a community college increased from 41 percent to 46 percent (National Science Board 2012). Unfortunately, although nearly 80 percent of first-time community college students begin with the goal of earning a bachelor degree or a higher-level credential (Horn and Skomsvold 2011), these students have a lower probability of success than those who begin at four-year institutions (Bahr et al. 2013; Wang 2015), perhaps because of challenges in building academic momentum in community college settings (Attewell, Heil, and Reisel 2012).

One high-impact practice that increases the likelihood of perseverance of both STEM and URM students is a mentored undergraduate research experience (URE; Dinh and Zhang 2020; Eagan et al. 2013; Hernandez et al. 2013; Russell, Hancock, and McCullough 2007). Among the multitude of reported benefits, UREs help clarify interests in STEM careers, increase confidence in research skills

and expectations of obtaining a PhD, as well as resulting in gains in independence, intrinsic motivation to learn, and active participation in subsequent courses, particularly for transfer and URM students (Carpi et al. 2016; Dinh and Zhang 2020; Espinosa 2011; Graham et al. 2013; Lopatto 2017; Russell, Hancock, and McCullough 2007). A faculty-mentored URE can also enhance transfer students' academic and social adjustment to four-year institutions (Lopez and Jones 2017).

Given their positive impacts, UREs at community colleges could serve to improve retention of URMs in STEM by addressing lagging interest in STEM fields and providing meaningful preparation for research at four-year institutions (Goldrick-Rab 2010). Unfortunately, UREs at community colleges remain rare despite National Science Foundation (NSF) funding to support UREs at primarily undergraduate institutions. For example, over 27 years of NSF Research Experiences for Undergraduate award funding, only about 2 percent of recipients were associate-level institutions (Barney 2017). The low rate of UREs at community colleges represents a lost opportunity for students and for improving the STEM pipeline to four-year institutions. The cost of this lost opportunity is further magnified by the demographic reality that, as previously noted, nearly half of all undergraduates attend a community college at some point in their college career, and most of these students are URMs or from low-income backgrounds (Ma and Baum 2016).

One method of overcoming potential barriers to creating URE programs at community colleges is to form collaborations between two- and four-year institutions. For example, both Barber and colleagues (2020) and Hirst and colleagues (2014) undertook five-year partnerships in suburban-urban communities (i.e., two Hispanic-serving institutions [HSIs] in the Houston area and a partnership in southeastern Massachusetts, respectively) in which community college students were placed on research teams either led by or co-mentored by faculty at the four-year institution. This article presents an overview of an eight-year effort to establish a URE at a two-year HSI in a primarily rural, agricultural area. Like Barber and colleagues (2020) and Hirst and colleagues (2014), the role of partnerships, particularly with regional four-year institutions, was essential in the development of the program discussed here. However, in contrast to the previously cited programs, the majority of student and faculty participants in the current program conducted their research independent of partner four-year institutions.

Research Program Structure, Funding, and Assessment

College Context

Yakima Valley College (YVC) is a two-year college located in the agricultural region of south-central Washington state with a full-time enrollment of approximately 4,000 students. One-third of the students seek two-year transfer degrees. YVC's student population is 83 percent first-generation and 71 percent low-income—percentages that exceed the national average for public two-year institutions. With the region's history of intensification of agriculture, the Hispanic student population has grown to 60 percent, and the institution has maintained federal designation as an HSI since 2002. More than 95 percent are commuter students living in the immediate urban area of Yakima or in the rural valleys that extend from the city center. Students intending to pursue a STEM degree at a four-year institution enroll at YVC to complete their first- and second-year general education courses; they are designated STEM Pathway students and complete general education requirements as well as multi-quarter course sequences in the sciences and mathematics.

YVC's Summer Undergraduate Research Experience (SURE)

The YVC SURE program has developed within a context in which the students and faculty have limited time and resources to contribute to a research experience. In contrast to participants in longer, more intensive UREs offered at four-year institutions, students and faculty in the YVC SURE program commit 120 hours to a project that lasts from three to seven weeks in the summer. Faculty develop single-summer projects or mentor individualized segments of multiyear projects. Each project usually has one mentor and two students. Research during the academic year is exceedingly rare; the faculty teach full time with no contractual research expectations. YVC has approximately 30 STEM faculty with core disciplines that include biology, chemistry, computer science, engineering, geosciences, mathematics, nutrition, psychology, and physics. The majority of SURE students are second-year students, although first-year students are eligible to participate in the program. Over the program's length, 194 students have been enrolled (see Table 1). From 2012 to 2019, students earned a $1500 stipend, whereas faculty received a $3000 stipend; in 2020, the student stipend was increased to $1725.

YVC SURE Program Funding Sources

Funding for the program was initially provided in 2011 by an HSI STEM grant from the Department of Education to Heritage University, a four-year private university on the Yakama Indian Reservation that is approximately 20 miles from YVC. The grant included funds for partnering with YVC to support experiential learning in STEM. Over the five years of that grant, the YVC SURE program was managed by Heritage University with YVC's role expanding from initial identification and recruitment of participating faculty and students to a shared partnership in which YVC managed the growing number of student applications and established standardized goalposts and curriculum, including a requirement of research posters as an end-of-project

TABLE 1. YVC SURE Student and Faculty Information

Program year	Student number	Student demographics	Student success rate[a]	Project disciplines	Returning faculty as a proportion of all faculty
2012	6	No data[b]	No data[b]	Biology, Chemistry	–
2013	10	No data[b]	No data[b]	Biology, Chemistry	3 of 4
2014	15	No data[b]	No data[b]	Biology, Chemistry	4 of 5
2015	18	42% women; 38% URM	88%	Biology, Chemistry, Mathematics	3 of 6
2016	24	33% women; 45% URM	100%	Biology, Chemistry, Engineering, Mathematics, Physics	6 of 12
2017	35	46% women; 47% URM	83%	Agriculture, Biology, Chemistry, Engineering, Mathematics, Nutrition, Psychology	7 of 15
2018	31	55% women; 43% URM	84%	Biology, Chemistry, Engineering, Geology, Mathematics, Nutrition, Physics, Psychology	12 of 16
2019	30	48% women; 48% URM	83%	Biology, Chemistry, Engineering, Geology, Mathematics, Nutrition, Physics, Psychology	15 of 15
2020	25	48% women; 64% URM	88%	Agriculture, Biology, Computer Sciences, Mathematics, Nutrition, Physics	9 of 10

Note: [a]Student Success Rate refers to the percentage of students who are still enrolled at YVC, have graduated and/or have transferred to a four-year institution.
[b]As the SURE program was managed by an external university partner, student-level records were not obtainable.

deliverable, an end-of-program symposium for students to present their work, and student enrollment in a research credit so that liability could be managed and the experience could be formally documented on student transcripts.

In 2016, YVC received NSF S-STEM and Department of Education HSI STEM grants to continue research funding and create a full-time STEM director position that included management of undergraduate research. Expansion of the YVC SURE program was further enabled by a partnership with Central Washington University, a four-year public regional emerging HSI approximately 40 miles from YVC. The partnership with the university included funding for several YVC student and faculty stipends as well as funds to incentivize Central Washington University faculty to share their research facilities and lead activities with YVC students, including instruction in new laboratory techniques. Additional monies were provided by a regional consortium funded by NSF's Louis Stokes Alliances for Minority Participation. Although student and faculty stipends were prioritized, activities also were funded such as weekly "Science & Pizza" seminars where guest speakers presented on STEM-related topics to enhance the research experience and promote cohort cohesion.

SURE Program Assessment Methodology and Results

Program growth was substantial for both students and faculty, and student demographic information indicates that 38–64 percent of YVC's SURE participants were URMs (see Table 1). Student success rate, defined as the percentage of students still enrolled at YVC or who graduated and/or transferred to a four-year institution, was consistently above 80 percent of participants (see Table 1), indicating that the program facilitated educational attainment. In 2019 and 2020, the Undergraduate Research Student Self-Assessment (URSSA) was incorporated into program assessment to evaluate self-reported student outcomes. The URSSA is modeled on the Student Assessment of Their Learning Gains instrument that is available for free public use (Student Assessment of Their Learning Gains n.d.) at www.salgsite.org and is intended for use by undergraduate research program administrators (Weston and Laursen 2015). Items from three constructs—"Thinking and Working Like a Scientist," "Personal Gains Related

to Research Work," and "Skills" (see Table 2)—were completed by a STEM Pathway comparison group in the spring (*n*s = 28 and 18, respectively, for 2019 and 2020) as well as 65 percent of YVC SURE participants after the program was finished (*n*s = 20 and 16, respectively, for 2019 and 2020). The STEM Pathway comparison group consisted of students who had not yet participated in a research opportunity and who were eligible to apply for the YVC SURE program. The item preface was "How comfortable do you feel…," and a 6-point response scale from very uncomfortable (0) to very comfortable (6) was utilized. Cronbach's alphas for items in the three construct areas were 0.89, 0.92, and 0.93, consistent with the ranges reported by Weston and Laursen (2015) who validated the URSSA in a sample of 3671 students across the United States and Canada.

Mean responses for items within each of the three constructs were calculated for each respondent. Response anonymity prevented matching responses between the STEM Pathway and SURE respondents; therefore, independent sample *t* tests were utilized to analyze group differences. Overall, for the combined 2019 and 2020 URSSA data, compared to STEM Pathway students who had not participated in a research project, YVC SURE participants showed significantly greater mean responses on "Thinking and Working Like a Scientist" and "Personal Gains Related to Research Work" items, as well as a marginal trend for higher responses on "Skills" items (see Table 3). These findings occurred in the YVC SURE program despite the fact that the program required only about one-third of the time commitment of a standard URE.

TABLE 2. URSSA Selected Items by Construct

Thinking and working like a scientist
Analyzing data for patterns
Figuring out how to start a research project
Figuring out the next step in a research project
Problem-solving in general
Formulating a research question that could be answered with data
Identifying limitations of research methods and designs
Understanding the theory and concepts guiding my research project
Understanding the connections among disciplines
Personal gains related to research work
Confidence in my ability to contribute to science
Comfort in discussing scientific concepts with others
Comfort in working collaboratively with others
Confidence in my ability to do well in future science courses
Ability to work independently
Developing patience with the slow pace of research
Understanding what everyday research work is like
Taking greater care in conducting procedures in the lab or field
Skills
Writing scientific reports or papers
Making oral presentations
Defending an argument when asked questions
Explaining my project to people outside my field
Preparing a scientific poster
Keeping a detailed lab notebook
Conducting observations in the lab or field
Using statistics to analyze data
Calibrating instruments needed for measurement
Working with computers and software
Understanding journal articles
Conducting database or Internet searches
Managing my time

Mechanisms of Program Development and Success

The YVC SURE program initially began through external funding from a partnership with a private, regional university; and funding from both institutional and community partnerships has been important in contributing to the longevity of the program. The success of the program was also heavily reliant on students and faculty who showed an interest in this opportunity. The sections below provide reflections on stakeholders who were important for this work and the mechanisms that have been vital to program development and success.

Mechanism 1: Student Interest

Undergraduate research has become a regular offering at YVC, and student interest appears to have stabilized across the years. In each of the last three summers, 30 to 40 applications were received, representing approximately 10 percent of STEM Pathway students. Student awareness of the YVC SURE program grew slowly but, in 2017, a multimedia marketing effort was initiated, employing websites, handouts, posters, emails, and face-to-face contact to increase the number of student applicants. These efforts were essential to improving awareness because, as previously noted, 83 percent of YVC students are first generation and likely do not know that college experiences can include research. In Yakima County, only 16 percent of households report earning a bachelor's or advanced degree, far below the state average of 37 percent. Thus, we feel that intentional campaigns to enhance awareness of the benefits of a research experience are a key component in stimulating student interest in research at two-year colleges.

Furthermore, many students completed projects oriented around the campus, community, or local region. Projects included analyzing student use of tutoring resources at YVC, measuring hygienic practices in local restaurants, evaluating local birdsong frequencies, and developing new technologies for local elementary students to experience STEM. These projects are tractable and are appealing to students seeking to connect their work with their community. In addition to the documented value of community-based research, URM students may be particularly motivated by projects with ties to their community (Ashford-Hanserd et al. 2020; Karukstis 2005).

TABLE 3. Student Self-Assessment of URSSA Constructs after YVC SURE Relative to a Comparison Group

URSSA[a] constructs	Survey results for combined 2019 and 2020 data Mean (SD); 6-point scale		Statistical comparisons between comparison group and post-YVC SURE
	STEM Pathway comparison group[b] (n = 46)	Post-YVC SURE (n = 36; 65% response rate)	
Thinking and working like a scientist	4.4 (0.8) CI[c] = 4.162, 4.638	5.0 (0.5) CI = 4.83, 5.17	$t(80) = 4.07$, $p < 0.001$
Personal gains related to research work	4.8 (0.7) CI = 4.592, 5.008	5.1 (0.5) CI = 4.931, 5.269	$t(80) = 2.03$, $p < 0.05$
Skills	4.5 (0.8) CI = 4.262, 4.738	4.8 (0.6) CI = 4.597, 5.003	$t(80) = 1.95$, $p = 0.05$

Note: [a]Undergraduate Research Student Self-Assessment
[b]Comparison group consisted of STEM Pathway students eligible for the YVC SURE who had not yet participated in research. The population size of STEM Pathway students who have not yet participated in research is unknown; therefore, a response rate cannot be calculated.
[c]95-percent Confidence Interval (CI)

Mechanism 2: Faculty Buy-In

Adding research responsibilities to faculty workload at a two-year institution has required the cooperation of multiple levels of college governance. Instructional supervisors, including a vice-president and deans, oversaw faculty workloads, and human resources managed contracts. YVC faculty are contractually obligated to fulfill their full-time workloads entirely by teaching, advising, and related committee work. Research is not mentioned in contracts. In addition, the majority of the faculty holds master's degrees as their terminal degree rather than PhDs. Thus, YVC faculty do not typically maintain research programs, because their skills are invested in the priorities of teaching and advising rather than research activities. Despite these limiting factors, program growth in faculty numbers as well as the high rate of faculty mentors returning to the program (see Table 1) was an essential element to the success of the program.

Several structural advantages in program design supported faculty buy-in. First, faculty with a strong desire for research could opt-into the program with little external pressure for those uninterested in becoming a research mentor. Second, summer teaching loads are lighter and more flexible than those in the regular academic quarter so that faculty could more easily add a few hours to each summer day for research. Third, in personal communication, faculty have commented that summer research is an opportunity to re-engage in their discipline and the cognitive process of doing science—an observation also documented by Osborn and Karukstis (2009). Fourth, research projects focused on the campus community also could contribute to curriculum development for the faculty mentors, allowing faculty to integrate research findings into their classroom work. Finally, faculty were incentivized to participate with a $3000 stipend that was approximately three-quarters of the pay available for a standard five-credit summer course.

Mechanism 3: Partnerships with Universities

Partnerships with four-year universities greatly increased YVC's capacity to support undergraduate research. First, faculty at four-year institutions who often maintain year-round research programs had a deep knowledge of discipline-specific opportunities that the YVC students and faculty could pursue. Second, the expectation of performing research among four-year university faculty typically motivates the pursuit of grants. YVC benefited when colleagues at regional four-year universities included funding for the YVC program to increase the pipeline of STEM students from two- to four-year institutions. As previously noted, the neighboring private, nonprofit Heritage University received a grant in 2011 that included start-up funding for YVC student research. In 2016, the nearest public four-year university, Central Washington University, also secured funding to partner with YVC. This partnership included support for research students and their mentors as well as campus visits and faculty-led science workshops. These collaborations had the additional benefit of building relationships among faculty at both institutions, providing a foundation for subsequent, multiple joint efforts to secure funding that could support student research.

Mechanism 4: Partnerships with Community

Community stakeholders have also been key to the program's success. YVC SURE research projects were supported by agricultural businesses, such as projects on quality assurance assessment of hop products, or projects

requiring that farmers provide access to their apple orchards. Partnerships were formed with governmental organizations, such as the US Forest Service, US Department of Agriculture and the Washington State Department of Ecology, as well as with nongovernmental organizations such as the Nature Conservancy, Northwest Harvest, and the Cowiche Canyon Conservancy (a nonprofit land trust protecting the shrub-steppe habitat). These partnerships involve staff members from the partnering organization providing guidance on key questions, leading field trips, and engaging in lengthy discussions with students about the applicability of their results. In a few cases, these partnerships have led to financial commitments in which individual organizations have funded a student stipend or the continuation of a project further into the summer. Unfortunately, a sustainable financial model is not yet foreseen based on these contributions alone. From the perspective of a business owner or an agency director, funding students for a project is a commitment of finite resources that might be maximized with more conventional strategies like employment at minimum wage.

Lessons Learned

Multiple lessons can be learned from this experience that are applicable to other two-year institutions. First, the program does not mimic the standard URE common at four-year universities. This design was intentional. The financial burden of paying stipends to students and faculty for a research model of 30^{+} hours per week for eight weeks would have substantially limited the number of students that could have been accommodated. Moreover, the program design meets the needs of many students who are balancing the demands of summer school, jobs, and family responsibilities. Second, the STEM faculty represent diverse disciplines with different approaches to research, and they have significant latitude in designing projects that are challenging and educationally fulfilling. Third, program assessment of student outcomes indicates educational achievements such as high continued enrollment at YVC, transfer and/or graduation rates, as well as self-reported increases in constructs such as "Thinking and Working Like a Scientist," "Personal Gains Related to Research Work," and "Skills."

Finally, YVC is an HSI that continues to adapt institutional practices from an "Hispanic-enrolling" institution to a "Hispanic-serving" institution. The "serving" spirit of an HSI-campus is multidimensional (Garcia, Núñez, and Sansone 2019), and YVC has primarily focused on educational metrics to monitor progress. As progress is made in reducing educational achievement gaps, there is much work to be done in nurturing student self-agency and helping Hispanic students identify their futures in STEM careers. Through a combination of one-on-one advising and multiple forms of advertising, high percentages of URMs were enrolled in YVC's SURE. The future challenge is that this model of research still only serves a small fraction of YVC's STEM students; expanding opportunities for more students requires additional financial support and redesigning curriculum to increase the availability of course-based research experiences.

Summary and Future Directions

This article reviews the eight-year development process of an URE at a two-year college. Partnerships, particularly with regional universities, played a key role in securing funding. As further evidence of the value of partnerships, the authors of this article are a mix of personnel from two- and four-year institutions. YVC's SURE has greater stability because its partners are invested in the idea that UREs lead to student success and to greater transfer rates to four-year institutions. The partner institutions expand the ability to secure grant funding. Although the size of the program will likely vary due to fluctuations in funding, it seems highly probable that YVC SURE has a long-term future. Even the constraints imposed by the SARS-CoV2 pandemic did not dim hopes. Faculty and students switched to online projects and persisted through summer 2020, resulting in a successful online student symposium at the end of the program. YVC SURE will continue to adapt to logistic and financial hurdles so that as many students can be served as possible.

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PRACTICE

Institutionalization and Sustainability of Undergraduate Research across Disciplines at a Public, Urban Community College: Successes and Challenges

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Abstract

Undergraduate research (UR) is an integral part of the culture at Queensborough Community College, CUNY (QCC), an urban community college with a diverse student population. Since 2015, more than 400 students participate in undergraduate research experiences each year, working with more than 40 faculty mentors from several academic departments. Although a large proportion of this research occurs within STEM fields, the social sciences, nursing, business, arts, and the humanities are also represented and have increased research activity each year. This article describes the various approaches of QCC to institutionalize, promote, and support UR; approaches to handling the challenging aspects of sustaining UR at a community college; and recent initiatives to expand UR across disciplines.

Keywords: *high-impact practices, institutionalization, partnerships, sustainability, undergraduate research*

doi: 10.18833/spur/4/3/16

Community colleges face a number of unique challenges when establishing an undergraduate research program. Heavy teaching loads and other commitments leave faculty with limited time to pursue their research interests. Community colleges often lack adequate facilities and funding resources to support faculty research. In addition, many nontraditional students face their own barriers to seeking out research experiences: they often have significant work and family obligations, and may not perceive themselves as researchers. These challenges are particularly prevalent at public, urban institutions like Queensborough.

Despite these difficulties, numerous reports show that engaging undergraduate students (including community college students) in research has a strong positive impact on STEM students (President's Council of Advisors on Science and Technology 2012; Brandt and Hayes 2011; Hensel and Cejda 2015) and non-STEM students (Stanford et al. 2017). Recognizing this connection, QCC has developed a well-structured and sustainable program that supports UR in its various modalities (shown in Figure 1).

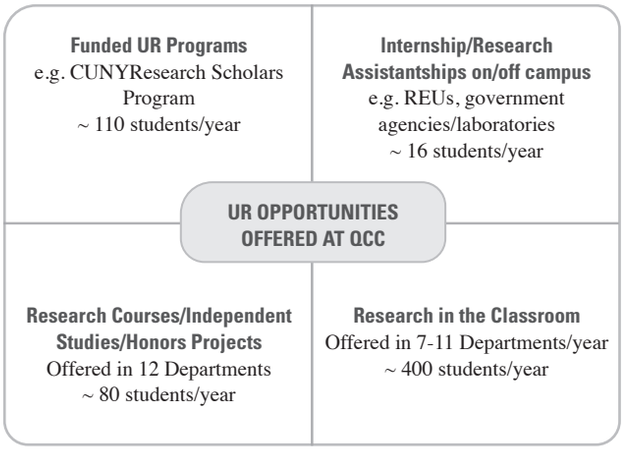
Undergraduate research at Queensborough Community College (QCC-UR) was formally institutionalized in 2014, leading to a larger and more unified presence on campus. This successful expansion has been facilitated by a multifaceted approach that includes a robust administrative support system (at the college and university levels) and several campus programs and initiatives.

About Queensborough

Queensborough Community College (QCC) is part of the City University of New York (CUNY), the largest urban, public university system in the United States. It is located in the northeastern part of Queens—one of the most diverse counties of the nation. QCC's student body reflects the borough's diversity: students come from 130 countries, and 32 percent report speaking a language other than English at home. The college employs about 415 full-time faculty within 17 academic departments. QCC offers 37 associate degree programs, five certificate programs, and for-credit/nondegree programs.

Equally committed to open-admission access and academic excellence, QCC thus supports student learning in innovative ways. For example, the college has institutionalized

FIGURE 1. Research Opportunities Offered at QCC



Note: QCC = Queensborough Community College, CUNY. UR = undergraduate research. REU = Research Experience for Undergraduates. Students may participate in more than one opportunity (e.g., students can be supported by a UR program while taking a UR course).

6 of the 11 high-impact practices (HIPs) described by the American Association of Colleges and Universities (Kuh 2008). HIPs are teaching and learning practices proven beneficial to college students from all backgrounds: some reports suggest that students from historically underserved populations benefit the most (Brownell and Swaner 2009; Finley and McNair 2013; Huber 2010; Kuh 2008; NSSE 2007). Each QCC HIP has a faculty coordinator who works closely with the Center for Excellence in Teaching and Learning (CETL) to promote and support HIPs on campus. Pedagogical and financial support for the HIPs fall under the purview of CETL (CETL n.d.).

The Development of the QCC-UR Program

QCC has had a long-standing history of involving undergraduate students in research, primarily as the result of externally funded faculty-driven efforts. This commitment to UR resulted in numerous publications and presentations at national conferences, as well as multiple student awards.

Participation in CUR's NSF Community Colleges Initiative (Council on Undergraduate Research n.d.) in 2012 helped the Office of Academic Affairs assert its readiness for the institutionalization of UR. UR benefited from de facto inclusion in the college's strategic planning and leveraged the structure and resources already dedicated to support HIPs at the college (CETL office). Additionally, efforts by the CUNY Office of Research to promote and support UR at community colleges provided momentum for the development of QCC-UR.

A multidisciplinary Faculty Inquiry Group (FIG) was charged with jump-starting the research in the classroom modality, developing student learning outcomes, and designing and facilitating professional development training for new faculty practitioners. UR became an official HIP in spring 2014, and the chair of the FIG became the faculty coordinator for undergraduate research and the research integrity officer. Members of the FIG formed the "UR Team" that helped mentor faculty and assisted CETL and the UR coordinator in advancing the UR agenda on campus. In 2016–2018, the UR team was expanded into a Research Committee composed of faculty representatives from each academic department, the library, the Office of Grants/Sponsored Programs (OGSP), the Kupferberg Holocaust Center, and the UR-HIP faculty coordinator. The Research Committee meets monthly and provides a forum for faculty to receive updated information about research events and resources on campus, and to discuss each department's questions, concerns, and suggestions.

The Research in the Classroom (RIC) modality gained further momentum when QCC became a partner college of the Community College Undergraduate Research Initiative (CCURI) in 2016. This modality promotes equity and inclusion in UR, as it reaches a greater number of students than the apprenticeship model (Caplan and MacLachlan 2014) and is not restricted to select students (Hewlett 2018; Shanahan et al. 2017).

In 2018, the college created an Office of Research and established a dean for research position (unique for CUNY community colleges) to provide oversight of all research (including UR) on campus. The dean oversees the OGSP and the Research Committee, directs QCC's CUNY Research Scholars Program (CRSP), collaborates with CETL and the UR-HIP coordinator, acts as a liaison between faculty and administration, and maintains the Undergraduate Research and Office of Research webpages. These webpages highlight student and faculty success and share information about UR opportunities. The dean also ensures compliance with IRB regulations and research training for students and faculty.

The UR-HIP coordinator works closely with the dean for research and CETL to collect information about UR initiatives on campus via periodic surveys, offers UR-HIP training for new practitioners, and arranges gatherings ("checking in" sessions and brown-bag lunch discussions) where experienced UR practitioners share their best practices with others. A timeline of the events that led to the development of QCC's current UR infrastructure is shown in Figure 2; a diagram outlining that infrastructure is shown in Figure 3.

Programs and Partnerships That Support QCC-UR

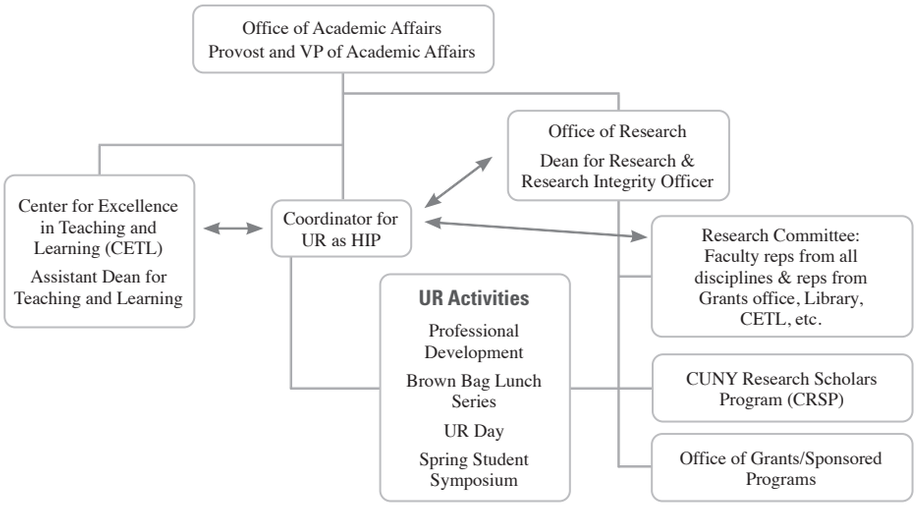
QCC-UR is supported by several grants, programs, and partnerships that provide funding and other resources for both faculty and students. For example, the CUNY Research Scholars program (CRSP) was developed in

FIGURE 2. Timeline for QCC-UR Institutionalization and Sustainability Efforts

Year	Event
2012	CUR Community Colleges Initiative Workshop held at QCC
2013	OAA announced plans to institutionalize UR: five-member Faculty Inquiry Group (FIG) appointed to lead institutionalization efforts
2014	UR is institutionalized as a HIP: Professional development efforts and the research in the classroom (RIC) modality are launched, FIG renamed UR Team The CUNY Research Scholars Program (CRSP) is launched - Cohort 1: 15 QCC students
2015	CRSP Cohort 2: 20 QCC students
2016	QCC participates in CUR's National UR Week celebration CRSP Cohort 3: 30 QCC students UR Team grows into college-wide UR Committee with reps from all departments QCC becomes CCURI College Partner QCC holds 1st Annual UR Day
2017	National UR Week Celebration CRSP Cohort 4: 32 QCC students
2018	National UR Week Celebration QCC establishes its Office of Research and Dean for Research position CRSP Cohort 5: 29 QCC students Purview of UR Committee expanded/committee renamed Research Committee
2019	National UR Week Celebration and QCC's 1st virtual UR Showcase QCC's 1st Student Spring Symposium CRSP Cohort 6: 28 QCC Students QCC's UR Brown Bag Lunch Discussion Series is launched
2020	UR Brown Bag Lunch Discussion Series CRSP Cohort 7: 32 QCC Students 5th Annual UR Day (virtual)
2021	2nd Student Spring Symposium and UR Brown Bag Lunch Discussions Series scheduled (virtual)

Note: QCC = Queensborough Community College, CUNY. UR = undergraduate research. HIP = high-impact practice. CCURI = Community College Undergraduate Research Initiative

FIGURE 3. UR Infrastructure at QCC



Note: UR = undergraduate research. HIP = high-impact practice

2014 by the university to provide paid UR student-mentor opportunities in STEM and social sciences, as well as build a research community on campus. Each year, about 30 QCC students participate in CRSP and present at campus and CUNY-wide symposia (CRSP n.d.).

Several faculty members/teams have obtained external funding that directly supports student research (see Table 1A). The QCC NIH Bridges to the Baccalaureate program has been funding about 15 students per year since 2002. In addition, faculty frequently obtain CUNY grants that support their research and may provide opportunities for students as well (see Table 1A). The OGSP works closely with faculty and the Office of Research to apply for and manage grants.

Many individual faculty members partner with outside organizations and maintain collaborations with other educational institutions to support and sustain their research. Table 1B shows examples of those partnerships and collaborations that have supported UR efforts, as well as government agencies that have hosted QCC student interns.

Activities That Promote UR

QCC has developed several special events and initiatives to support UR on campus, encourage interdisciplinary collaborations and student participation, and celebrate faculty and student UR accomplishments.

Professional Development

Professional development workshops (offered biannually), facilitated by the UR-HIP coordinator and CETL, help both novice and seasoned UR practitioners develop a research idea into a pedagogically sound, student- and learning-centered research experience for students. This approach differs from the more traditional, product-centered view of UR. UR-HIP practitioners may implement their projects as Independent Research courses, Honors projects, and/or Research in the Classroom experiences. Figure 4 shows the impact of UR-HIP trained mentors on student research exposure from 2014–2019.

Undergraduate Research Day

In 2016, a multidisciplinary group of QCC faculty representing biology (Joan Petersen), chemistry (Sharon Lall-Ramnarine), mathematics and computer science (Maria Mercedes Franco), physics (Rex Taibu), and social sciences (Rommel Robertson) attended a CCURI Strategic Planning Workshop. The group decided to plan and implement the first Undergraduate Research Day—a campus-wide event that would bring together UR from all disciplines and in all modalities while celebrating the UR efforts of faculty and students. The first Undergraduate Research Day was held in December 2016 and included a luncheon, student poster session, and networking session. UR Day has become a highly successful annual event that occurs each fall and attracts more than 200 attendees. Participation in UR Day 2020 remained high despite the challenge of having to work remotely since March 2020. The number of UR faculty mentors who participate in UR Day each year remains steady at about 42–50 (Figure 5A). All six STEM departments at the college have been represented each year: participation by non-STEM departments has increased from 2 in 2016 to 5 in 2020 (see Figure 5B).

Brown-Bag Lunch Discussion Series

In fall 2019, QCC-UR launched an informal series of talks where faculty from various STEM and non-STEM disciplines speak about their UR projects and experiences (Office of Research n.d.) These talks provide a forum to encourage interdisciplinary collaborations and foster a greater understanding and appreciation of the various forms of UR across disciplines. Virtual brown-bag lunches in 2020–2021 included discussions of faculty adaptations of their UR projects to an online format.

National UR Week

Since spring 2016, QCC has celebrated national UR week by planning events in individual departments. In 2019, QCC hosted a virtual celebration that highlighted UR projects on the QCC website throughout the week (Office of Academic Affairs n.d.a). The event was shared with CUR to promote UR initiatives.

Spring Student Symposium (SSS)

In 2019, QCC-UR added a springtime campus-wide event that included oral presentations, musical performances, and readings to highlight all student accomplishments, including UR and other HIPs. Seventy-six UR students presented at this event. Although the campus closure forced cancellation of the 2020 event, it will be held virtually in 2021 during UR Week (Office of Academic Affairs n.d.b).

QCC UR Journal

This journal will publish results of student research from all disciplines. The inaugural issue, scheduled to be published in fall 2021, will include literature reviews and research plans of CSRP students who have been unable to do laboratory benchwork during the pandemic (Office of Academic Affairs n.d.c).

The QCC-UR Student Experience

Since QCC offers several modalities of UR across disciplines, students may have extensive research experiences before graduating. For example, a student who is exposed to UR in the classroom may then continue working one-on-one with a faculty mentor, enroll in sequential research courses, and/or serve as a summer intern. CRSP participants are supported for a full year of UR (including summer). QCC-UR events ensure that all participants have at least one or two chances to present their work. In addition to on-campus events and recognition, many

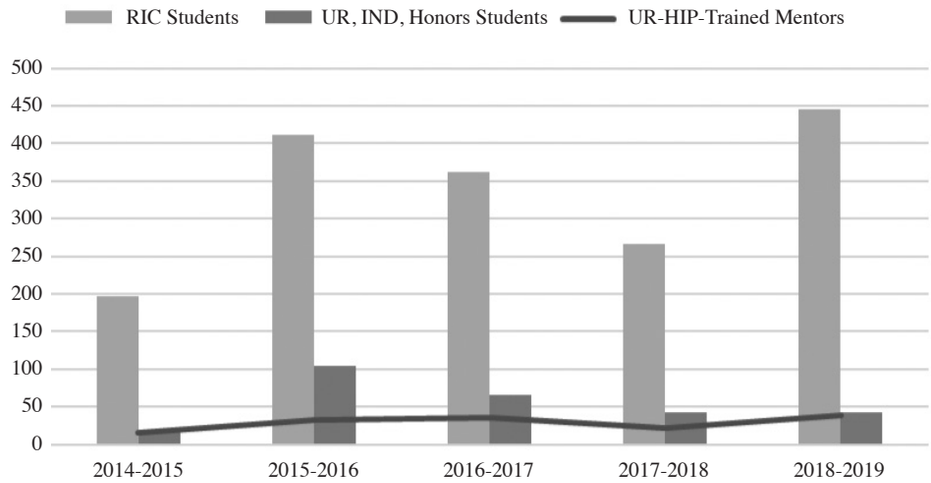
TABLE 1. Select Funding Sources and Partnerships That Support UR

A		Program name	Funding source	Description (students served; year started)
What makes sustainability possible:	Support for UR students	Bridges to the Baccalaureate	National Institutes of Health	URE focused on underrepresentation and transfer to baccalaureate programs in biomedicine or science (15 per year; 2002)
		Science Education Alliance-Phage Hunters Advancing Genomics and Evolutionary Science (SEA-PHAGES)	Howard Hughes Medical Institute (HHMI)	Research in the classroom (up to 25 students per class; 2011)
		Research Experiences for Undergraduates (REU)	National Science Foundation (NSF)	Research in physics, physics education, or interdisciplinary projects in biology, the geosciences, or astronomy (approximately 9 per year; 2014)
		CUNY Research Scholars Program (CRSP)	City University of New York (CUNY)	Year-long, laboratory-based research experiences in STEM and social sciences for associate degree students (30 students in 2019–2020; since 2014)
		CUNY-NASA Solar and Atmospheric Research Program and Education Partnership	National Aeronautics and Space Administration (NASA)	URE focused on underrepresentation in STEM (4 students in 2018–2019; 2015)
		Smart Energy Scholars	NSF	Scholarships for academically talented students who demonstrate financial need, guaranteed transfer to Binghamton University–SUNY (7 students in 2018–2019; 2017)
		Summer Intensive Research Program	CUNY (since 2019)	Trains social science students in research methods (12 students in 2019; 2017)
		The Harriet and Kenneth Kupferberg Holocaust Center	National Endowment for the Humanities (NEH) and fund-raising	Internship/fellowship project areas include archival research, exhibition development, public programming, and social media/marketing (approximately 6 students per year)
	Support for faculty research	Community College Research Grant program	CUNY	Track 1: Collaborative Research Incentive grants; UR student participation highly encouraged. Track 2: Mentored Undergraduate Research Grants (2016)
		Research in the Classroom Fellows Program	CUNY	Supports projects that integrate authentic research in the curriculum (2016)
		William P. Kelly Research Fellowship Program	CUNY	Provides release time for tenured community college faculty (2014)
		PSC-CUNY Research Award Program	CUNY and Professional Staff Congress-CUNY	Created and funded by the Collective Bargaining Agreement between CUNY and the Professional Staff Congress/CUNY, it supports the research and creative works of full-time instructional staff
		Pedagogical Research Challenge Award	QCC	Focused on research projects that impact student learning outcomes

B	Program name	Description
What makes sustainability possible: Partnerships and collaborations	Council on Undergraduate Research (CUR)	The Community Colleges Initiative is a catalyst for institutionalization efforts; offer support for faculty/students presenting at CUR conferences. Showcases UR activities on its national platform (e.g., Undergraduate Research Week)
	Community College Undergraduate Research Initiative (CCURI)	Funds professional development workshops and conferences; supports networking among UR practitioners. Supports and showcases the works of community colleges on the national stage. QCC has been a partner college since 2016.
	Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS)	UR students, faculty, and staff are fully or partially funded to attend and present at its national conference. UR students started a SACNAS chapter in 2016.
	Other	Individual faculty efforts lead to collaborations that help expand the range of UREs in which students can participate. Recent collaborations have involved the Dept of Environmental Protection (DEP), Food and Drug Administration (FDA), Brookhaven National Laboratory (BNL), NYC Parks, and Presencing Institute

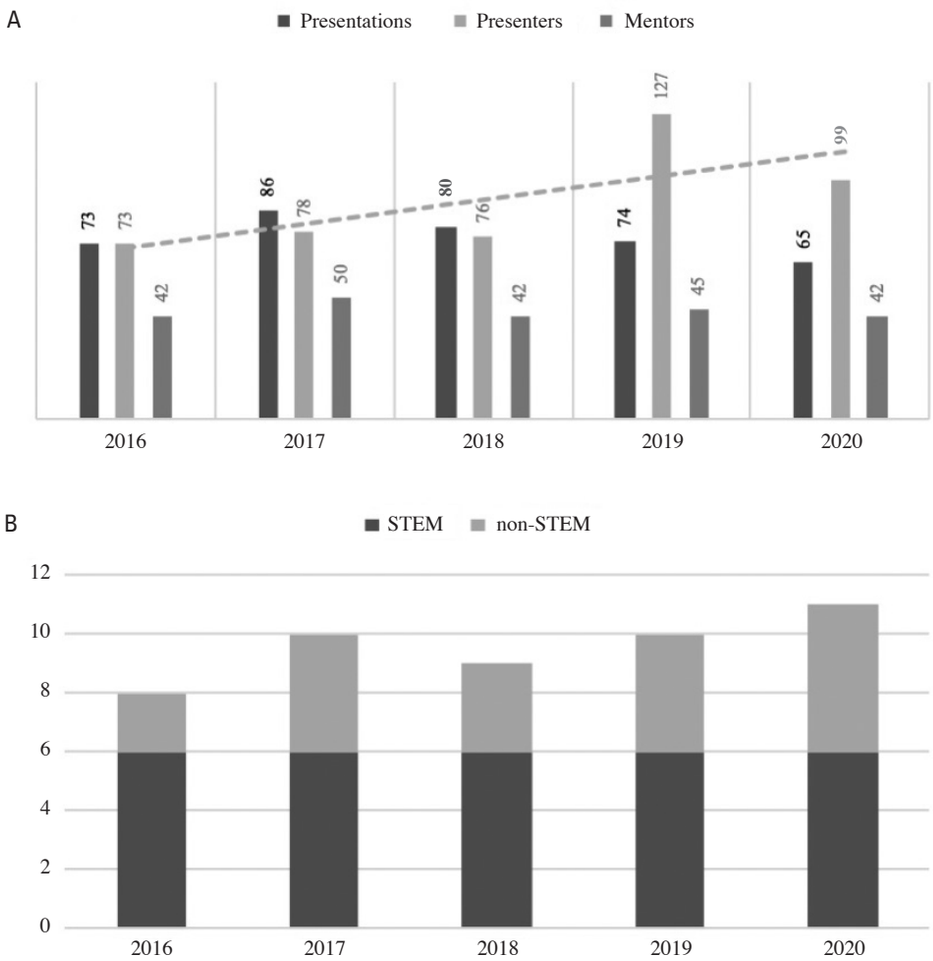
Note: UR = undergraduate research. URE = undergraduate research experience. QCC = Queensborough Community College, CUNY

FIGURE 4. Impact of UR-HIP Trained Mentors on Student Research Exposure



Note: Figure only reflects the number of students who have participated in undergraduate research (UR) with UR-HIP trained faculty either in Research in the Classroom (RIC) or Honors/Independent Research courses. HIP = high-impact practice

FIGURE 5. UR Day Participation, 2016–2020



Note: Number of undergraduate research (UR) students and mentors (A), and number of departments (B), represented at UR Day. UR Day participants do not represent all QCC students who participate in research.

students present and receive awards at regional, national, and international conferences. Travel may be funded by the research grant, the college, and/or by travel scholarships provided by the conference organizer.

QCC-UR students have received significant recognition for their achievements. Each year, QCC-UR students are accepted into Research Experiences for Undergraduates programs at highly regarded research universities (e.g., University of Pennsylvania, Vanderbilt University, and Columbia University) and participate in summer internships in industrial, national, and research laboratories (see Table 1). QCC students also have coauthored several peer-reviewed publications.

As a result of these extensive UR experiences, QCC students are well-trained and highly competitive for opportunities beyond their QCC experience (Office of Academic Affairs n.d.d). Professional organizations, four-year colleges, and graduate programs have recognized the comprehensive UR preparation of QCC students and therefore recruit QCC students for educational and career opportunities.

The QCC-UR Faculty Experience

QCC-UR faculty also benefit from their mentoring experiences. UR practitioners recognize both the personal satisfaction and the positive impact on students, and most continue with this HIP after their first experience. Working with student researchers allows faculty to collect and analyze data that may be presented at conferences, published in peer-reviewed journals, and used to apply for additional funding. They may also publish and present the pedagogical aspects of their UR projects that may then be adopted by others. In faculty focus groups, CRSP mentors mentioned that having year-long support resulted in students who were both better trained and more committed to their research (Nerio et al. 2019). In addition, several UR mentors have been invited to participate in external UR initiatives, further enhancing their own professional development.

The Measurement of UR Impact on Students

Faculty surveys have provided information about the measurement of the impact of UR experiences on students. Individual UR practitioners assess learning outcomes in several ways, including evaluation of laboratory reports, laboratory notebooks, research papers, and presentations. They also use student surveys such as the Undergraduate Research Student Self-Assessment (URSSA), Classroom Undergraduate Research Experience survey (CURE), Survey of Undergraduate Research Experiences (SURE), and Student Assessment of Their Learning Gains (SALG) to track students' self-reported gains. All UR-HIP activities include student reflections. Currently, student assessments and reflections vary by discipline and by individual practitioners; one challenge that remains is developing a universal assessment of all UR experiences across disciplines and for all modalities of UR. Developing and implementing this assessment is planned for the 2021–2022 academic year.

The impact of CUNY's CRSP program, which supports approximately 240 STEM and social science projects per year throughout all CUNY community colleges, has been evaluated (Nerio et al. 2019); the results showed that participants were significantly more likely to graduate (59 vs. 50 percent) in almost all STEM fields. CRSP participants also demonstrated better retention in STEM and were more likely to transfer to research-active four-year institutions. Surveys of self-reported gains revealed that students felt more connected to their college; many attributed this to the efforts of their mentors.

Success and Sustainability

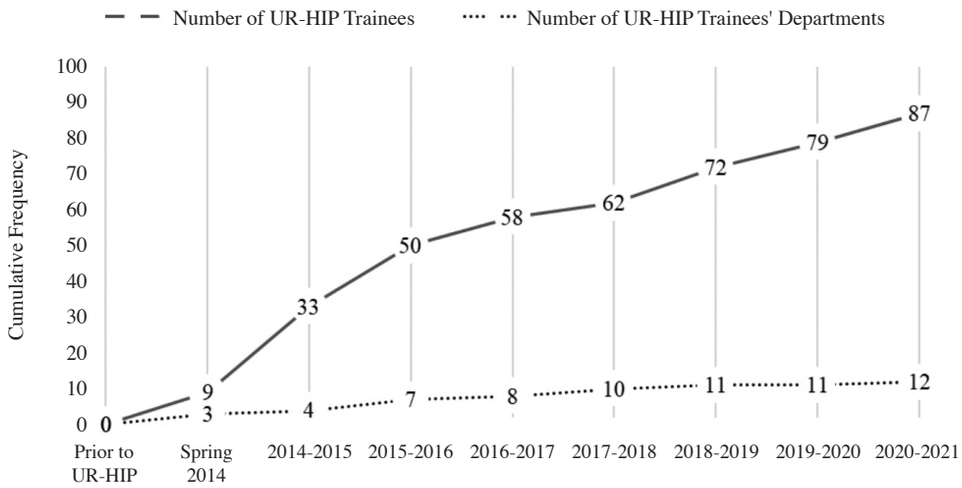
Four main components of the UR program have contributed the most to its success and sustainability:

1. Strong administrative support
2. Faculty buy-in
3. On-campus collaborations
4. External partnerships

Strong administrative support has clearly affected the ability to foster and grow the culture of UR on campus. This includes financial support for UR initiatives and faculty travel; logistical support for promoting UR on campus; and recognition and value placed on UR mentoring in the reappointment, tenure, and promotion process.

Faculty buy-in also has been an integral component of QCC-UR success. The college has adopted an inclusive view of what constitutes UR, recognizes that it can take many forms across disciplines, and encourages an interdisciplinary and transdisciplinary approach. Faculty are given opportunities to attend professional development sessions, check-ins, and other events that offer support throughout the planning and implementation of their UR projects. This has resulted in growth and continuity in UR: about 71 percent of the faculty members (58 out of 82) who have participated in UR-HIP professional development in the period 2014–2019 have continued to implement their UR course designs, affecting large numbers of students. In addition, new faculty continue to attend professional development for UR-HIP each year. To date, 87 faculty members from 12 departments have attended professional development workshops in UR-HIP (see Figure 6). In a spring 2021 UR survey, 23 percent of respondents (40 out of 174) indicated that they have published and/or presented with UR students, or about the impact of UR. In addition, 26 percent of respondents (45 out of 174) are currently implementing RIC or teaching independent research courses. This is consistent with five years of UR

FIGURE 6. Participation in UR-HIP Professional Development Workshops



Note: : UR = undergraduate research; HIP = high-impact practices

Day participation data indicating that, in a typical semester, 40–50 faculty engage in UR. It is remarkable that UR activity is being sustained at this level despite the college's closure and completely remote status for the past year due to the COVID-19 pandemic. The RIC modality has been particularly effective: an average of 400 students engage in RIC in a typical year (see Figure 4).

Another key to QCC-UR's success has been strong collaboration on campus that includes regular, effective communication among all faculty, staff, and administrators involved to discuss ideas, share information, and collectively support UR initiatives. In addition, several external partnerships—including collaborations with professional organizations, educational institutions, and government agencies that support UR—have resulted in countless opportunities for UR faculty and students that would not have been possible otherwise.

The success of QCC's UR model is also demonstrated by the growth of research courses in several departments. Between spring 2011 and fall 2013, the Department of Biological Sciences and Geology offered 1–2 sections per year of research courses (8–9 students): since institutionalization, the department has offered an average of 11–12 sections per year that enroll 39–40 students per year from spring 2014 to fall 2020. In the Mathematics and Computer Science Department, no research courses were offered before institutionalization—the department now offers 9–10 sections per year that enroll 12–13 students. Currently, UR courses are offered in 12 academic departments: Art and Design, Biological Sciences and Geology, Business, Chemistry, Engineering Technology, English, History, Mathematics and Computer Science, Nursing, Physics, Social Sciences, and Speech Communication and Theatre Arts.

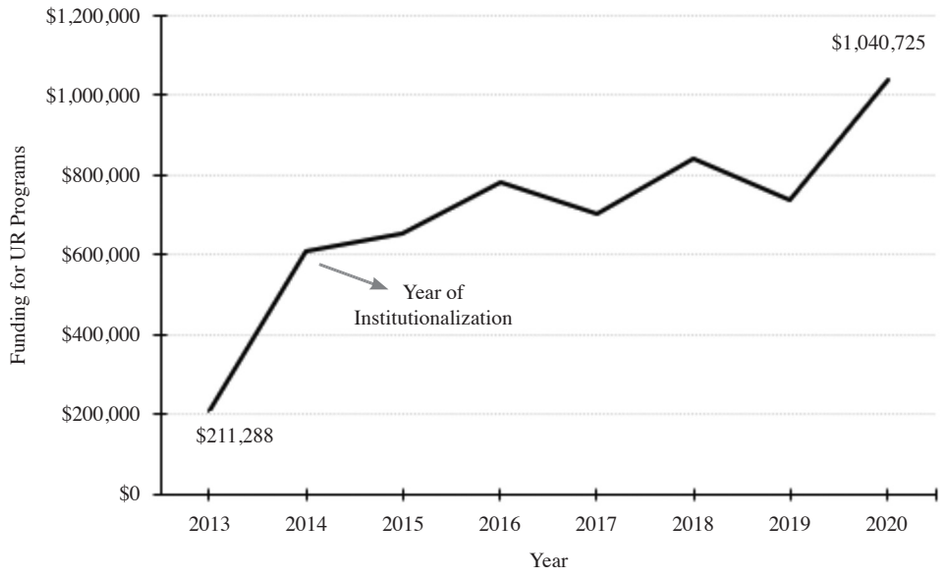
The increased presence of UR on campus also is reflected in the amount of funding that directly supports UR students (see Figure 7). Grants that include direct support for UR students have increased about fivefold from 2013 to 2020.

Challenges and Goals

On a recent faculty survey (spring 2019), the three most prevalent challenges identified by UR practitioners were time (41 percent of respondents, or 23 out of 56), lack of resources (20 percent of respondents, or 11 out of 56), and student readiness (12.5 percent of respondents, or 7 out of 56). Both faculty and students noted several other commitments that limit the time available to work on research. In particular, UR in the classroom practitioners mentioned facing challenges in balancing the research component with course content. Several faculty mentors also reported that the college does not have adequate facilities (lab space, supplies, and equipment) to support their research. Many faculty conduct their research at off-campus facilities, and difficulties with student travel, time schedule, and security access to these remote sites prevents the inclusion of QCC students. Student readiness was also mentioned as a challenge: students may lack the requisite skills needed to engage in research. This presents a unique challenge for course-based research when projects must be balanced with traditional course content, and limited time is available for research training.

Despite these challenges, faculty mentors persist in engaging students in UR, as they recognize the benefits to both students and to their own professional development (Laursen et al. 2010). QCC-UR has remained an integral part of the campus culture even during the pandemic as faculty have continued to engage students remotely.

FIGURE 7. Growth in Funding for UR Programs on Campus



Note: : UR = undergraduate research. The figure reflects funding for programs that provide student stipends.

To address these challenges and increase the number of practitioners across all disciplines, the QCC-UR program seeks to expand the methods of support to faculty and students. Specific program goals include (1) developing a uniform assessment plan to measure the impact of UR and inform future initiatives; (2) promoting UR across all disciplines, with particular focus on the research in the classroom modality; and (3) increasing awareness of UR opportunities (conferences, funding resources, and publications) for both mentors and students, especially in non-STEM disciplines.

Summary

By institutionalizing UR as a HIP, QCC increased and diversified the opportunities for students to participate in meaningful research. The college has successfully grown UR to include authentic research embedded into the curriculum (resulting in an increase in the number of students reached) and created a student-centered and learning-centered approach to UR that stands across disciplines and research modalities. The UR infrastructure that has been built over the years provides students with a strong research background and a valuable skill set that will contribute to their success at a four-year institution and beyond. Recognition of QCC's successful UR program by institutional partners has led to collaborative research and professional development opportunities for faculty as well as scholarly and career opportunities for students. The QCC-UR program has been made sustainable by strong internal support as well as successful partnerships with outside organizations. The successful structure established by QCC can serve as a model for other institutions that seek to create or enhance UR programs on their campuses.

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Joan Petersen is a professor of biology, coordinator of the Environmental Science Program, and the UR-HIP coordinator at QCC. She has mentored many students via the apprenticeship model as well as in course-based research. In addition, she has worked extensively with local high school students and has engaged precollegiate students in course-based research. She is a currently a CUR Biology Division Councilor.

Maria Mercedes Franco is an associate professor of mathematics. In 2013-2014, she co-led institutional efforts that established UR-HIP and launched the research-in-the-classroom modality on campus. Between 2014-2016, Franco served as UR-HIP coordinator and founding campus director for the CUNY Research Scholars Program and was instrumental in securing QCC's participation in CCURI. She is co-principal investigator/co-director of MSRI-UP and CURM, two NSF-funded programs that support UR and address issues of underrepresentation in the mathematical sciences.

Sharon Lall-Ramnarine is a professor in chemistry, faculty fellow for research activities, and research integrity officer at QCC. In 2016–2018, she served as the UR-HIP coordinator and director of the CUNY Research Scholars Program. She was instrumental in creating the Research Committee and Office of Research on campus. She has mentored 35 UR students at QCC and Brookhaven National Laboratory, and coauthored 14 research papers with her mentees.

Shiang-Kwei Wang, vice president of academic and student affairs at Harold Washington College, City Colleges of Chicago, served as QCC's dean for research in 2018–2020. She was responsible for expanding and developing research activities and creative works on campus, ensuring compliance with federal legislation and CUNY policies, and for supporting QCC's research mission. Her research focuses on the impact of new media and technology on learning motivation and performance.

PRACTICE

Research Opportunities for High School Students at the Ocean Research College Academy

Ardi Kveven, *Everett Community College*

Abstract

Providing opportunities for students to engage in undergraduate research is well supported as a high-impact educational practice. Shifting research experience earlier in the undergraduate career provides opportunities for more students to yield gains (both personal and professional) earlier in their career. At the Ocean Research College Academy (ORCA), undergraduate research starts when students are in their third year of high school. As part of a dual credit/enrollment program in Washington state, students earn an associate of arts and science degree when they graduate from high school. With 17 years of data and more than 500 graduates who have compelling matriculation rates and baccalaureate degree attainment, ORCA provides a model for program and course-based undergraduate research replicable by others.

Keywords: *community colleges, course-based undergraduate research, dual enrollment, high school, mentoring, oceanography*

doi: 10.18833/spur/4/3/13

One of the most exciting attributes of providing research experiences for students is the voyage of discovery resulting from their engagement. The research process reveals discoveries not only about the science but about the students as well. For example, students are participating in the emerging trend of studying scat (fecal matter) as a noninvasive means to determine diet, population, disease, and genetics. Sieving and filtering river otter scat samples and teasing out the otoliths (ear bones) of prey items reveals not only fish species but also the presence of soft-shelled crab, eye lenses of fish, microplastics and feathers. Students learn attention to detail, persistence, resiliency, lab and data management skills, networking, and the ability to tolerate certain smells. Although this type of research may be most typical of fourth-year undergraduates or graduate students, it was actually conducted by students in their last year of high school as part of a dual-credit program paired with earning an associate's degree at a community college in Washington state. This is just one example of student research at the Ocean Research College Academy (ORCA) at Everett Community College over the past 17 years.

Dual Enrollment

Engaging students earlier in research and facilitating college attendance has tremendous potential to increase persistence in STEM fields, particularly for underserved students. Dual-enrollment programs (in which students earn high school and college credit simultaneously) have proliferated in community colleges in the last 20 years. Community colleges in Washington state offer multiple dual transcription opportunities for students. The two largest programs, College in the High School (CHS) and Running Start, vary in where the course is taught and by whom (College in the High School is taught in high schools by high school instructors with students paying tuition, and Running Start is taught at colleges by college faculty with tuition covered by the state and students paying course fees). Although the CHS opportunity is often another avenue for high-achieving students with the ability to pay, Running Start could be further utilized by underserved populations (Fink, Jenkins, and Yanagiura 2017). Both programs represent ways for middle-income families to save money, and the momentum built by students with a college transcript carries through to university regardless of whether Running Start students in Washington state enroll at the sponsoring community college or a university.

Everett Community College pioneered the Running Start Program 30 years ago and operates the largest College in the High School program in the state. The majority of credits earned by students is often in social science and humanities (due in part to the need to fulfill remaining high school graduation requirements), and only 11 percent of enrolled students completed the associate of arts and sciences degree. Now more than ever, dual-enrollment programs are recommended to accelerate time to degree completion and reduce costs for families, students, and the state. According to research on dual credit, students with dual credit go on to college and earn postsecondary degrees earlier than students without dual credit (Shapiro et al. 2016). There are limited examples, however, that use undergraduate research in the context of this dual-enrollment educational model.

ORCA Launch

After 14 years of teaching high school students, Kveven combined reflections on effective STEM education that is discovery- and research-based with the emphasis on building a community of learners (Kveven and Searle 2008). To provide greater access to underserved students in STEM (women, students of color, low-income students, and first-generation college attendees), Kveven received a grant from the Bill and Melinda Gates Foundation, which invested $3.36 million in small school programs in Washington state in 2003 based on research from *How People Learn* (National Research Council 2000).

Kveven experienced how central relationships were to student success, particularly for underserved students. Thus, the research-centric ORCA began with a small community of active, responsible, and inquisitive learners, engaging them in pioneering efforts to study the local estuary and share the results with the local community. ORCA planned a two-year program to meet both high school graduation requirements and associate degree requirements. Recent research emphasizes the influence of kindness and community on broadening participation in STEM (Estrada, Eroy-Reveles, and Matsui 2018). This community emphasis at ORCA aligned with high-impact practices (Kuh 2008). ORCA now admits 60 new students annually to a full-time, two-year program that incorporates most of the high-impact practices, starting with a first-year seminar based in the community and undergraduate research conducted as part of a learning community.

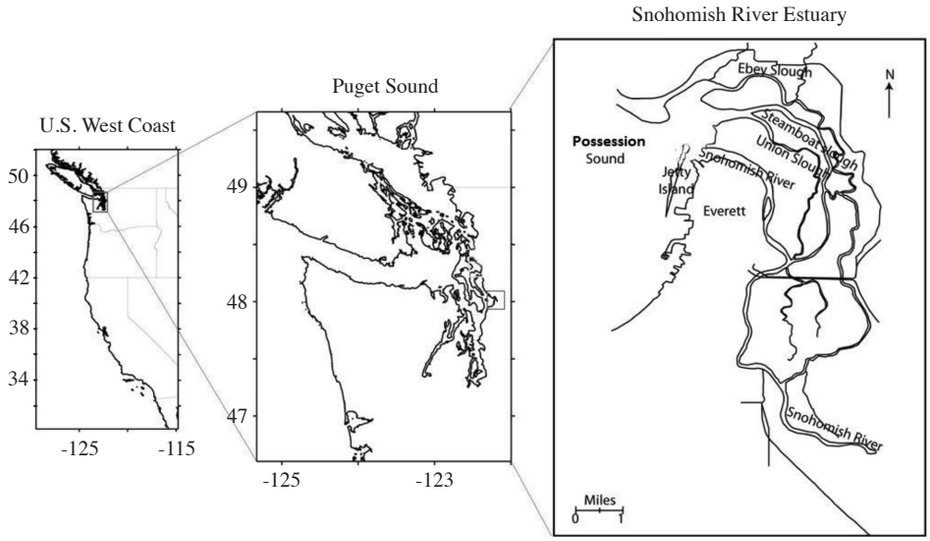
Research Experiences at ORCA

With startup funding and planning time provided by the Bill and Melinda Gates Foundation grant, ORCA designed student learning outcomes around active engagement in research centered on the local estuary. The seminal project that drove student research was developed by Kveven and founding faculty members to engage students in the core academic content while they studied the local marine environment in the field. This one-year course/program undergraduate research experience involves first-year students collecting and analyzing a suite of oceanographic parameters to monitor marine waters and health conditions—a process similar to what is measured by state agencies. By adapting some of the long-term monitoring of temperature, salinity, and dissolved oxygen and pH for the local region, course objectives in Oceanography 101 are met. Expanding research to include biota (plankton, fecal coliform bacteria, seabirds, and marine mammals) incorporated learning outcomes for the Marine Biology 130 course. This project, called the State of Possession Sound (SOPS; see Figure 1), blends course learning objectives in science and mathematics coursework with research skill development and collaborative research (Kveven and Searle 2013). Students apply statistical methods from their mathematics courses to collect and analyze their data. The establishment of longitudinal data provides opportunities for students to ask broad questions about the ecosystem, as they continue to contribute to the long-term database. Most important, however, the program documents the capabilities of high school students when they have the opportunity to do research in a rich, mentored environment. Evolving collaborations include academic institutions, but local and state governmental agencies as well as a local environmental consulting firm have thus far provided the greatest support for the students.

Timely investments and grants supported students in their second year so they could continue to enhance and expand on their first-year research. Support from the National Science Foundation (NSF) from four funding initiatives provided time and support for students to dive deeper into research through a dedicated student research lab, supplies, equipment, faculty time, technical support, student stipends, and a research vessel. The Community College Undergraduate Research Initiative (CCURI) was catalytic in providing sponsored travel so that students could present their research at professional events and inspired ORCA to create the Possession Sound Student Showcase and Talks, a showcase event for the local community. Teaching students how to tell a story and to establish networks are tremendous outcomes from this annual event (see Figure 2). The graph highlights a significant increase of student engagement in original research in the 2014–2020 period, where students build upon the questions they asked during the first year through SOPS and have the resources in place through grant funding and community connections.

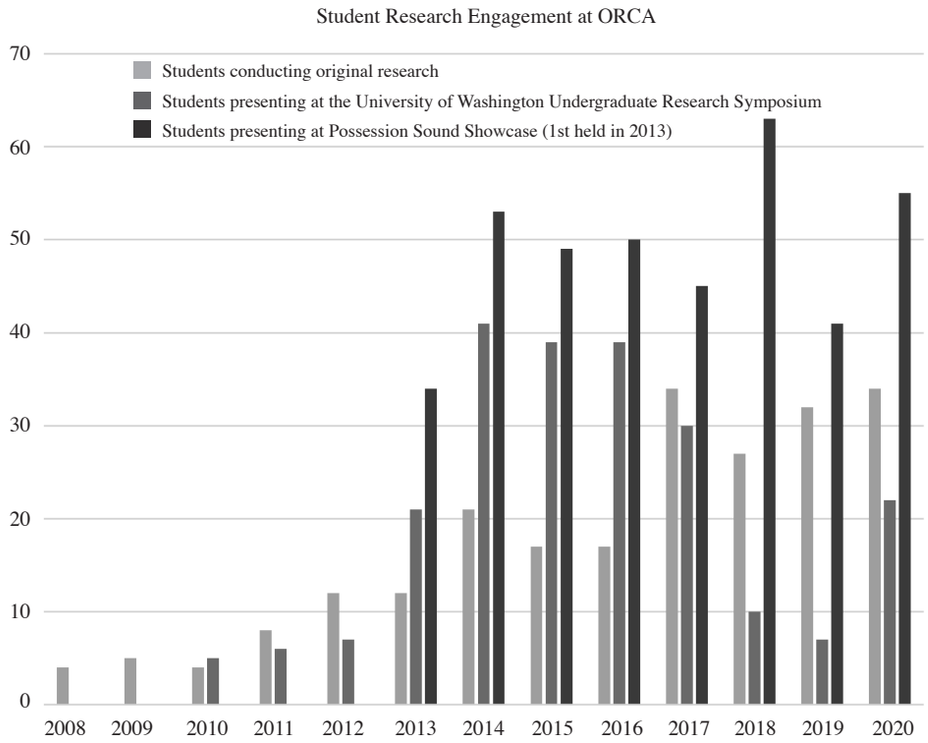
CCURI and NSF grants facilitated sharing the ORCA origin story to continue to garner support for students' work. Another giant leap forward came when the NSF program officer from the student research laboratory encouraged ORCA to submit a proposal for a research vessel. This proposal was funded through NSF's Field Stations and Marine Labs, and for more than six years, ORCA has operated its own research vessel: the custom-built *Phocoena* (see Figure

FIGURE 1. The Region in the Pacific Northwest Known as the Salish Sea, Located North of Seattle



Note: The maps provide details on Possession Sound, the study location for the State of Possession Sound Project (SOPS).

FIGURE 2. Students Engaging in Original Research at ORCA and Presenting Their Work at Symposia



3). This research vessel transformed student research opportunities, as the program was no longer confined to a ferry schedule with a limited sampling route and could work in shallow areas for as long as the students needed (Kveven 2016). This capability continues to enhance the quality and depth of student research questions. More than 34 ORCA students have presented at scientific conferences, predominantly at the Salish Sea Conference, with the following sample research titles:

- Ecosystem Legacy Lead Isotopic Signature in Riverine Sediments in Everett, Washington

FIGURE 3. Custom-Built Research Vessel *Phocoena* (Funded by NSF) on the Waters of Possession Sound with Student Researchers and Author/Captain Ardi Kveven

- Patterns of Heavy Metal Concentration and Distribution in Sediment and Marine Invertebrates
- Effects of Tidal Fluctuations and Current Speed on Variations in Temperature, Salinity, and Dissolved Oxygen in the Snohomish River Estuarine System
- Determination of Tidal Influence on River Otters in Estuarine Systems
- Silicate as a Limiting Nutrient to Diatom Growth in Possession Sound
- Eelgrass Distribution in Possession Sound
- Correlation between Anthropogenic Influence and Microplastic Concentration in Possession Sound
- Plankton Density and Larval Fish Abundance in Possession Sound, Washington

One unique attribute of the type of student-driven original research is that it is not apprentice-type work, where the students participate in an offshoot of the principal investigator's work. These wide-ranging questions put each student in charge, and all instructors support students. The mathematics instructor helps students with visual representation of data and data analysis, often using statistical tools, whereas English instructors support the writing of the capstone research paper. Local scientists provide support and inspiration for students as they develop a wide range of skills that are transferable to any discipline. The previously mentioned student projects represent a wide range of eventual university degrees earned by these researchers. One student is in medical school, another is in veterinary school, one graduated with bachelor's and master's degrees in biochemistry, one double majored in psychology and art, one majored in bioengineering, one graduated in forestry, and another earned a double degree in oceanography and nursing.

Program Outcomes

The large increase in student engagement in original research in their second year of the program comes from grant support providing deliberate time and focus (see Figure 2). The ebb and flow in participation at the University of Washington Undergraduate Research Symposium represent timing and an emphasis on presenting at the Possession Sound Student Showcase and Talks (ORCA n.d.a).

Students have been active participants in providing feedback. Students are in the program for two years, providing qualitative feedback on their experience at the end of year 1 and in the quarter before they graduate. Survey tools have evolved over time from internally developed reflection questions to questions from the Undergraduate Research Student Self-Assessment Survey (URRSA). Faculty review this feedback annually, reflecting on the student experience and using the feedback to enhance the program. Key takeaways from the student narrative include (via self-report):

- Creating curiosity and comfort with asking questions
- Recognizing and appreciating support from faculty and peers
- Developing enhanced skills in working in teams
- Analyzing data
- Building scientific writing skills
- Networking
- Achieving heightened confidence
- Acquiring awareness of the process and nature of science
- Applying learning from the program across disciplines
- Wishing for more boat or field time

Student Outcomes

Since the program's inception in 2003, 86 percent of enrolled students have earned the associate of arts and science (AAS) degree along with their high school diploma as part of the two-year program. The Washington statewide average of AAS degree attainment is 23 percent in three years. Nearly 66 percent of ORCA graduates pursue and earn STEM university degrees. The historically underserved demographics in STEM include 70 percent female enrollment, and more than 33 percent of graduates include students of color, low-income students, and first-generation college students.

Now that a large percentage of ORCA graduates have completed baccalaureate degrees, tracking alumni in the National Student Clearinghouse data is underway. The Institutional Research Office at EvCC provided the following numbers available through the National Student Clearinghouse. Table 1 highlights that 73 percent of ORCA graduates have earned a bachelor's degree. Part of the lag of baccalaureate degree earners could be the amount of time needed for students to earn university degrees. Additionally, finances play a role in time to degree. Continued tracking as each cohort at ORCA advances to university will be ongoing. It would be ideal to capture more of the student gains from the program that last beyond their enrollment.

TABLE 1. National Student Clearinghouse Data of ORCA Graduates and University Degrees Earned

Degrees earned in the period 2005–2016	Number	Percentage
Total ORCA graduates	397	—
ORCA graduates earning a bachelor's degree	290	—
% ORCA graduates earning a bachelor's degree	—	73%
Master's degrees earned by ORCA graduates	46	—
% Master's degrees earned by ORCA graduates	—	12%
Doctoral degrees earned by ORCA graduates	15	—
% Doctoral degrees (includes MD, DVM, PhD, and Pharm D)	—	4%

Due to NSF GEOPAths funding, an external evaluator has also monitored student outcomes in context of the Undergraduate Research Student Self-Assessment Survey (URSSA; Weston and Laursen 2017). Tracking student engagement over time includes the following metrics with three years of participants ($n = 34$). Figure 4 represents the gains made by students in data management (100 percent reported "great gain"), visual representation (91 percent reported "great gain," 9 percent "good gain") and statistical tools (36 percent reported "great gain," 45 percent "good gain").

Each year, ORCA graduates matriculate at local, national, and international universities, where they collectively receive between $200,000 to $500,000 in annual scholarship support to pursue their work at baccalaureate institutions. There have been five ORCA students who have received support from the NOAA Hollings Scholar Award. ORCA alumni have earned NASA Space Grant awards, National Merit Finalist distinction, NSF Graduate Fellowships, the NOAA Nancy Foster Graduate Fellowship, and thousands of dollars of local scholarship support.

The largest NSF grant to date is an IUSE GEOPAths Award, which provides summer research opportunities for students halfway through the ORCA program. The outcomes of this grant include connecting high school students to a wide variety of geoscientists to increase their awareness of geoscience careers, build mentoring relationships to increase the number of underserved students in STEM fields, and facilitate student use of big data as they increase their understanding of the local estuary. Students develop exciting original research projects with mentoring and network support and include cutting-edge sampling in the estuary. For example, two students who were interested in engineering engaged with a program partner on a vertical profiling project from the ORCA's research vessel. Given the pycnocline (density gradient) movement due to tidal exchange and river flow, the students envisioned horizontal profiling as the boat moved through the water at 18 knots. With another collaborator (and dedicated research time due to the GEOPAths grant), these students participated in the design, welding, and fabrication of a device that pumped water over a probe to monitor the parameters and create a geospatial map of the data taken every quarter of a second. One of these students received a NASA Space Grant scholarship, and another is now studying at the University of Munich.

The validation provided by the multiple investments by NSF and the invitation to share ORCA's work while emphasizing these student demographics is encouraging and provides further motivation to target this emerging population of potential researchers and adapt the strategies used successfully for nearly two decades.

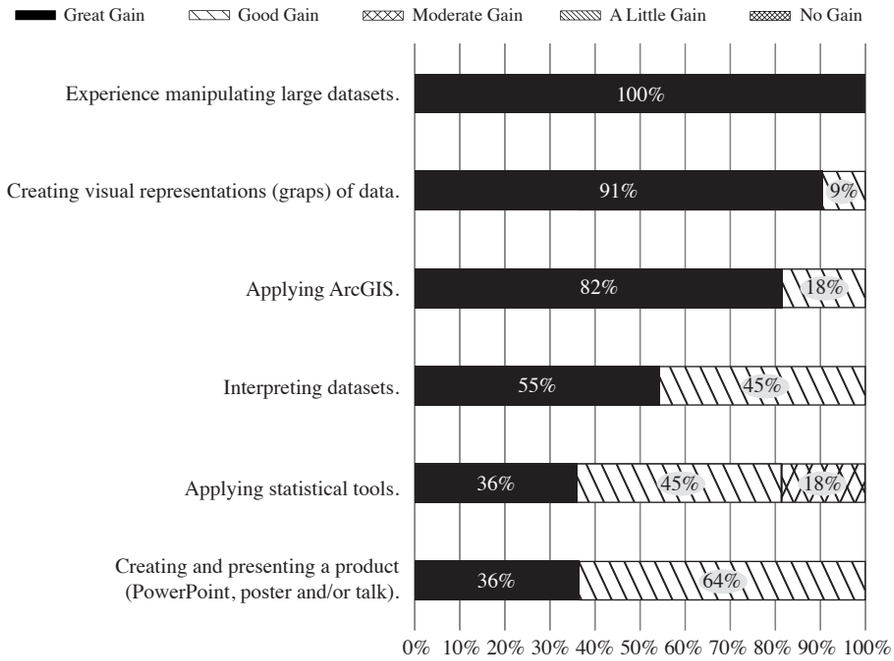
Recommendations and Lessons Learned

The following advice can be offered to aid in transferability of the ORCA experience to other institutions:

- ***Find the focus.*** Due to ORCA's location, the program's focus is on marine/estuarine dynamics. However, any regional focus that is studied by a state or local agency is ripe for students to add to the data and network within the community. It was unknown 15 years ago that temperature changes would drive massive deaths of sea stars on the Pacific coast and be evident in the local estuary. Ultimately, the focus is not the elements that drive the work but rather the process of doing the work, evidenced by this student quote: "From experiencing research firsthand, I ask more questions about everything than I used to without even realizing it." The graduates go on to many fields, from medicine to political science, and the skills they develop from research are transferable to any discipline.

- ***Secure funding.*** Connect to the institution's grants office. In addition to the NSF awards, ORCA has received small local grants that support the deployment of real-time instrumentation (ORCA n.d.b).

FIGURE 4. URRSA Responses to GEOPAths Grant Outcomes Over Three Years



Note: URSSA = Undergraduate Research Student Self-Assessment Survey. Students were asked, "How much did you gain in the following areas as a result of your most recent research experience?" (n = 34). Moderate to great gains on all outcomes were reported by all students.

Engage in dialogue with institutional administrators and connect funding to student outcomes by inviting administrators to observe student work. Once the Gates Foundation's start-up grant ended, the college administration agreed to allocate the student enrollment full-time equivalent revenue directly to the ORCA program as the operating budget. Now that many graduates are gainfully employed, there are several who have made financial contributions to new research initiatives.

- ***Embrace failure.*** It is important to discuss research failures with students, so they understand that learning can occur from failure and that sometimes the search for the "right" answer may be a long and multifaceted process. Much of the research in science does not support the hypothesis, so providing opportunities for emerging scientists to embrace failure and develop problem-solving skills coupled with resiliency is a lifelong skill.

- ***Find collaborators.*** Powerful programs are about the students, faculty, and others who choose to be a part of them. Find out what dual enrollment programs are offered in the institution's region and connect to local high schools, particularly to college/career counselors. Kveven and Searle (2013) have written about the structure of a two-year, cohort-based program that integrates core academic disciplines in the humanities, natural sciences, and social sciences, and committed faculty are at the core of the program's active learning, relationship building, and connection to place that contributes to student retention.

- ***Solicit essential feedback.*** In the early years, students were surveyed every quarter about their experience, which provided valuable feedback to mentors. It is also extremely valuable for mentors to share their response to the feedback with students, as it builds trust that their perspectives matter. Students are now surveyed annually via standardized surveys such as URSSA (Weston and Laursen 2017) in addition to the in-house surveys.

This student quote below embodies the legacy of the ORCA program, and asking students to engage in reflection and think deliberately about their learning is a rich part of the process. This passion for connecting students to the science of where they live and engaging them in the study has been tremendously rewarding and can be replicated by other committed, passionate educators.

> Words cannot express how ORCA has impacted my life. Over the past two years, I have not only grown as a learner, but as a person. My life would not be the same without this experience. I think of the world as a scientist and a writer now. I am not afraid to ask questions

and find my own answers. With these skills I know that I can do anything. The academic and personal support provided at ORCA was instrumental, and what I have learned at ORCA will impact me for the rest of my life.

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PRACTICE

BUILDing Equity in STEM: A Collaborative Undergraduate Research Program to Increase Achievement of Underserved Community College Students

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Abstract

Undergraduate research programs at community colleges maximize their impact through partnerships with baccalaureate-granting institutions, which provide much needed access to subject matter experts, research labs, and funding to underserved students. The program Building Infrastructure Leading to Diversity: Promoting Opportunities for Diversity in Education and Research (BUILD PODER) partners baccalaureate-granting California State University, Northridge with community college faculty and students to facilitate undergraduate research and development at community colleges. Eighty-one community college students and 41 community college faculty mentors have participated in BUILD PODER, performing research in STEM and biomedical disciplines. The authors document student, faculty, and institutional outcomes as well as share best practices in forming community college–university partnerships. Future directions also are offered in the development and implementation of transdisciplinary, multi-institutional community college collaborations.

Keywords: *community college partnerships, equity, faculty mentoring, interdisciplinary undergraduate research*

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Data compiled by the Community College Research Center (CCRC) show that 49 percent of students who have completed baccalaureate degrees enrolled in a community college at some point in their educational career (CCRC 2020). Moreover, 49 percent of Black students and 51 percent of Hispanic students started their collegiate career at a community college, compared to 36 percent of white students. With increasing career opportunities in science, technology, engineering, and mathematics (STEM) fields, many adult learners enroll in community colleges to further their education in the sciences (Chen 2019). It has been shown that undergraduate research is an educational practice that maximizes the impact of a postsecondary education early in a student's academic career (Bowman and Holmes 2018), particularly with Black, Indigenous, and people of color (BIPOC) student populations. Specifically, undergraduate research has been shown to cultivate self-efficacy and career ambitions in BIPOC students (Carpi et al. 2016). Given that nearly half of postsecondary students begin their academic education at community college, where the student population is largely composed of BIPOC students who benefit the most from research experience, it is imperative that community colleges provide undergraduate research opportunities.

Providing a comprehensive research experience at a community college is challenging for a variety of reasons (Cejda and Hensel 2009). Limited financial resources and lab space, extensive teaching loads, disengaged faculty and students, the lack of connection to research networks, the experience of feeling marginalized in the science research experience, and insufficient administrative support make the pursuit of a community college undergraduate research program appear insurmountable (Hewlett 2018). Through active engagement with university partners, however,

TABLE 1. Enrollment and Transfer Data for BUILD PODER Community Colleges

College	Enrollment	Percent BIPOC	Overall transfer
ELAC	60,146	71%	5%
LAPC	28,876	53%	9%
LAVC	26,975	57%	10%
PCC	40,372	54%	8%

Note: Overall transfer data obtained for student cohort beginning spring 2017 and transferred by summer 2019 (CCCCO n.d., 2020). ELAC = East Los Angeles College; LAPC = Los Angeles Pierce College; LAVC = Los Angeles Valley College; PCC = Pasadena City College. BIPOC = Black, Indigenous, and people of color.

community colleges can overcome these obstacles and create a transdisciplinary undergraduate experience that will change students' perceptions of science education and allow them to develop a research identity. In addition to creating an opportunity for community college students to gain meaningful research experience, these partnerships also help community college faculty grow as educators as they become research mentors to students who desire their support in STEM.

Multi-institutional, course-based research partnerships do exist. For example, the Genomics Education Partnership (Reeves et al. 2016) and Science Education Alliance–Phage Hunters Advancing Genomics and Evolutionary Science (Laungani et al. 2018) each provide professional development and curriculum in genomics for community college STEM faculty. These collaborative opportunities offer a mechanism to expand involvement of community college students in undergraduate research but lack the ability to sustain research over time and become institutionalized, a necessary component in optimizing the success of research experiences (Hernandez et al. 2018). Establishing faculty-driven community college research programs that partner with research universities provides a scalable and sustainable platform for longitudinal undergraduate research projects to maximize the success of BIPOC students in STEM.

BUILD PODER: A Model Research Partnership

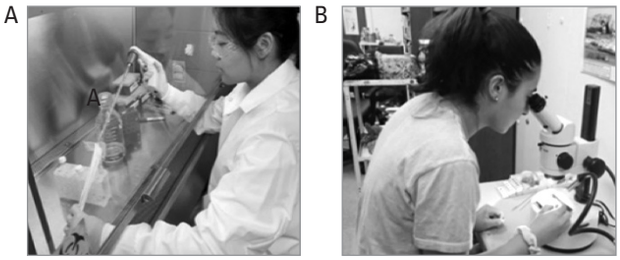
Federal agencies such as the National Institutes of Health (NIH) and the National Science Foundation (NSF) recognize the importance of representation and diversity in STEM and are committed to supporting BIPOC scientists through sustainable opportunities (NSF 2016; Valantine, Lund, and Gammie 2016). In 2014, the NIH launched the Building Infrastructure Leading to Diversity (BUILD) initiative aimed at implementing evidence-based practices in the research education of BIPOC students as well as facilitating faculty development and enhancing institutional research infrastructure. The BUILD program encourages partnerships between community colleges and baccalaureate-granting institutions to enrich research activities and expand the pool of engaged, underrepresented graduate students. The BUILD PODER (Promoting Opportunities for Diversity in Education and Research) program at California State University, Northridge (CSUN) is part of a 10-campus national consortium dedicated to making a broad impact by enhancing the diversity of the STEM workforce through community and educational partnerships. The goal is to increase students' interest in biomedical research to nurture their interest in pursuing research careers.

To promote interdisciplinary perspectives and support underfunded community college research programs seeking to recruit talent at inflection points in BIPOC student trajectories, BUILD PODER partnered with four California community colleges, as highlighted in Table 1: East Los Angeles College (ELAC), Los Angeles Valley College (LAVC), Los Angeles Pierce College (LAPC), and Pasadena City College (PCC).

In alignment with the BUILD program's mission to enhance diversity and equity in STEM, these community college partners are all minority-serving (MSI) and Hispanic-serving institutions (HSI). Faculty and students at each campus participate in mentoring activities that focus on providing equity in education and building research skills. Community college faculty mentors further their students' research knowledge while providing opportunities to view their STEM journey through the lens of critical race theory over the one-year research program. At the conclusion of the BUILD PODER–funded community college research, students can choose to transfer to CSUN and continue their research training, funded by NIH BUILD for two additional years. The early introduction of students to multifaceted, interdisciplinary research and progression to a university lab upon transfer are unique opportunities for community college students that increase engagement and promote continuity in their research endeavors, as shown in Figure 1. One student commented:

> I gained confidence as a scientist, felt more certain while conducting research in lab, and learned more

FIGURE 1. Students Participate in All Facets of Research



(A) Christine Lee performing biological assays at Oak Crest Institute of Science;
(B) Alina Shahin using a microscope at Pasadena City College

about graduate schools. The pipeline between CSUN and LAVC also offered me a support system once I transferred to CSUN. Being an undergraduate researcher made my transition from a community college to a university easy, helped me learn about myself, and awarded me with friendships that will last a lifetime.

BUILD PODER: Critical Race Theory and Program Components

The BUILD PODER program is unique among other BUILD programs in that its foundation in critical race theory (CRT) encourages participants and institutions to assess and address systemic and institutional factors that influence students' science-related educational decisions. CRT in education has five basic assumptions, as follows: (1) race and racism are central and defining characteristics of US society and embedded in structures such as universities; (2) dominant ideologies such as university objectivity, meritocracy, and race neutrality should be challenged; (3) a social justice agenda is critical to eliminating inequality; (4) experiential knowledge of people of color is a legitimate and critical resource central to understanding inequalities and solutions; and (5) historical contexts and interdisciplinary perspectives are necessary for analyzing race and racism in larger systems (Solórzano, Villalpando, and Oseguera 2005). CRT is infused into BUILD PODER objectives and program activities (Saetermoe et al. 2017). The inclusion of community colleges in BUILD PODER advances the CRT component in that the majority of student and faculty participants have BIPOC demographics.

Selection Criteria

Prior to the BUILD PODER program, students may not have been expected to have a commitment to a research career, since few may have considered research as a career option. Through participation in BUILD activities, students develop interest in research activities, graduate school, and pursuit of research careers. BUILD PODER community college students are selected for the program using the following inclusionary criteria: (1) being a current student at one of the four partner campuses; (2) having full-time enrollment status; (3) having a STEM field major relevant to biomedical science (e.g., biology, psychology, or public health); (4) having a 3.0 or higher grade point average; (5) being a US citizen or noncitizen national or permanent resident; (6) being Black, Indigenous, or a person of color or having a disability or disadvantage; and (7) having completed at least 30 units of undergraduate-level courses and having a one-year commitment to the program.

Summer JumpStart

New BUILD PODER students are funded to participate in a four-week Summer JumpStart (SJS) program that focuses on team-building exercises, research skills development, exposure to ethical considerations in research with human subjects, and exploration of the mentor-mentee relationship. SJS activities increase students' sense of community, research abilities, and program expectations. Students also are introduced to CRT and develop strategies for challenging and countering microaggressions and stereotype threat in academia. SJS commences at CSUN and continues with online meetings that occur bimonthly over the course of the academic year. Community college students are afforded student housing at CSUN for the four-week SJS session, which increases engagement and promotes interactions with students and faculty at the host institution.

Mentorship and Support System

The organization of BUILD PODER at each community college includes one faculty liaison who assists the respective institution's financial expert and BUILD PODER recruitment specialists. Together, these team members organize efforts to publicize and promote program initiatives, help establish student tutoring, address questions from mentors and trainees, and report on updates and common concerns at strategic meetings with the program's administrative team. Community college liaisons work with program specialists at CSUN to coordinate cross-institutional meetings, organize recruitment workshops, and track student progress.

Given the CRT emphasis, faculty mentors are exposed to historical and structural perspectives about race during mentor training before working with mentees. Students and faculty collaborate on a defined biomedical research project. They are given a stipend and research funds to engage in projects that leverage science to address health disparities. Additionally, they have access to conference travel funds to collaboratively engage with researchers in the scientific community. All program participants and the university community are invited to talks and workshops led by speakers from diverse backgrounds who specialize in biomedical research. Additionally, community college faculty mentors use current events to open CRT-based discussions on equity, inclusion, and diversity in STEM. For example, they might discuss the

impact of the political landscape and the Black Lives Matters movement on racial disparity as related to the mental health and well-being of BIPOC groups, with a specific focus on effects in STEM education.

Summer Internships

Performing undergraduate research at a community college provides students the opportunity to submit a more substantial application for a career-enhancing summer undergraduate research internship. Unfortunately, many of these internship programs select students from elite universities who have shown a history of research participation, making it difficult for community college students to be competitive for inclusion in these experiences. To remove this barrier, the BUILD PODER partnership includes negotiated or supplemental spots in many of these summer undergraduate research internships for participants who choose to continue the program at CSUN. Although community colleges are ideal for the initial development of students' research identity, summer internships in highly regarded research labs allow students to independently flourish and develop deeper professional networks. During summer 2019, 43 of the 81 BUILD PODER community college students participated in paid summer undergraduate research internships.

Conference Presentations

Effective undergraduate research experiences should encourage students to attend and present their research findings at conferences and, if warranted, publish their work. These opportunities can be transformative experiences for students, many of whom have never traveled out of their home states. Attending a national conference, even without doing a presentation, allows students to learn networking skills and increases their knowledge of current research being performed in their fields of study. Presenting at a conference is an especially beneficial practice for new researchers. Typically, every aspect of a research study must be complete to present work at a conference. This often is not feasible for undergraduate research students, especially at a community college where faculty advisers are challenged by the constant carousel of participating students. It is difficult for students to generate the data needed for project completion in the short time they are at a community college. Furthermore, it is unreasonable to expect students who are taking four or more courses and typically have external employment and familial obligations to have 20 hours per week available to complete a research project. It is much more likely that community college students have only four to five hours of time per week to work on research, which may not overlap with faculty availability. To address this obstacle, one strategy is to form student project cohorts, which consist of one student leading three to four other students on a project and allow for more widespread research. These cohorts maximize engagement by encouraging students to take the lead on projects and by providing research dissemination opportunities that are resume builders. The major benefits of the BUILD PODER–community college partnership are that students can form cohorts within a community college research structure, present at an end-of-year conference at CSUN, and receive travel scholarships to present at a conference of their choice. Over the first five years of this partnership, all 81 students have presented at regional or national conferences, and 27 community college undergraduate research students have been published in 12 peer-reviewed publications.

Curriculum Development

Formal curricula have been established through BUILD PODER community college partners to complement research and introduce social justice in STEM education and health to a broader audience. A Public Health for Social Justice course was created at PCC, LAVC, and ELAC, which introduces health disparities research and the role of biomedical research in generating health equity. The LAVC course Public Health, Social Justice, and Biomedical Research is an independent study umbrella course within the biology program. This course incorporates speakers from public health departments who speak on social and public health matters within the community. University researchers and scientists, as well as graduate students, discuss research topics and introduce scientific research as a career pathway. The course also incorporates field trips that showcase urban plight, fewer grocery stores, and other societal disparities.

BUILD PODER: Community College Student Impact

Data regarding the race or ethnicity of students who transfer to baccalaureate-granting colleges and universities in specific STEM fields are challenging to obtain. However, all community college BUILD PODER students who transferred to CSUN earned associate's degrees (e.g., AA–Transfer, AA–Natural Science) from their community college before transferring. Therefore, the graduation rates for BUILD PODER students can be compared to that of BIPOC students at the partnering campuses, where overall graduation rates are considerably less than 40 percent (see Table 2).

As seen in Table 3, 81 community college students have participated in the BUILD PODER partnership program. Thirteen out of the 16 community college students from cohort 1 transferred to CSUN to continue in BUILD PODER. In total, 14 students (87.5 percent) graduated with a bachelor's degree. This is higher than the overall five-year graduation rates for CSUN first-time transfer students from the same cohort (2015–2016) from institutions representing biomedical fields such as schools of social and behavioral sciences (82.8 percent), health and human development (81.4 percent), engineering and computer science (64.9 percent), and science and math

TABLE 2. BUILD PODER Community College Graduation Rates by Race/Ethnicity

Race/ethnicity	ELAC	LAPC	LAVC	PCC
Asian	52%	37%	45%	55%
Black	46%	19%	13%	18%
Latinx	28%	29%	22%	25%
White	88%	39%	36%	48%
Avg. grad. rate	35%	32%	27%	37%

Note: ELAC = East Los Angeles College; LAPC = Los Angeles Pierce College; LAVC = Los Angeles Valley College; PCC = Pasadena City College

TABLE 3. Yearly Outcomes and Completions for BUILD PODER's Community College Students

Year	Total BP students	Transfer CSUN-BP	Transfer to other university	Graduated with BA/BS	Graduate school
2015–2016	16	13	2	14	9
2016–2017	15	8	5	9	2
2017–2018	19	6	10	6	2
2018–2019	23	5	15	N/A	N/A
2019–2020	8	6	2	N/A	N/A

Note: CSUN = California State University, Northridge; BP = BUILD PODER. Average time to completion at a baccalaureate-granting institution was three years after transfer.

(75.3 percent), particularly for BIPOC students (77.1, 80.1, 57.6, and 74.1 percent, respectively). Furthermore, 9 students (56 percent) from that initial cohort enrolled in graduate school. Across all five years, only 9 students (11 percent) have not graduated or are no longer enrolled in a community college or university. The average time to completion at a baccalaureate-granting institution after transfer is three years. Therefore, only the first and second cohorts of students have had sufficient time to complete their degrees and apply for graduate school. The BUILD PODER research program increased the desire of many students to obtain doctoral degrees, as demonstrated by student narratives such as, "I moved from probably wanting to get a graduate degree to knowing I wanted to earn a Ph.D. in order to research the questions that I want to answer."

BUILD PODER students share their experiences about the program and what they are doing via outreach and presentations to other students. This has proven to be an effective strategy for encouraging other students to pursue research experiences, otherwise known as "the BUILD effect." What follows are some categories of benefits reported by students due to BUILD PODER opportunities:

1. *Gaining lab experience*. Research opportunities, taking place in local summer internships, allow for increased competency in laboratory skills within a research setting, which is essential to development of a science identity:

   > During the first Summer JumpStart training we learned about what research is and I got to work in a lab with real equipment and live cells. It was straight out of a movie and I had never thought I could do that. My perception of a scientist was the complete opposite of who I am. . . . During my year at LAVC I was able to build my confidence and improve on my grades/study skills and learn some of the foundational lab skills which have shaped the scientist I am today.

2. *Applying academic skills to real-world settings*. Research opportunities facilitate students' ability to design research questions that have real-life applications that are, if possible, tailored to each student's interests:

   > I studied the impact of chemicals such as heavy metal nitrates and nanoparticles on plant growth and development. This project taught me valuable research skills such as how to operate scanning electron microscopes (SEMs), construct posters, and communicate scientific research at conferences. The results of this experiment emphasized the importance of preventing contamination of soils by industrial contaminants.

3. *Learning the research process*. Through research opportunities, students can apply the scientific method and build their critical thinking skills, inspiring them to become lifelong learners: "I enjoyed all of the time I spent both working in the lab and reading background literature, and I slowly began to realize that I never wanted to stop learning biology."

4. *Building networking and support systems*. Summer research and conference presentations provide opportunities to meet with scientists and industry leaders to discuss future academic and career directions and guide students on their academic path:

   > The pipeline between CSUN and LAVC offered me a support system once I transferred to CSUN. I did not feel alone while at CSUN, and I always felt as if I had someone that I would be able to turn to if I had questions about anything. Being an undergraduate researcher made my transition from a community college to a university easy, helped me learn about myself, and awarded me with friendships that will last a lifetime.

   This support system may be especially powerful for BIPOC students:

   > As a first-generation college student, I had limited role models that could guide me towards an academic route. As a result, being a part of the mentorship program positively influenced my outlook on mentoring because it helped me combat the imposter syndrome-feelings I encountered during my first year in college, such as not feeling good enough.

5. *Developing collaboration skills*. External summer research opportunities in particular encourage and foster a collaborative environment in which fellow interns, graduate students, and postdoctoral fellows work on a common project. Students recognize that mentorship is an interdependent, two-way relationship that results from collaboration:

   > Collaborating with a community college faculty mentor enriched my undergraduate experience. Working alongside my faculty mentor encouraged me to become academically driven and explore graduate programs, something I did not consider before. Learning about my mentor's academic experience also helped shape my view on mentoring because it provided me with a framework on how to approach my educational path.

6. *Preparing future professionals*. Summer research facilitates a discussion of the STEM education pursuit and disseminates shared knowledge of how to become a professional scientist, which is an effective motivator for community college students. Students reported that they were more informed and "learned more about graduate schools," confiding that research mentorship was "the biggest influence on my career path."

Community college students in BUILD PODER obtained skills, confidence, mentorship about professional choices, and tangible outcomes. Such outcomes included presenting at conferences; receiving support when applying to baccalaureate research institutions and graduate schools; and networking with a community of scholars, instructors, and students, all of whom inspire students who have traditionally been discouraged to believe that their work can generate social justice through health equity research.

Other Programs: eCURE–BUILD PODER Model

Prior to partnering with CSUN and BUILD PODER, PCC developed a distinct undergraduate research program to provide research experience for BIPOC students early on their STEM career pathway. The Early Career Undergraduate Research Experience (eCURE) utilizes a tiered research approach: (a) course-based undergraduate research experiences, (b) faculty-mentored research, and (c) summer internships (Ashcroft, Jaramillo, and Blatti 2020). Many students that begin with eCURE apply to BUILD PODER. Two aspects of eCURE that most benefited participants were the development of one-semester research method courses at PCC and additional internship partnerships with California State Polytechnic University, Pomona; Oak Crest Institute of Science; the Jet Propulsion Laboratory; and Huntington Medical Research Institute.

A total of 37 students, several of whom eventually participated in BUILD PODER, enrolled in three research methods courses at PCC. These courses included a biological research methods course—which had 7 students—and two physical science research methods courses that had 12 and 18 students, respectively. Presurveys and postsurveys were given to students (24 students completed both) to ascertain their experiences with four components of research:

1. *Relationship of research*. Does research address real-world problems? Does research relate to STEM coursework?
2. *Understanding of research*. Does research connect key ideas with other knowledge? Can research students apply what they learn to other situations?
3. *Research skills*. Can students critically read STEM articles, identify patterns in data, develop an argument for a research topic, recognize strong evidence, present data in presentations and in papers, and work well with others when performing research?
4. *Attitudes toward research*. Are students understanding research concepts, confident in applying research methods, interested in discussing research, willing to ask instructors for help, planning to participate in internships, and enthusiastic about research?

TABLE 4. Presurvey and Postsurvey Comparisons of Students' Self-Reflection on Research Gains after Research Methods Course

	Pre (SD)	Post (SD)	Change	Wilcoxon signed rank test		
				N	*Z*	*P*
Relationship of research	8.3 (1.4)	8.6 (1.3)	4.0%	23	1.078	0.281
Understanding of research	7.7 (1.7)	8.6 (1.6)	11.7%	**23**	**2.123**	**0.034**
Research skills	28.0 (7.0)	32.7 (5.6)	16.6%	**24**	**3.214**	**0.001**
Attitudes toward research	33.0 (5.5)	34.5 (4.9)	4.7%	24	1.814	0.070

Note: Boldface signifies statistically significant data.

Analysis of survey data based on student self-reflection is shown in Table 4. Survey data have been shown to be an acceptable method of evaluation (Morales-Doyle 2017). Two components of the research process, understanding of research and research skills, both showed statistically significant improvement based on a Wilcoxon signed rank test after the research methods course. The Wilcoxon signed rank test is a nonparametric statistical hypothesis test used to compare two related samples—in this case, the presurvey and postsurvey results for each of the research gains. Relationship of the factors "Research" and "Attitudes toward Research" also showed improvement, although the changes were not statistically significant. This demonstrates that the research methods courses strengthened students' knowledge of research and connection of research to real life. These aspects of research are more challenging to simulate in a classroom setting.

BUILD PODER: Community College Faculty and Staff Perspective

Community college faculty, staff, and CSUN recruitment specialists were invited to share their personal assessment of the BUILD community college partnership program by reflecting on the following:

1. *Successes*. What do you view as successes of the BUILD Partnership? What strategies were instrumental in developing these successes?
2. *Challenges*. What do you view as challenges in the BUILD partnership? What strategies might be used to address them in the future?
3. *Recommendation*s. Overall, what are your recommendations for individuals hoping to build cross-institutional partnerships?

Categories and themes from six personal reflections were constructed from open and axially coded data (Corbin and Strauss 1990). The personal narratives afforded insights on participants' attitudes, beliefs, and actions. Related to successes, three themes emerged: student empowerment, faculty interdisciplinary productivity, and benefits of community college strengths. Regarding challenges, two broad themes emerged: challenging ideologies about science and need for institutional support. Recommendations will conclude this section.

Successes

Student empowerment. Given the emphasis on student success of the undergraduate research program, faculty and staff focused on how the program empowers students. Specifically, community college faculty mentors noted student improvement in the ability to critically review literature, collect and analyze data, and prepare and deliver presentations. Additionally, students developed confidence and organizational skills that prepare them for transfer to a university. These research and academic gains can be attributed to applied research experience and psychosocial factors related to the expanded relationships gained through faculty mentorship at a community college (Villasenor et al. in preparation). Community college students tend to have a "commuter school mentality," and many entry-level STEM courses (such as chemistry) can feel like gateway classes meant to weed out students. By providing research experiences and opportunities to discuss socio-scientific issues through CRT with faculty-facilitated peer support groups, students are provided with encouragement, helping them through critical junctures experienced by all undergraduate students. This is particularly true for students whose family or friends are unable to provide such support. Through partnerships such as BUILD PODER, these supportive community networks empower students to succeed.

Faculty interdisciplinary productivity. Among faculty, the partnership has increased interdisciplinary research and productivity. As part of the BUILD PODER program, community college faculty can apply for sponsored projects. These sponsored projects (shown in Table 5) include participation in a summer writing group, research exchanges and pilot studies, equipment grants, and skills-building workshops. In some instances, equipment such as fluorescent and optical microscopes as well as augmented

TABLE 5. Collaborative Community College Projects Supported by the BUILD PODER Partnership

Collaborative community college project	BP activities	Outcomes
Success of CSUN and Community College Education in Science Study (SuCCESS)	Skills-building workshops	In-preparation manuscripts
NSF Bridges to the Baccalaureate	Research funds	Submitted CSUN-Community College pipeline grant
Virtual/augmented reality simulation lab	Research exchange	VR/AR lab and project
NSF grant: Micro Nano Technology Education Center	Writing group	NSF grant awarded
Evaluation and research on utilization of targeted nanoparticles for use as cancer therapies pilot	Pilot project	NIH grant in final review
Informal science learning microscope laboratory	Equipment grant	Fluorescent and optical microscope lab

Note: CSUN = California State University, Northridge; BP = BUILD PODER; VR = Virtual Reality; AR = Augmented Reality

and virtual reality devices were supplied for community college research programs. Access to subject matter experts at CSUN through the sponsored projects enhanced research capabilities at the community colleges. In addition, through the BUILD PODER partnership community college faculty can seek out opportunities to share research and to be compensated for the additional work. BUILD PODER also has made inroads in seeking administrative support, which is crucial to faculty retention and program sustainability. Partnerships with research universities allow faculty at the community college to develop relationships and increase scientific research capacity, which helps build competitive resumes for grant applications. For example, PCC applied for and was awarded an NSF Advanced Technological Education pilot grant specifically for the eCURE program. By leveraging this partnership experience, community colleges can obtain funding to support and expand their research programs, which in turn will support and provide students with opportunities not previously offered.

Benefits of community college strengths. The community college environment is viewed as a strength and potentially more conducive to BIPOC student development than traditional research institutions. The greatest success of the BUILD community college partnership was the development of one-on-one research mentorships for students in a formative environment. One student commented: "My mentors really pushed research. I am glad they did. BUILD gave me access to key mentors through community college and made for an easier transfer to CSUN. Now having mentors that have helped me build a strong foundation in education and research, I feel confident that I will succeed in a career in science." Research labs can often be competitive and summative in nature, rather than cooperative and formative. University research institutions are hypercompetitive for faculty, and such a situation can be conveyed to students. This can become a fraught environment in which students are concerned with self-presentation rather than research exploration, and the inherent mistakes are costly.

In a CRT framework, community college mentors are key to the outreach and support of students who have little exposure to research and role models who look like them. Challenging racist stereotypes by speaking openly about racism, recognizing the power of research to build social justice, holding high expectations, and providing essential mentoring allows educators to draw upon a much broader, more diverse pool of students who are inspired to solve the problems they see around them (Jain, Melendez, and Herrera 2020; Ledesma and Calderon 2015). Critical mentoring allows students to overcome stereotype threat and believe that they can contribute to their families, their communities, and their society (Steele, Spencer, and Aronson 2002). Community college research experiences can provide an environment that supports students' science identity in the safety of a scaffolded environment where mistakes are opportunities for growth. A student commented: "Through BUILD PODER, the lessons I was given in the classroom were no longer just limited to a test but transcended to my initial research experience at LAVC and the rest to come. BUILD has imbued me with the confidence and identity needed to pursue a career of science."

Challenges

Science ideology. Program recruitment specialists reported that students' beliefs about the relevance of research to their daily lives was a major challenge to recruitment. In addition to challenging the "gateway mentality" of science faculty, the competitive culture of science, and the community college emphasis on transfer, the BUILD recruitment specialists outlined how students who met the minimum requirements for the program then had to be informed about what research entails and how it could be leveraged for social justice. For many students, especially BIPOC, the word *research* was pushed aside since they believed it did not apply to them or was an unreachable

goal. The presence of multi-institutional partnerships such as BUILD PODER at community colleges has enriched the university experiences of BUILD and non-BUILD students by shifting mind-sets and motivating them to seek research opportunities that are integrated into their everyday lives and social justice goals.

Cultural expectations at different levels can hinder BIPOC student participation in science at community colleges and, hence, research. On the individual level, students may not associate their interest or major with science. For example, many BIPOC female students in nursing may associate with the allied health field but not necessarily view themselves as STEM students or in a "science research" field. In addition, BIPOC students from families with expectations that the students will provide financial support make juggling education and expected employment difficult to manage. Students feel the pressure from two directions: education and familial obligation (Vasquez-Salgado, Greenfield, and Burgos-Cienfuegos 2015). These obligations inhibit participation in a research program.

On an institutional level, community college culture emphasizes employment and transfer rather than development of a science identity and research (Jain, Melendez, and Herrera, 2020). Therefore, community college students may prioritize coursework and getting an A in class over participating in research programs or internships, which are deemed unimportant. The presence of multi-institutional partnerships, including BUILD PODER, at community colleges has helped enrich students, provided financial support for students, and served as a motivator for other students in seeking out research opportunities.

Institutional support. Across faculty, concerns about infrastructure and delay were common and highlighted the need for administrative support and recognition for efforts above and beyond heavy teaching loads. This has often led to the withdrawal of qualified faculty mentors who, if BUILD PODER students were not assigned to them, may not have had the funding required to continue their research. The challenges of conducting research at a community college due to a lack of funds or resources such as time, money, and qualified personnel have been documented in other programs (Brothers and Higgins 2008; Hirst et al. 2014). Lapses in funding between students was a frequent barrier for faculty. Once established and furnished with BUILD PODER students, laboratories could be supported with supplies and small stipends. Despite this support, faculty who invested heavily in their research labs and did not subsequently secure a BUILD PODER student had their work interrupted, a discouraging situation that led many mentors to leave the program.

The lack of access to a readily available IRB committee and procedure at the community college level also has posed significant challenges to students and their faculty mentors in social and behavioral sciences. This often disrupts the student's experience and hinders the mentor-mentee pair from recruiting participants and proceeding with the data analysis and presentation of their research. Although they can utilize the IRB at the university partner institution, the mechanism is often cumbersome, and delays have meant that some projects could not start quickly enough to provide students with a comprehensive research experience.

The ability for a community college to design and implement an undergraduate research program that is scalable and sustainable depends on a funding source, administrative support, and partnerships with universities or industry. Administrative support is especially essential. Relying on faculty mentors who are simultaneously developing a research program to act in an administrative role in the partnership overburdens faculty. Ideally, the institution can commit to assigning a nonteaching staff member to manage day-to-day operations, freeing time for faculty to focus on research and mentoring. Grant writers should note that, in addition to allocating funding for a faculty liaison, each campus requires a financial and logistics coordinator because of the heavy workload in these areas, at least in the first year.

PCC has developed an effective faculty-administration partnership, in which the dean of natural sciences takes an active role in the organization of research activities. The Early Career Undergraduate Research Experience originated at an NSF undergraduate research workshop attended by faculty and the dean from PCC. This partnership provided a way to grow the program that included construction of an undergraduate research laboratory dedicated to student research projects. Active engagement in the undergraduate research program by administration optimizes the undergraduate research opportunities at a community college.

Challenges overcome. The challenges of scaling a community college undergraduate research program can be mitigated through partnership with and support from a baccalaureate-granting university. A community college instructor's main responsibility is teaching. which can inhibit development of new research or ongoing learning about current research. The partnership with BUILD PODER provides access to research scientists active in their fields, opening research experiences for community college students. For example, the PCC research program applied for and was awarded an NIH pilot program grant in collaboration with a CSUN instructor to design and study energy transfer between gold nanoparticles and antibodies. This partnership allowed PCC students access to an advanced femtosecond pulse laser and funds to buy the reagents and supplies needed for the project.

Serving as a faculty mentor for the BUILD PODER program does require additional work. Funding should not be the sole issue considered for participation in undergraduate research, but access to compensation as well as travel and supply funds can increase motivation for BUILD PODER mentors, especially when a teaching workload seems overwhelming. Obtaining funding for undergraduate research programs without university partnerships and experience will not happen at most community colleges. Even in the absence of lab space or equipment and limited financial resources, there are still opportunities for students to learn. Even if it requires creativity about projects or the application of survey-based methodology, students can still obtain a full research experience at the community college level.

There may be concern that students and faculty will feel isolated or marginalized working so much on their own projects, but that has not been the experience. Students have the opportunity to collaborate with other labs, present at conferences, and share the work they are doing with others such as friends and family. In addition, the singular relationship between the students and their mentors is meant to feel like an equal partnership, allowing students to oversee and lead all aspects of the research process.

Recommendations

Based on the perceived challenges, recommendations were made that emphasized the following ideals for those wishing to build a similar program and partnerships: maintaining communication, establishing trust and common goals, and developing a plan specific to each partner institution. For example, during the preparatory phase, program developers should understand that each community college has a distinct culture and therefore must enlist local administration support for creating a research partnership. During this exploratory phase, it also is important to have transparent and goal-oriented conversations with the administration to establish shared goals and missions, develop a timeline, and assign a division of work. This early stage is an opportunity to learn about one another, develop a shared language, and set objectives for the partnership (Asimow, Kennedy, and Lees 2016). This is particularly important for partnerships between community colleges and university research institutions, given the differences in schedules, expectations, demographics, structures, and cultures.

It is unlikely that community college faculty will receive reassigned time or extra pay to establish an undergraduate research program. Therefore, it is the obligation of the faculty member to search out and find networks and programs with dedicated resources for research. Faculty can contact organizations such as the Community College Undergraduate Research Initiative (CCURI); participate in organizational meetings sponsored by the Council on Undergraduate Research (CUR); and identify potential collaborative partners at nearby universities, nonprofit laboratories, and industries. Many federal grants prioritize programs that work with community colleges. Finally, faculty should be willing to prepare grant proposals to fund their research programs. PCC began eCURE with three faculty, 12 PCC STEM students, and a small amount of funding from a Department of Education Title III Strengthening Institutions Program grant. With guidance from a workshop on community college undergraduate research, eCURE was developed as a tiered research approach. Over time eCURE fostered various partnerships to help the program grow such as CSUN's BUILD PODER. It took three years for the eCURE program to begin to show results. After eight years of eCURE at PCC and collaborations with CSUN's BUILD PODER and several other university and industry partners, the program has been awarded an NSF Advanced Technological Education (ATE) pilot program grant and will be the lead institution for the NSF ATE Micro Nano Technology Education Center. Although time, effort, and persistence are required, this new designation of an educational center at PCC shows that institutionalization of research at a community college is possible.

Conclusion

The BUILD PODER partnership of CSUN and several local community colleges has had several benefits for students and faculty who, in turn, have played a part in developing scientific research cultures across all institutions. Critical race theory is infused in BUILD PODER activities and highlights the importance of recognizing cultural strengths and needs across institutions, leveraging the strengths of community college environments and challenging dominant ideologies about science in the community college context as a tool for recruitment. Overall, to be effective, program developers must understand institutional cultures, discuss shared goals and expectations, provide continued support and workshops to expand research awareness, and maintain communication with stakeholders.

The student results show a stronger science identity and passion for research as a result of collaborative research experiences, enabling the continuation of research opportunities after transfer. The analysis of narratives is qualitative and meant to represent the lessons learned from a small sample of participants of one program in the unique higher education context of southern California. Despite limitations, the results highlight how partnerships between a baccalaureate-granting university and community colleges have the capacity to foster interest in undergraduate research, with a focus on BIPOC students, to promote transfer, and to cultivate diverse perspectives in research.

The power of undergraduate research lies in the connections formed via mentorship that can have a significant impact on a student's academic journey. Community

college–university partnerships provide this important path. As one student wrote:

> My community college mentor was someone that inspired me to pursue a degree in Biochemistry. When I initially paired up with my mentor through BUILD PODER, I was a Nutrition/Dietetics major, and after much discussion with my mentor, not only did I become aware of the opportunities in pursuing a chemically based degree, but I decided I wanted to become a researcher. I recently graduated from CSU Northridge with a B.S. in Biochemistry and this fall I will attend the University of California, Irvine to pursue a Ph.D. in Chemistry. Without my community college mentor that I was paired up with through the BUILD PODER program, I am certain none of this would have been possible.

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Vignettes

Leveraging a Service Experience into a Course-Based Undergraduate Research Experience in an Introductory Geology Classroom

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Whatcom Community College is a small, suburban public college situated near a large agricultural region. A local, nonprofit, organic farm (Growing Veterans n.d.) sought to partner with the institution in a service opportunity examining its soil health. The outcome was a course-based undergraduate research experience (CURE) for students in an introductory environmental geology course for nonmajors.

During a field trip to the farm early in the quarter, the farmers shared their current seasonal growing challenges. The farmers, who were experimenting with different kinds of cover crops, weeding methods, and plant rotations, wished to determine how these practices affected soil health. Student research compared the results of simple soil tests by field or over time. For example, groups of students examined the relationship among elements such as nitrate, pH, earthworm concentration, soil infiltration, and soil bulk density as they compared different types of cover crops to noncovered areas. This partnership has operated since 2014, and data have accrued to support the farm's practice decisions such as employing specific cover crops to maintain soil health. Each year, students enter the raw data results from their research projects into a Google spreadsheet. This allows students to compare their results to those from previous years. As part of the CURE, students present their findings in a formal, academic-style poster session, to which the farmers, faculty, and staff are invited to attend. This poster session is in lieu of a final exam as a celebration of learning. The research posters and raw data are available for the farmers to reference throughout the year, which are used to make planting decisions.

Students completed a survey as part of their experience (Kortz and van der Hoeven Kraft 2016) in which they were asked three open-ended questions about how they benefited, how the project matched what they expected, and how their ideas about science changed. The responses captured similarities to the benefits and challenges described by Kortz and van der Hoeven Kraft (2016) such as an increased appreciation of science and scientists as well as more confidence in themselves. As one student wrote, "[I] gained confidence and experience in working with a team. And confidence in my science skills." In addition, as this CURE was performing a service for a local organic farm, students also described the benefit of feeling like their work contributed to something greater beyond their own college experience. For example, as one student noted, "This was a different type of project w[h]ere you get to visit a place and try to help fix problems. It helps you get more involved and is more fun." Students benefited from this learning experience, and the farm receives ongoing consultation that informs its practices.

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Community College Ceramics and Student Research: Cooperative Work Experience Projects in the Arts

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Allan Hancock College is a California public community college located in northern Santa Barbara County, serving 11,500 students per semester. For the past three semesters in the Fine Arts Program, student researchers have been sampling, researching, and firing natural clay deposits found in the campus region. Students research local clays by firing them at various temperatures and adding variable fluxes to experiment with eutectic melting points. In 2020, a collaboration began with the California Department of Conservation. The Mineral Resources Program will provide resources for students to research the geological lifecycle of kaolins, gain an understanding of how clays are mined, and learn about other historical contexts of the region (brick-making factories, etc.). Amiko Matsuo, a faculty member in the college's 3D Fine Arts Program, worked with engineering geologist Greg Marquis to pilot a cooperative work experience (CWE) project to develop a model outreach/interdisciplinary curricular guide for the Minerals Resources Program.

This student research emerges from an effort to develop cross-disciplinary student research opportunities through the structure of internships. Matsuo worked with the

CWE internship under the Career Center to develop community partners. Students sign up for one unit and work with a faculty mentor and community partners such as La Purísima Mission, Adamson House, Santa Barbara Food Bank Empty Bowls, and Santa Maria Open Streets to develop individual research goals. All CWE research projects in 3D Fine Arts are designed to culminate in signature events such as pop-up exhibits and peer-to-peer learning workshops. Additionally, all CWE projects stress elements of service learning.

La Purísima Concepción De María Santísima was founded in 1787 and was the 11th of 21 Franciscan Missions in California. One artifact in its collection was broken in an earthquake, and a California State Parks employee contacted the college seeking an interested student to re-create the object. CWE student Margaret Barker was paired with La Purísima with oversight from the instructor. Barker was prepared for the historical reproduction project because of her work in the Ceramics Workshop class. During the previous semester, Barker had taken soil samples from her grandfather's vineyard to create a refined slip as a coating on her relatively large-scale ceramic objects. For the Purísima project, Barker worked to reproduce the historical form, which was approximately 12 inches in diameter at the base, 12 inches in diameter at the throat, 30 inches at the circumference at the fullest point, and 18 inches in height, which were measurements of the historical vessel provided by California State Parks. Based on observations of photographs and sherds, Barker researched hand-building processes necessary for the re-creation of the object. She combined a coil-building and paddling process, carefully following a template of the profile as she built the clay from the base upward. The template was prepared, taking into consideration the shrinkage rate of the clay body in the drying and firing process. According to her self-determined objectives, Barker completed a slideshow documentation of her process, wrote a reflection on her research experiences, and created a historical reproduction using hand-building techniques and terra-sigillata specific to the region. Her piece is now part of the La Purísima Mission exhibit.

Undergraduate research at the college has been solely student/faculty driven. In particular, the Fine Arts Program reframes objectives inherent to creative problem-solving. High-impact practices and student-centered pedagogy develop critical thinking skills and a research mind-set. Aspects of this project have been presented in the form of signature class events that a faculty member featured in a professional development lecture for the college.

Such collaborative projects demonstrate how the arts can be supported by deliberate and intentional local partnerships while strengthening ties with the community.

Spreading Undergraduate Research Experiences across a Community College

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Undergraduate research, although common at the university level, has been a slowly growing endeavor at community and technical colleges around the nation. Reasons for this situation include the mission of community and technical colleges, cost, and faculty workload. However, the proposed and realized impacts of authentic undergraduate research experiences on student success make these worthwhile activities for students at two-year institutions (Adedokun et al. 2014; Balster et al. 2010; Corwin, Graham, and Dolan 2015; Fechheimer, Webber, and Kleiber 2011; Kelly et al. 2007; Nadelson, Walters, and Waterman 2010). This vignette discusses the impacts of undergraduate research experiences on the students of Northeast Wisconsin Technical College (NWTC) through models for course and summer undergraduate research experiences (CURE and SURE, respectively; Kolokithas and Calderón 2018).

For the CURE, instructors at NWTC have joined the Tiny Earth Initiative (Tiny Earth n.d.), a network of students and instructors that focuses on student sourcing of antibiotics from soil. The World Health Organization has declared that an era is coming in which once simple infections treatable by antibiotics will be deadly again (Nisnevitch 2016). Although some institutions participate with a course section or two, it was decided that all sections of the Microbiology course at NWTC would join in the search for antibiotics. The Tiny Earth initiative shares curriculum, resources, and training for interested partners, which makes the transition into this model relatively simple to adopt. The labs involve collecting soil, isolating bacteria, screening for antibiotic producers, and identifying genotypes and phenotypes. Further isolation of antimicrobial substances and eukaryotic testing also can be done.

At NWTC, the Tiny Earth initiative curriculum has been in place for the past three years, and the results have been quite positive. Students were surveyed before and after completion of their course. Students were asked a range of questions, including applicability of the subject to their daily lives. Before the adoption of the Tiny Earth curriculum at NWTC, the perception of students that microbiology was applicable or very applicable to their daily lives, not just their program, increased from 23 percent of students in the presurvey to 50 percent of students in the postsurvey (n = 75). However, when the Tiny Earth curriculum was adopted, students seemed to have a better appreciation of the applicability of microbiology to their daily lives, as the data collected showed an increase from

32 percent of students in the presurvey to 70 percent in the postsurvey (n = 152). Comments on the surveys indicated the students were excited to be a part of a worldwide movement and to potentially find a new antibiotic that could save countless lives.

In fall 2018 and fall 2019, NWTC and the Tiny Earth Initiative, as well as several colleges and universities in Wisconsin, teamed up with the Green Bay Packers to have a poster symposium of student work at the Packers' Lambeau Field. The NWTC students were required to involve the community in their soil acquisition, comparing two sites for antibiotic-producing bacteria. This was done not only to potentially discover new antibiotics but also to raise awareness and educate the community on the problem of antibiotic resistance. Over the two fall semesters, 250 allied health NWTC students—most in their third term of college—produced 140 high-quality posters for the Tiny Earth in Titletown annual symposium, which many community members attended.

At NWTC, many students are unable to commit to full-time science internships, as they have other commitments. To address this situation, a SURE was created in which students commit to an internship in virology research of 8 hours a week for 10 weeks (the minimum required for science programming at NWTC). Students were able to agree to this time frame and, after training, were quickly executing their own experiments and troubleshooting results. For the past three summers, students have progressively moved research forward and have learned how cellular restriction factors restrict viral infectivity.

These CUREs and SUREs have been so successful that the college had started a new initiative to spread these models into other disciplines at the college. A committee has been created to oversee the process of interested instructors proposing UREs and the provision of college resources to support them. In time, it is expected that these UREs will result in greater student success across the college.

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Accessibility in Undergraduate Research Experiences: A Novel CURE

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Course-based undergraduate research experiences (CUREs) can have profound and lasting impacts on students. CURE participants often show gains in content knowledge, self-confidence, and enculturation into their field of study. Exciting is the recent momentum in providing CUREs at the two-year degree level (Hensel 2018; Patton and Hause 2020). However, the impacts of CUREs on students with disabilities—particularly those at the associate degree level—are not yet fully understood.

CURE courses were developed for Deaf and Hard-of-Hearing (D/HH) students in the Laboratory Science Technology (LST) program (Lynn et al. 2020) at the National Technical Institute for the Deaf (NTID) of Rochester Institute of Technology (RIT). Notably, the developed CUREs enrolled all D/HH students and also fulfilled a requirement for the two-year degree program. Attending to accessibility, the courses were taught in American Sign Language and focused on best practices for working with D/HH students in the laboratory. Best practices included using different modalities/guidelines for clear communication, optimizing visibility in the laboratory, and seeking continual feedback from participants (Smith, Ross, and Pagano 2016).

The educational benefits of CURE-type instruction were clear as early as 2005 when the first CURE course for D/HH LST students was taught at RIT/NTID. The CURE focused on the isolation and analysis of isoeugenol from nutmeg and served as a capstone course for the program that was interdisciplinary (as it had chemistry and biology components). Chemical extractions, instrumental analyses (spectroscopy and chromatography), bacterial inhibition testing, and general laboratory techniques were used in the research. The level of research and scientific details of this earlier CURE offering can be found in the publication of Pagano and colleagues (2016). Although this effort predated the structured assessment movement for CUREs, strong student learning and technical skill development were evident. Due to scheduling and program logistics, the course was not taught again for some time.

In 2020, RIT/NTID offered a newly designed LST CURE. Similar to its predecessor, the course involved the use of laboratory analytical techniques—this time through the analysis of honey. In this iteration, CURE-enrolled students were given precourse and postcourse surveys to self-assess aspects of their experience (Grinnell College 2020). All students who completed the survey (n = 11) either agreed or strongly agreed that the CURE ". . . was a good way of learning about the subject matter," and most (n = 9) students also agreed or strongly agreed that the CURE was a good way of "learning about the process of scientific research." The student responses demonstrated that the significant benefits of the CURE included "becoming part of a learning community," "learning lab techniques," "skill in the interpretation of results," and the "ability to analyze data and other information" (all students identified these items as areas in which they believed that they experienced a moderate to very large gain). The demonstrated learning outcomes from the redesigned CURE are encouraging, and the course is expected to continue as a program fixture.

Graduates of the LST program either enter the workforce (often as laboratory technicians) or matriculate into baccalaureate degree programs. Students' reactions to the CURE indicate that it provides them with vital skills that can assist in their transitions to the workplace or baccalaureate, graduate, and professional education. Given that the students are undertaking authentic research projects using the scientific method, they are inherently confronted with critical thinking and problem-solving scenarios that can build their skills for future academic and professional careers. After experiencing CUREs, D/HH participants may also be more likely to continue in faculty-mentored research projects—a positive development, as D/HH students frequently have fewer research opportunities compared to their hearing peers (Pagano, Smith, and Ross 2015). In addition to providing students with a strong experiential curriculum, this initiative can bring a much-needed focus on the D/HH experience in science programs and demonstrate the advantages of providing students with inclusive CUREs.

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For the Benefit of All: Faculty-Led Undergraduate Research in the Humanities at LaGuardia Community College, CUNY

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Although undergraduate research at community colleges is gaining more attention, the opportunities for faculty-student collaboration within the humanities in these institutions is still neglected. Given the assumption that humanities research is "necessarily more individualistic than research in the social or natural sciences," requiring years of training and immersion (Schantz 2008, 27), it is often not given much attention at two-year institutions that have a limited time to develop strong, discipline-specific, student-faculty connections. Yet students and faculty alike have much to gain from such work. This case study highlights

the benefits of one example of humanities student-faculty collaboration at LaGuardia Community College, CUNY, in which a critical editing project was enhanced by student contributions, while the students gained skills that encouraged retention and nurtured future success.

In 2012, Naomi Stubbs (LaGuardia Community College, CUNY) and Amy Hughes (Brooklyn College, CUNY) began collaborating on two critical editions of the diary of actor, manager, and playwright Harry Watkins (1825–94; Hughes and Stubbs 2018a and 2018b). The goal was to produce a fully annotated print edition of selections of the diary and a digital edition of the full text, which would be freely available online. Early in the process, they sought ways to work with students to enhance the collaborative nature of the project as well as to create opportunities for students at their respective colleges. As someone with a considerable teaching load at a community college, Stubbs was also keen to identify ways to convert some of her workload into time on this project.

Students involved in the project were either paid as editorial assistants (through grant funding) or offered college credit for work as interns. They variously transcribed, encoded, and proofread pages of the manuscript; developed original projects related to the diary; tagged playbills; researched play titles; and presented on the project for external audiences. In these ways, they directly contributed to the project through completing tasks and helped Stubbs and Hughes clarify goals and policies. Interns were also required to develop an original project that would involve an external audience, which led to creative products (such as a song, poem, and fan fiction), pedagogical tools (a primer for Watkins's handwriting and how-to video for XML encoding), research projects (building Watkins's family tree and tracing the touring circuits described in the diary), and publicity for the project (blog posts, promotional postcards, the Twitter feed @WatkinsDiary, and a college newspaper article). These projects drew upon the particular skills and interests of the students, as well as enhanced the quality and reach of the project.

Beyond the benefits to the faculty members (Stubbs 2019), the students gained tremendously from their work on the project. Far from performing routine and mundane tasks, the students identified unique contributions they could make to the project and developed a variety of skills and abilities. Students reported developing specific skills (such as close reading, locating and assessing sources, XML encoding, and managing time) and familiarity with software (Excel, oXygen, and PowerPoint) that helped them in their studies at LaGuardia and beyond.

Community college students tend to enter postsecondary education needing more academic and pastoral support than those at four-year institutions; many are first-generation students who may doubt their abilities. Two students reported that working on the project allowed them to feel like they were "part of something"; they came to LaGuardia via two previous colleges and completed their degrees at LaGuardia. After mastering challenging material, several students presented publicly on the project in roles such as conference presenter, workshop co-leader at New York University, and participant in a roundtable on humanities research. From specific skills and experiences to the less tangible benefits of building community and pride, this work was of great benefit to all concerned.

There were challenges, certainly; there were frustrating moments, limited funding, and an inability to view the physical manuscript. Still, this project illustrates the rich potential for faculty-led research projects at community colleges in the humanities that embrace student participation and lead to increased retention and success for students.

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Developing UREs at a Community College Branch Campus: A Collaborative Approach

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Northampton Community College (NCC) is an open-enrollment institution that has grown to become the largest postsecondary institution in Pennsylvania's Lehigh Valley. Today, NCC offers college degrees, certificates, and specialized diploma programs to more than 30,000 students on three campuses. As such, NCC serves industry partners with employee career training, offers professional degrees and certifications in high-demand jobs, encourages community engagement through Smart Workshops for children, and offers adult education programming.

In the past, faculty at NCC offered a limited number of undergraduate research experiences (UREs) to students, mostly as sporadic independent research courses in STEM fields (biology and microbiology); capstone projects in various disciplines; and some experiential, course-embedded projects (chemistry, biology, ecology, psychology, and research methods in the social sciences).

Faculty in STEM and administrators at the NCC-Monroe Campus recognized the importance of UREs as high-impact teaching practices but were realistic about the limitations of a two-year institution. As community and institutional partnerships are important in the creation of long-standing programs, faculty sought a community grant from a local pharmaceutical company, which provided the first NCC Stem Pipeline Project for 2016–2018. The project was designed to benefit students from high school through postsecondary education, with dual-enrollment scholarships, STEM scholarships for NCC students, equipment purchases, and co-disciplinary UREs. The primary goal of adopting the co-disciplinary model was to improve overall scientific literacy amongst all students from multiple viewpoints, using science and non-science faculty partnerships. Examples of these projects involved biology-speech communication (oral presentations) in academic year 2016–2017 and chemistry-English (written presentations) in 2017–2018.

This initial grant supported the purchase of additional new technology for the labs; tuition funding for additional STEM students in need; and, most important, retention of STEM students.

These outcomes were recognized by both the institution and stakeholders, resulting in an award of an additional two years of support to expand the regional STEM education pipeline. Consequently, the 2018–2020 project was designed with three goals: (1) to maintain student support through dual-enrollment and STEM scholarships, (2) to increase faculty and institutional support for UREs, and (3) to establish permanent research sites. A faculty survey sent in 2019 revealed that students' lack of time and preparation as well as faculty teaching load, remuneration, and lack of research space were some of the main challenges at the institution. To address these issues, selected faculty developed a strategic plan to expand offerings of UREs, researching the best models and continuing conversations with administrators and staff to develop internal support and enable wide-scale adoption. The funding provided by this project allowed for the establishment of two permanent research sites on campus: an avian research center that has been active since fall 2018 and a greenhouse, currently under construction.

Based on these experiences, the following recommendations are offered to those initiating UREs at a community college:

- Identification of the challenges for the development of UREs at the specific institution is essential. Teaching loads, remuneration, and lack of space are important limitations that need to be addressed by the institution to increase faculty participation.
- Local support through community grants can help provide the funds needed for UREs. A multipurpose project that provides scholarships to students as well as infrastructure can be recognized as a successful long-term investment.
- Creation of UREs that best fit an institution's unique characteristics is paramount, but starting simple is important: embedded course experiences seem to be the best fit for those new to UREs (such as collaboration with local organizations and citizen science projects).
- For first- and second-year undergraduate students, learning about the research process is more valuable than finishing a successful project. They should be encouraged to learn from even disappointing results.

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Full-Spectrum Undergraduate Field Research at a Community College

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Conceptualizing and designing undergraduate research programs for general studies community college students can be challenging. However, there are frameworks available through which a cogent design can be developed. Two broad categories of thinking guided the development of an undergraduate research agenda in the Geography and Environmental Sustainability (GES) Program at Northwest Vista College (NVC) in San Antonio.

The first category was a paradigm shift in categorizing need. Employers assert that new college graduates need both field-specific and broad-ranging knowledge and skills—the latter, which are more highly valued, are often referred to as *marketable skills*. These interdisciplinary skills typically include communication, teamwork, decision-making, critical thinking, and knowledge application. A study of 400 employers indicated that organizations are more likely to hire recent graduates who have completed projects that required research, problem solving, and communication. Moreover, employers are more likely to hire graduates with collaborative research experience and those with study abroad experience (Hart 2015).

Marketable skills are often bifurcated into cognitive/noncognitive or soft/hard skills. Decontextualized, noncognitive, "soft" skills such as communication and teamwork—as opposed to discipline-based concepts and hard facts—are often viewed as mushy and valueless (Hora, Benbow, and Smolarek 2018). However, to be considered a capital asset (i.e., having value), communication, teamwork, decision-making, critical thinking, and knowledge application must be addressed in the cultural context of a *specific* workplace or industry sector. That is, they must be viewed in the context of professional communities and organizations, not in an unnuanced, illusionary, generic vacuum of workplace skills, so that they are truly applicable and free of soft and mushy associations.

The second category consisted of measuring research levels in the GES program. With the cultural capital context paradigm in mind—in this case, that of the environmental sector workplace where investigation and problem-solving are key—an undergraduate research program was developed with four levels: (1) course-based activities, (2) course-based projects, (3) student-faculty collaboratives, and (4) external research. From there, a 31-item inventory of cultural capital-informed marketable skills—the Marketable Skills Inventory for Geography and Environmental Sustainability Fieldwork (MSIGES)—was developed. This inventory was used to measure the extent to which students were offered skill building opportunities, and their perceptions of gaining these skills, in NVC's Adventure Science field studies program in Morocco. Sample skills in the context of environmental sustainability that are culturally determined and dependent on context include the following: analysis, synthesis, application of knowledge, research skills, adaptation to new situations, and ability to work in international contexts.

In the Adventure Science program, undergraduate field research was connected to marketable skills. The program partnered with the nongovernmental Atlas Cultural Foundation (ACF) in Morocco to conduct research that superseded typical study abroad goals and included levels 1–3 research. Some of the participating students ($n = 6$) opted only for in-class research as a part of their for-credit study abroad course, whereas others opted to use the class-collected data and write a technical report modeled on that of a private environmental engineering consulting firm that had conducted the same research two years prior. These community college students wrote a professional, 24-page technical report they submitted to ACF, as well as used it as the basis for an academic conference presentation and a peer-reviewed journal article.

At the end of the Moroccan hydrology field study, students' perceptions were measured in terms of marketable skills specific to geography and environmental science with the MSIGES. On a 1 = never occurring to 5 = often occurring scale, items related to diversity, teamwork, interpersonal skills, and application of knowledge had the strongest results ($\bar{x} = 4.7$ to 5.0). Items related to leadership, which are perceived as important to employers, were not perceived as strong by the students themselves ($\bar{x} = 4.3$), despite their work in teams and as leaders. Further, "capacity to apply knowledge" and "teamwork" were perfectly correlated ($r = 1.00$, $p = 0.01$), as was "working in interdisciplinary teams," "appreciation of diversity," and "working in an international context" ($r = 1.00$, $p = 0.01$).

Two themes emerged from the open-ended items:

1. Students perceived "teamwork" as a skill that employers would find important and were able to give concrete examples of their collaborations in teams, and
2. Students equally believed employers would find "leadership" as important; however, none offered any concrete examples of leadership from their fieldwork, despite the observation of this quality by the leading faculty, demonstrating that marketable skills sometimes need to be highlighted for students who are experiencing them.

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Summit Recommendations Provide Guidance to Expand Undergraduate Research Experiences at Community Colleges

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The Community College Undergraduate Research Experience Summit was a rare opportunity for educators from various STEM disciplines and a cross section of institutions to share their perspectives on efforts by two-year colleges to build, implement, and sustain undergraduate research experiences (UREs).

The enthusiasm of the 120 thought leaders for UREs was evident in the lively poster showcase, plenary sessions, and small-group discussions where participants were mixed intentionally to seed candid dialogue about scaling and sustaining UREs at two-year colleges and related topics. The top recommendations from each small group were reviewed by all participants.

Their collective recommendations in the *Community College Undergraduate Research Experience Summit Proceedings Report* (Patton and Hause 2020) offer guidance for administrators and faculty at associate-degree-granting institutions and community partners to enhance students' learning by offering UREs.

The summit was convened on November 20–22, 2019, in Washington, DC, by the American Association of Community Colleges with support from the Advanced Technological Education (ATE) program of the National Science Foundation (NSF). As summit partners, the Council on Undergraduate Research and the Community College Undergraduate Research Initiative assisted with planning.

The summit organizers defined UREs as instructional opportunities that use the scientific method or engineering design process to investigate a problem where the solution is unknown to students and faculty. This broad definition encompassed internships, competitions that blend academic and technical skills, and STEM design challenges (e.g., the Community College Innovation Challenge) as well as more traditional course-based research and honors projects.

Summit participants identified relationships of community college URE leaders with employers and universities as priorities second only to garnering institutional support for UREs. To ensure life-cycle support for UREs, they encouraged faculty to tailor UREs to the particular region's job market, to engage partners intentionally with frequent communication and recognition, and to establish pathways that help students progress from UREs to immediate entry to STEM careers or baccalaureate programs.

The following are other key recommendations from the summit for community college administrators and faculty:

- Scale and sustain UREs by incentivizing participation and cultivating inclusive campus cultures to engage all stakeholders in creation of UREs that align with the strategic plans of community colleges.
- Mobilize partnerships for UREs by developing collaborations with student organizations, faculty across disciplines, and employers. Also, share quantitative program assessments and qualitative data from students and alumni.
- Ensure equitable access to UREs by introducing students to research in the first term and by educating faculty about Universal Design for Learning concepts.
- Assess impact by using multiple measures (i.e., retention, completion, precourse and postcourse assessments, student stories, and gap analysis) within a standard set of assessment tools.

Outcomes of the summit include a grassroots community-of-practice that meets remotely each month to increase faculty engagement in research. To participate, contact Jared Ashcroft, Pasadena City College chemistry professor, at jmashcroft@pasadena.edu.

Summit discussions also encouraged NSF program directors. They issued a Dear Colleague Letter in March 2020 offering supplemental funding for ATE projects and centers to create new UREs or expand existing ones. NSF program directors helped ATE principal investigators who expressed interest in the opportunity but were impeded by COVID-19, by extending the deadline for submitting proposals through 2020.

In addition to the full proceedings report, the summit website (AACC n.d.) has notes from the moderated discussions, videos and posters featuring the UREs of participants, and URE outreach materials.

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INTERNATIONAL PERSPECTIVES

The Kungullanji Program: Creating an Undergraduate Research Experience to Raise Aspirations of Australian Aboriginal and Torres Strait Islander Students in the Sciences

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Abstract

Australian Aboriginal and Torres Strait Islander communities face complex challenges that require Indigenous-led research. Increasing the Indigenous research workforce depends on structural change within higher education institutions, including better pathways to research training and careers for Aboriginal and Torres Strait Islander students. Undergraduate research experiences can improve student success and encourage more students to progress to research programs and careers. The Kungullanji Summer Research Program offers research experiences for Australian Aboriginal and Torres Strait Islander undergraduates while recognizing their contributions to research. The Kungullanji program approach is a strengths-based research training framework that recognizes existing ability outside of institutional definitions of success and adapts to student needs with multi-layered support. The initial results suggest that this approach increases students' self-confidence and interest in conducting research.

Keywords: *equity, Indigenous students, minority students, STEM, undergraduate research, underrepresented students*

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Despite the growing need for more diversity in the science workforce (Hernandez et al. 2013; Hurtado et al. 2009; Ong 2005; Villarejo et al. 2008) Aboriginal and Torres Strait Islander students in Australia are less likely to enroll in disciplines within science, technology, engineering and mathematics (STEM) (Kippen, Ward, and Warren 2006; Trudgett, Page, and Harrison 2016). Aboriginal and Torres Strait Islander students also are underrepresented in higher degree research (HDR) programs and research positions. Although studies have investigated potential factors that affect undergraduate participation and HDR progression (Barney 2018; Behrendt et al. 2012; Hutchings et al. 2019; Kippen et al. 2006; Milne, Creedy, and West 2016; Pechenkina, Kowal, and Paradies 2011; Trudgett 2009; Trudgett et al. 2016), there is little understanding of how to bridge the divide between undergraduate coursework and graduate research programs (Hutchings et al. 2019). Globally, undergraduate research experiences (UREs) are used to bridge this divide and have shown to have numerous benefits, including increasing research skills, confidence, and progression to HDR programs (Garrison et al. 2010; Hernandez et al. 2013; Hunter, Laursen, and Seymour 2007; Hurtado et al. 2009; Linn et al. 2015, Lopatto 2004; Russell, Hancock, and McCullough 2007; Villarejo et al. 2008; Slovacek et al. 2012).

UREs also have been shown to have additional benefits for minority students (Adedokun et al. 2014; Garrison et al. 2010; Hernandez et al. 2013; Hughes et al. 2013; Hurtado et al. 2009; Linn et al. 2015; Moodie et al. 2018; Nagda et al. 1998; Slovacek et al. 2012). Underrepresented students in STEM can have the added challenge of balancing their professional identity with their social identity (Hurtado et al. 2009; Kang, Peterson, and Hernandez 2011; Ong 2005). Tailored URE programs that address needs of underrepresented students can provide social and emotional support to reduce isolation and tokenism (Kang et al. 2011) while developing their identity as a scientist or researcher (Hunter et al. 2007; Hurtado et al. 2009).

Although UREs have been shown to be successful for minority groups, including First Nations students outside of Australia (Garrison et al. 2010; Hughes et al. 2013; Naepi and Airini 2019), UREs in Australia are not designed to support Aboriginal and Torres Strait Islander students. Restrictive selection criteria of Australian UREs focusing primarily on grade point average (GPA) and institutional measures of success (Jewell and Brew 2010) can disadvantage Aboriginal and Torres Strait Islander participation. If designed specifically for this cohort, UREs could have the potential to address this institutional disadvantage and create a new space in the institution for Aboriginal and Torres Strait Islander research. This article explores the development of a URE designed to provide research training support for Aboriginal and Torres Strait Islander researchers while providing a platform to strengthen their voices in research.

Historical Context

Represented as the most highly researched populations (Bessarab and Ng'andu 2010; Moodie et al. 2018; Walker et al. 2014) are the Aboriginal and Torres Strait Islander peoples (the word *peoples* is used respectfully here to recognize the diverse groups of people within this demographic, each with their own cultural practices). This is symptomatic of the colonial history and subsequent research conducted with non-existent, minimal, or tokenistic involvement of Aboriginal and Torres Strait Islander peoples in the research design and implementation of research outcomes (Garrison et al. 2010). More research engagement and Indigenous leadership are needed (Kippen et al. 2006), which requires a larger community of Aboriginal and Torres Strait Islander researchers to change the conduct of research and ensure that Indigenous knowledges are respected, protected, and included (Barney 2018; Behrendt et al. 2012; Hutchings et al. 2019; Moodie et al. 2018; Trudgett 2009, 2010; Kippen et al. 2006).

Although research can be perceived as unfamiliar and foreign (Kippen et al. 2006), Aboriginal and Torres Strait Islander peoples are not new to research and have been researchers and scientists for many thousands of years (Rigney 2001). Long before colonization, each generation passed on and perfected knowledge and practices that supported communities to live and thrive in diverse and dynamic environments (Morrison et al. 2019). Therefore, research is not new; however, non-Indigenous institutions are now seen as the primary knowledge creation spaces, and access is determined by the non–Indigenous academic elite. This results in research production and training in universities excluding and systemically discriminating against Aboriginal and Torres Strait Islander peoples (Behrendt et al. 2012; Hart and Whatman 1998; Rigney 2001). Further efforts are needed to address structural disadvantage in research training of Aboriginal and Torres Strait Islander students. This could be addressed by creating new spaces in these institutions for the recognition and respect of Aboriginal and Torres Strait Islander research and empower researchers from the undergraduate level to produce research of importance to Aboriginal and Torres Strait Islander peoples and their communities.

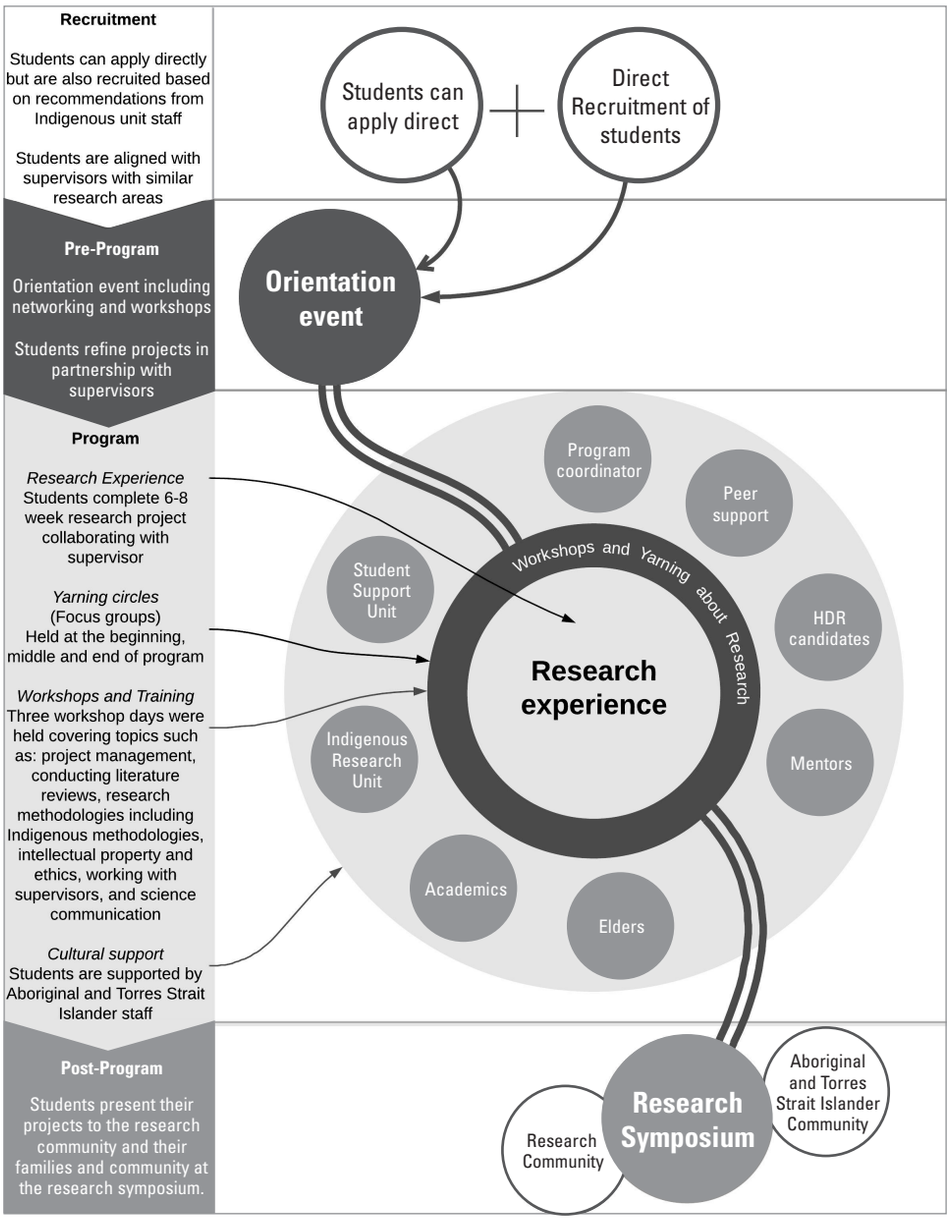
The Kungullanji Summer Research Program

To address the need for better research training opportunities for Aboriginal and Torres Strait Islander students, and support the transition from undergraduate to HDR programs, a new URE designed for a cohort of Aboriginal and Torres Strait Islander students was piloted at Griffith University, a public research university on the east coast of Australia. In 2014, when the first Kungullanji program commenced, Griffith University had more than 40,000 students in undergraduate and graduate programs, of which 1.4 percent were Aboriginal and Torres Strait Islander students (Griffith University 2014). At the time, Griffith University was one of the top universities for attracting Aboriginal and Torres Strait Islander students; however, most of these students were enrolled in non–STEM fields of study, and the students who were in STEM were not progressing to higher degree research (HDR) programs.

The Kungullanji Summer Research program (hereafter the Kungullanji Program) is named in the Yugambeh language (the Aboriginal language of the Gold Coast region) and translates as "to think" (Griffith University 2020; Yugambeh Museum 2020). The Kungullanji Program therefore challenges Aboriginal and Torres Strait Islander students to think about research careers and to think about how they can reclaim research spaces. Led by Aboriginal and Torres Strait Islander staff, the Kungullanji Program consists of several key components (as shown in Figure 1) such as supplying training in research skills, offering an opportunity to participate in a research symposium, and providing overarching cultural support.

The Kungullanji Program aims to improve cultural safety in research by creating a new space within the institution for Indigenous undergraduate research so as to better support inclusiveness, leadership, and cross-cultural collaboration between Aboriginal and Torres Strait Islander students and non-Indigenous researchers. As the students are engaging with research dominated by non-Indigenous ideologies and knowledge, creating a culturally safe space is paramount in empowering students (Trudgett 2009). Cultural safety allows students to conduct research in a spiritually, socially, and emotionally supportive environment, where their views are acknowledged, respected, and valued, allowing them to be confident in their own identity without being harassed or challenged (Behrendt et al. 2012; Garrison et al. 2010; Kippen et al. 2006; Trudgett 2009; Williams 1999).

FIGURE 1. Structural Elements of the Kungullanji Program



Culturally safe spaces are created in the Kungullanji program by (1) incorporating cultural approaches and methodologies in the workshops; (2) using Indigenous methodologies for program evaluation such as yarning, also known as talking circles (Bessarab and Ng'andu 2010; Garrison et al. 2010; Walker et al. 2014); (3) supporting students through a network of Aboriginal and Torres Strait Islander academic staff, general staff, and Elders; and (4) recognizing their unique contributions to the research through the symposium event (see Figure 1). Additionally, the use of a cohort model also encourages peer support—an important enabling factor (Eagan et al. 2013)—and encourages sharing of interdisciplinary perspectives across the group.

Admission and Selection of Summer Scholars

Prior to the program implementation, the program coordinator met with Aboriginal and Torres Strait Islander students to discuss their interest in research. After direct discussions with undergraduate students, it was found that many students did not feel comfortable applying for existing "mainstream" undergraduate research experiences because of the restrictive selection criteria, intimidating application process, or feelings of "it wasn't for them." The recruitment of students for the Kungullanji Program takes a different approach by recruiting in two ways. First, students can apply directly to the program through the website (Griffith University 2020), which attracted students

TABLE 1. Demographic Data on Kungullanji Program Participants, 2014–2015

Demographic	Demographic details	*n* = 8
Gender	Female	5
	Male	3
Year level	First year	1
	Second year	5
	Third year	2
	Fourth/final year	0
Discipline	Engineering (four-year program)	2
	Environmental science (three-year program)	5
	Biomedical science (three-year program)	1

already looking for summer opportunities but believing they would not be eligible for existing UREs. Second, students were recruited directly, based on recommendations from Aboriginal and Torres Strait Islander staff, especially if they had shown in interest in pursuing a personal research project or developing research skills. This direct recruitment led to students taking part in the program who would not normally consider applying but who have done so because they were directly encouraged and mentored to apply. This also created mentoring relationships prior to the start of the program between the program coordinator and potential summer students. Unlike UREs that have competitive selection criteria (Jewell and Brew 2010), students do not need to be in their final year or have a record of high academic achievement. In the recruitment process, the Kungullanji Program admits all Aboriginal and Torres Strait Islander STEM students regardless of GPA or year level. This recognizes the research capacity of all students regardless of academic achievement in coursework. This is supported by several researchers who share the view that undergraduate research allows all types of students, regardless of grades or year, to thrive in the research environment (Jones, Barlow, and Villarejo 2010; Nagda et al. 1998; Rowland et al. 2014; Russell et al. 2007; Schneider 2002). The first program held in 2014–2015 supported eight Aboriginal and/or Torres Strait Islander summer scholars from STEM disciplines at Griffith University (demographic detail is in Table 1).

Project and Supervisor Selection

The selection process, rather than focusing on the students, focuses instead on selecting the right supervision based on the students' interests. Rather than predefined projects decided by the supervisors, the students propose a research area of interest and co-design the project with a mentor. Examples of projects can be found on the program website (Griffith University 2020).

Research Skills and Training

The Kungullanji Program approach focuses on creating layers of support (see Figure 1) that are flexible and adaptable to each student's needs. This support structure has been discussed as crucial to supporting Aboriginal and Torres Strait Islander students (Milne et al. 2016). Although the workshops and research skills training are centered on developing transferable or generic research skills (see Figure 1), they change depending on the needs of the students who attend and recognize the diversity of student experience and existing knowledge. This flexibility also allows discussions to emerge about Indigenous research, including topics such as Indigenous methodologies, ethics, and resilience.

Program Evaluation and Feedback

Throughout the program, yarning circles (focus groups) are held to obtain ongoing feedback throughout the program as well as to provide a culturally safe space for students to discuss their experiences. A yarning circle is a conversational, semi-structured interview style that incorporates the cultural practices of yarning, storytelling, and sharing of experiences in a relaxed and informal setting. Yarning circles are recognized as a credible Indigenous research methodology (Bessarab and Ng'andu 2010; Hutchings et al. 2019; Walker et al. 2014) and have been used to provide cultural support in a similar program outside of Australia (Garrison et al. 2010).

Yarning circles are used in the Kungullanji program to create a peer mentoring and group feedback session by creating a safe space where students can openly share their opinions and feelings about research. To open the session, focus questions are used to guide the conversation, building trust, confidence, and conversational freedom. Some questions used include the following: "How do you feel your research is going so far?", What have been some of

TABLE 2. Averaged Self-Reported Scores for Confidence and Interest in Research

	Pre-program	Post-program
Confident "doing research"	3.57	4.00
Confident presenting research	2.86	4.17
Confident communicating with researchers/academic staff	3.43	5.00
Confident working with researchers/academic staff	3.43	4.83
Interested in doing an honors program	4.14	4.50
Interested in doing a PhD program	2.71	3.67
Interested in a research career	3.29	4.17

Note: scored on a 5 Likert scale of 1 = strongly disagree to 5 = strongly agree (n = 7)

TABLE 3. Average Rating Scores on the Program Elements

Program element	*n*	Is useful	Is informative	Feel more supported	Feel more confident	Is enjoyable	Is essential
Orientation	7	4.43	4.43	4.43	4.43	4.43	4.57
Workshop 1	5	4.80	4.80	n/a	n/a	4.80	4.40
Workshop 2	2	4.50	4.00	n/a	n/a	4.00	4.50
Workshop 3	5	4.80	4.80	n/a	n/a	4.80	4.80
Yarning circles	7	4.71	4.43	4.71	4.71	4.57	4.57
Symposium	7	4.71	4.57	4.71	4.71	4.71	4.86

Note: scored on a 5 Likert scale of 1 = strongly disagree to 5 = strongly agree, n/a = not asked (n = 7)

the challenges and successes?", and "What do you want to achieve/What are your goals?". It is important to note that the questions asked are not as important as creating supportive relationships and space where students feel they can discuss topics freely.

A survey also was administered pre-program and post-program asking students to self-report their confidence doing research, presenting research, working with research staff, as well as responding to statements about their views on honors and PhD programs, and pursuing a research career. In addition, the postsurvey asked students to evaluate aspects of the Kungullanji program structure.

Initial Findings from the 2014–2015 Pilot Cohort

Seven out of eight of the summer scholars responded to the survey administered. The responses are summarized in Tables 2–4. Table 2 shows that the program has influenced the greatest increases of a point or more in students' self-reported confidence "presenting research" and "communicating with researchers." Although there was an increase in self-reported interest in honors and PhD programs, this was a smaller change.

Table 3 demonstrates that the students rated all program components highly, but the most essential element was the research symposium at the conclusion of the program. Table 4 further elaborates on these findings, showing that the symposium was possibly rated highly because it was perceived as an enjoyable experience and provided an opportunity to the students to present, showcase their research, and have a voice in the research community. A key finding raised in the open-ended questions (see Table 4) was that the students valued the program being offered to all Aboriginal and Torres Strait Islander STEM students who wanted to participate rather than admitting only high-achieving students based solely on GPA requirements.

Outcomes and Progression to Postgraduate Degrees

Since the first Kungullanji Program in summer 2014–2015, most of the summer scholars have continued to engage with research. Of the eight students discussed here, two students completed the program again. Three of the students completed honors work, and one completed a master's of science degree. Another student is enrolled in a doctoral program in medicine, and two are enrolled in a PhD program.

TABLE 4. Participant Responses to Open-Ended Questions in the Post-Program Survey

Question	Typical response	*n*	Sample quotes
Further comments about the yarning circles	Increased confidence from discussing similar issues	2	"It made me feel more comfortable with my progress in my research as it made me realise that most of the problems I was having someone else was experiencing"
Further comments about the symposium	Opportunity to present	3	"I think it was great to show how deadly our research was, and it also allowed barriers to be broken (i.e. stepping out of our comfort zone)"
What was the most enjoyable part of the program?	Hands-on experience	5	". . . being able to do field work and my own lab work"
	Presenting at symposium	2	"Presenting our work at the symposium and having people asking questions and showing their interest in something we'd been working on was very rewarding . . ."
What was the most useful part of the program?	Getting to know academic staff	3	"Getting to know academics and understanding how research is carried out"
	Support provided by the program and peers	3	". . . being able to talk to each other and discuss issues or achievements throughout the program"
Suggestions for improvement	Increasing opportunities	2	"Make sure it's a long-term program! Everyone should have the opportunity to have this exposure to research"
	Timing of scholarship/program	3	"Starting earlier to prevent running into the semester"
Would you apply again?	Yes (or similar response)	7	"Yes, I would, I enjoyed the program thoroughly"
What would you say to other undergraduate students thinking of doing research?	Do it (or similar response)	6	"Do it!! It is one of the best things you can do to get your name out there and meet and work with some great researchers/academics"
	Start early (or similar response)	2	"Start everything as early as possible"
General comments	GPA/admission requirements	3	"I loved that there was no GPA cut-off . . . some students might need a program like this to receive the confidence boost to achieve more. Also, just because someone is just passing [in coursework] doesn't mean that they can't do research it just means they haven't been given the opportunity to shine"

Discussion

Supporting more Aboriginal and Torres Strait Islander peoples in research builds research networks with stronger links to communities and builds community capacity for research (Smith 2006). This promotes self-determination within research, empowering communities to make decisions about the topics of research conducted (Hart and Whatman 1998; Smith 2005). One way to address this is to have Aboriginal and Torres Strait Islander students leading research, even at the undergraduate level. This can be created through undergraduate research experiences like the Kungullanji Program. In comparison to other initiatives that might focus on attracting high-achieving students (Jewell and Drew 2010), this program offers a strength-based approach by recognizing the students' existing abilities regardless of university-based research experience or GPA. The Kungullanji Program creates a new undergraduate research space specifically for Aboriginal and Torres Strait Islander undergraduate students to explore their research interests and develop research skills.

Rather than a traditional internship or apprenticeship model (Linn et al. 2015; Rowland et al. 2014; Seymour et al. 2004), the students have a more active role in the direction of the project. This view is consistent with approaches advocated in the literature to move from deficit thinking and toward creating cultures of success with a strength-based approach (Moodie et al. 2018; Naepi and Airini 2019). Flipping the selection process and encouraging students to design their own projects based on their strengths and interests encourages more positive relationships through collaboration between students and academic staff. This results in students feeling like an active part of the research community (Kang et al. 2011). By valuing students' contribution to research more highly, this could also lead to better acknowledgment of, and respect for, students' cultures and knowledge by the supervising academic staff (Milne et al. 2016).

Through the program, students receive continuous individual support from the program facilitator prior to commencement and continuing after the completion of the project, an approach shown to be an integral component of successful educational programs (Gould and MacPherson 2003; Naepi and Airini 2019). The students also are supported by many different Aboriginal and Torres Strait

Islander staff, including administration support staff and academic staff. In addition, increased frequency of contact between students and staff has been shown in other studies to correspond to an increase in retention (Jones et al. 2010; Nagda et al. 1998) and aspiration to apply for graduate research programs and pursue careers in science (Eagan et al. 2013; Hurtado et al. 2009; Slovacek et al. 2012; Villarejo et al. 2008).

The yarning circles and workshops also create spaces for sharing experiences and building a peer-support cohort model. In addressing the need to increase support for Aboriginal and Torres Strait Islander researchers, some of the students commented in the survey on the value of having support from the wider university community and their peers (see Table 4). The symposium event also allowed an opportunity for students to develop and demonstrate their ability to synthesize research findings, demonstrate autonomy and leadership, engage with a broader audience, and receive constructive feedback in a low-risk environment—findings that are consistent with other studies (Spronken-Smith et al. 2013). This event also created an opportunity to showcase Aboriginal and Torres Strait Islander researchers and student voices. Students were encouraged to invite family and community members to share in the experience and to create a "sharing space" of cross-cultural knowledge among supervisors, students, and the wider community. This support from family and community members has been discussed as critical to supporting the education of Aboriginal and Torres Strait Islander students (Milne et al. 2016).

Since completing the program, several students have commented that they felt they pursued advanced study because of the skills, awareness, or confidence gained during the Kungullanji Program. Further research is in progress to explore and evaluate program benefits and student outcomes for the cohort discussed in this article as well as subsequent programs since 2014. Exploration of the themes that emerged during the yarning circles also will be examined in detail in future research.

Conclusion

UREs create an opportunity to raise the awareness, aspirations, and skills of student researchers. These types of programs also recognize and value the unique knowledge and perspectives of researchers while facilitating cross-cultural knowledge exchange and interdisciplinary research. This creates the potential to support projects led by Aboriginal and Torres Strait Islander communities. The Kungullanji Program has demonstrated initial benefits of implementing an URE with Aboriginal and Torres Strait Islander students in STEM, including increased student self-confidence and participation in the university research community. The structure of the Kungullanji Program explored here presents a foundation for creating and improving research spaces for undergraduate Aboriginal and Torres Strait Islander students. UREs such as those offered through the Kungullanji Program present an untapped potential to improve educational disadvantage, increase student success, increase visibility of Indigenous research, and encourage students to pursue STEM and research careers.

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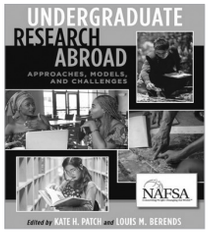
Book Review

Undergraduate Research Abroad: Approaches, Models, and Challenges

Edited by Kate H. Patch and Louis M. Berends



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The strength of the publication *Undergraduate Research Abroad: Approaches, Models, and Challenges* edited by Kate H. Patch and Louis M. Berends lies in the organization of the text and heterogeneous approach in considering international research by undergraduates, making the work valuable to faculty and administrators regardless of their level of experience in this area.

The editors introduce the text by identifying the practices of undergraduate research and global learning as high-impact practices shown to increase retention and student engagement (Kuh 2008). Patch and Berends establish a clear definition of undergraduate research abroad and identify the core principles of undergraduate research abroad based on emergent themes among the various models and institutions featured in the text. These central themes are student learning, partnerships, faculty collaborations, mentorship, trust, quality, ethics, and preparation. This framework established at the beginning of the text allows readers to consider both the definition and principles through their perspective developed through experience and institutional context. This makes the work foundational for those with limited experience and reflective for those with fully operational programming.

The book is divided into three parts, the first of which focuses on the critical components of undergraduate international research such as program building, managing faculty and student stakeholders, managing risk, considering ethics in operations involving diverse contexts, and discussing student development theory (the last by past CUR president Julio Rivera). The second part features a variety of program models and institutional perspectives relative to international undergraduate research. The third part supplies an overview of various program providers that presents missions, foci, and services. In this last section the editors walk a fine line between the inclusion of information that may be helpful to some institutions as they expand international research offerings and full-out advertisement, which may have a mixed utility for readers.

This publication is useful in terms of providing clearly articulated information that is foundational to a wide variety of international research programming. The inclusion of Victor Tricot Salomon's chapter "Colonialism and the Ethics of Undergraduate Research Abroad" is valuable. Recognizing and managing the power differential for students and faculty when conducting research in the context of the developing world is critical not only to the success of the project but also to student development of a true connectivity to the greater humanity through the experience. Additionally, the chapter "Undergraduate Research Abroad Risks: Health, Safety, Security, and Supervision" by Julie Anne Friend provides a structure to begin to assess and manage the risks inherent in international work. Such information was not easily available 20 years ago, and in retrospect, many operating at that time were somewhat naïve to the risks. Although attention to risk management has grown over the years, those involved in research abroad today, whether new to programming or experienced, must understand that to be complacent or ignorant of the risks is negligent. Multiple references to preparation and reentry throughout the publication also are beneficial.

Undergraduate Research Abroad: Approaches, Models, and Challenges concludes with a reflection by the editors on the central themes in the text. This efficacious conclusion allows readers to reflect on those parts of the publication most useful to their institutional mission and program objectives. Patch and Berends reiterate that this book generates a discussion and that much more research needs to be completed, but the text's concrete components based on years of experience and a variety of contexts and missions coupled with proven practice in research, study abroad, and student learning theory provide a valuable read for anyone in the field.

Reference

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*. Washington, DC: Association of American Colleges and Universities.

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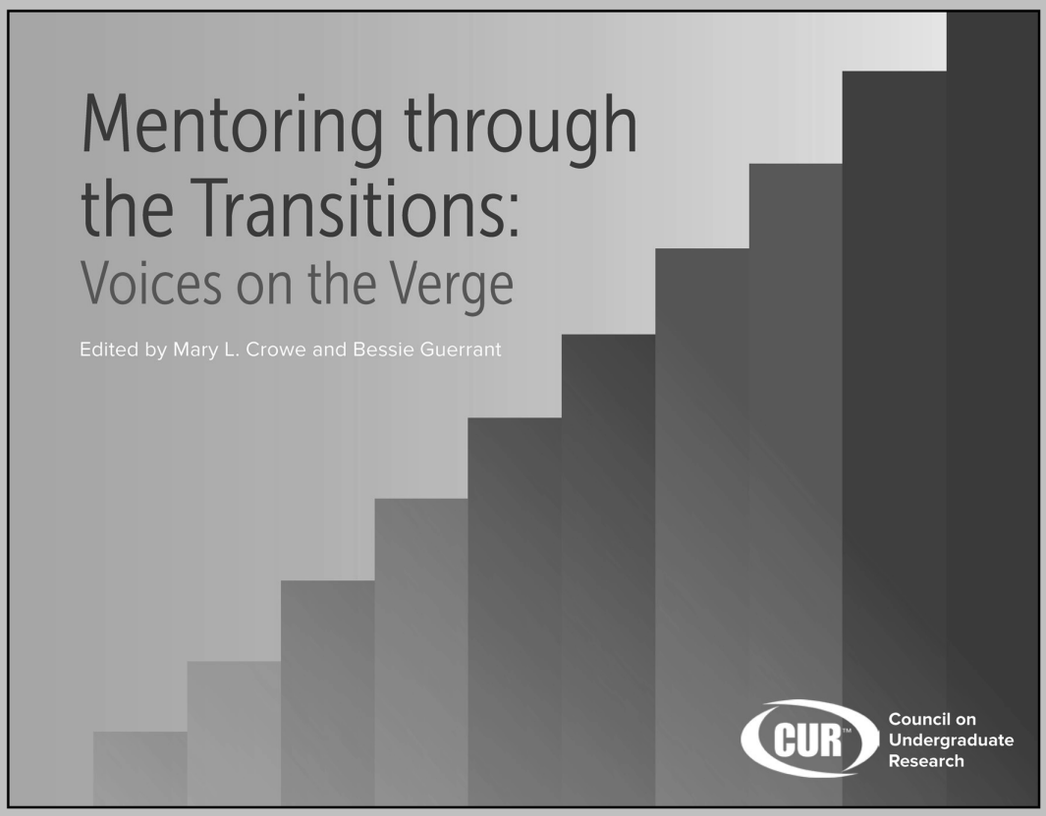

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The Journal of the Council on Undergraduate Research

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