Cross-disciplinary CURE Program Increases Educational Aspirations in a Large Community College

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ABSTRACT

Undergraduate research experiences have been widely demonstrated as a beneficial and essential component of the college experience. However, many community colleges face barriers and lack of support in implementing such research programs, which means a significant number of community college students miss out on these impactful experiences. Course-based undergraduate research experiences (CUREs) represent a feasible way to increase access to research experiences within community colleges. To investigate whether these CURE opportunities resulted in comparable to 4-year university CURE students, a CURE program was developed across various disciplines in a large community college and the impact on community college students was assessed. Analysis of both qualitative and quantitative data showed that students reported improvement in research skills, increases in confidence, and increases in educational aspirations. Peer interactions and instructor relationships in CUREs were identified as key factors associated with increases in research skills. Key factors associated with increases in educational aspirations included confidence in research-based courses, seeking additional research opportunities, and building a meaningful relationship with the instructor, but only if confidence increased as well. Our findings indicate that CUREs positively impact student outcomes in the community college setting and may provide increased access to research experiences.

INTRODUCTION

Undergraduate research is one of several high-impact practices that has been shown to increase student learning, success, and retention (Kuh, 2008; Davidson, 2018). A growing body of literature indicates that undergraduate research experiences, such as course-based undergraduate research experiences (CUREs) or apprenticeship-based experiences, have positive cognitive, psychosocial, and behavioral impacts on students. These experiences have been shown to increase content knowledge and understanding of the nature of science and to facilitate development of technical, collaborative, and communication skills (Lopatto, 2006, 2008; Bascom-Slack *et al.*, 2012; Adedokun *et al.*, 2014; Corwin *et al.*, 2015a). Psychosocial gains include increased confidence, self-efficacy, motivation, sense of belonging, and scientific identity and the development of meaningful relationships with peers and instructors (Harsh *et al.*, 2011; Hanauer *et al.*, 2012; Alkaher and Dolan, 2014; Shaffer *et al.*, 2010, 2014). Behavioral gains include increased persistence and completion of STEM degrees (Nagda *et al.*, 1998; Barlow and Villarejo, 2004; Seymour *et al.*, 2004; Gilmer, 2007, p. 200; Russell *et al.*, 2007; Carter *et al.*, 2009; Jones *et al.*, 2010; Espinosa, 2011; Eagan *et al.*, 2013; Graham *et al.*, 2013), as well as increased academic achievement (Kinkel and Henke, 2006; Gilmer, 2007; Jones *et al.*, 2010; Junge *et al.*, 2010) and educational aspirations of participating students (Hathaway *et al.*, 2002;

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Lopatto, 2007, 2008; Nevill and Chen, 2007; Carter *et al.*, 2009; Junge *et al.*, 2010; Eagan *et al.*, 2013; Rodenbusch *et al.*, 2016; Carpi *et al.*, 2017). One study of 4500 students found that 30% of students who had never considered pursuing a graduate degree planned to do so after participating in research (Russell *et al.*, 2007). While all students benefit from high-impact practices like undergraduate research, the students who benefit the most are those who are traditionally underrepresented—students of color and first-generation and low-income students (Jones *et al.*, 2010; Carpi *et al.*, 2017). Undergraduate research experiences therefore also play a critical role in closing educational equity gaps and increasing student success and retention.

National initiatives have called for widespread participation of undergraduate students in undergraduate research early on in their educational path in an effort to increase participation and persistence of diverse populations in science, technology, engineering, and mathematics (STEM) fields (American Association for the Advancement of Science, 2011; Olson and Riordan, 2012). Undergraduate research is often viewed as the purview of universities, as they have grant funding, extensive facilities, and faculty engaged in research. Community colleges are teaching focused, and often the majority of faculty either no longer participate in research or do so in a consulting capacity, away from campus. Yet community colleges offer the greatest opportunity to engage students in research early in their careers and include underrepresented students (Davidson, 2018; Hewlett, 2018). Community colleges account for nearly half of all U.S. undergraduates and represent highly diverse student populations, with roughly a third of the nation's first-generation students and approximately half of all African-American, Hispanic (Latinx), and Native American students (American Association of Community Colleges [AACU], 2021). Thus, generating a successful undergraduate research program across disciplines at a community college has the potential to reach a large number of underrepresented students in these fields.

Research experiences may be incorporated at the undergraduate level in a variety of ways. The traditional apprenticeship model of undergraduate research, which is often used at 4-year universities, involves a small number of students working directly with a faculty mentor to complete a research internship. This model is limited by the low student–faculty ratio and may not be feasible in community colleges, where faculty have higher teaching loads and often have limited resources for research (Hewlett, 2016). Additionally, these faculty-mentored internships typically occur later in the educational path of a student (often during the junior or senior year), and not all students have access to or understand the benefits of seeking out these opportunities.

CUREs offer a more inclusive and practical alternative to this model, as they incorporate the research experience into a course, broadening the impact from a few students to entire sections of students (Bangera and Brownell, 2014). CUREs are defined as broadly relevant, discovery-based research experiences that incorporate the use of research practices, collaboration, and iteration (Auchincloss *et al.*, 2014). CUREs often involve a redesign of the curriculum to intentionally engage students in the process of discovery and to invite students into a community of practice in which they are introduced to the scholarship, methods, and practices of a particular discipline (Wenger, 2010). The altered course structure in a CURE reconfigures the peer and instructor interactions, as the instructor becomes a collaborator and facilitator figure, rather than an authority figure. The iterative nature of CUREs may also cultivate a culture of collaboration between peers and the instructor. While CUREs can vary in the opportunities they offer for engaging in the process of science—ranging from structured experiences, in which some aspects of the research have been determined by the instructor, to more inquiry-based experiences, in which the students independently determine all aspects of the research project—all CUREs give students some ownership within their projects and build student confidence (Buck *et al.*, 2008; Brownell and Kloser, 2015; Ballen *et al.*, 2017). Many studies have shown that CUREs confer the same benefits as faculty-mentored apprenticeships (Shaffer *et al.*, 2010; Rowland *et al.*, 2012; Bangera and Brownell, 2014; Jordan *et al.*, 2014). Because these research experiences are incorporated directly into the curriculum, they can be introduced early on in introductory-level courses and made available to large sets of students. These students do not have to seek out or pay extra for these research experiences. Evidence indicates that engaging students in research experiences during the first 2 years of college increases retention in STEM fields (Davidson, 2018). Although much of the CURE literature has focused on CUREs in the STEM fields, CUREs have been used across disciplines, including in the social sciences and natural sciences (Ishiyama, 2002). Implementing CUREs at a community college level also increases the chance that most students will benefit from the experience of conducting research. Gains in social support from peers, research mentors, and instructors have also been found to increase the likelihood of students persisting in research experiences (Cooper *et al.*, 2019). Furthermore, community colleges offer the greatest opportunity to engage students in research early in their careers and include marginalized and historically underrepresented students due to their diverse student population makeup (Hewlett, 2018; AACC, 2021).

In spite of the many documented benefits of undergraduate research, there remain significant barriers to its implementation at community colleges. These barriers include: 1) a lack of time and resources for developing research projects, 2) heavy teaching loads, 3) lack of incentive in faculty promotion processes for the integration of research, and 4) a large percentage of adjunct instructors at community colleges with even fewer college resources available, high teaching loads, and limited promotion opportunities. Lack of institutional support, equipment, and space also make it difficult for faculty to implement CUREs in their courses. While undergraduate research is deeply integrated into the campus culture of many universities, community colleges may lack a campus culture that supports and prioritizes the integration of this high-impact practice. In some cases, there may be small pockets of faculty who integrate these practices, but the college as a whole does not have the infrastructure to support faculty development. Scaling and sustaining undergraduate research at community colleges requires multiple levels of support from the institutional level, to the faculty level, to the student level (Hewlett, 2018).

Despite the challenges of implementing this practice, we sought to create a CURE program at a large community college by taking a multi-pronged approach to 1) support faculty development of CUREs across multiple disciplines, 2) establish a

supportive campus culture that values and celebrates this practice, and 3) assess the impact of this initiative on both students and faculty. We supported faculty as they redesigned course elements to include a research component by establishing a community of practice and offering faculty development workshops and faculty learning communities. To foster a supportive campus culture, we established a quarterly campus-wide research symposium, in which students were able to present their research projects to members of the campus and foster collaboration across departments, disciplines, and various resources across campus, such as the college library.

A limited amount of research on implementing and assessing the effectiveness of CUREs exists (Dolan, 2016), specifically in the community college setting. However, in the research that has been done, CUREs at a community college have been found to effectively increase confidence in science and research skills (Ashcroft *et al.*, 2020). The Building Infrastructure Leading to Diversity: Promoting Opportunities for Diversity in Education and Research (BUILD PODER) program at California State University, Northridge, is one successful example of exposing community college students to CUREs in community colleges and supporting historically underrepresented students in pursuing careers in research (Ashcroft *et al.*, 2021).

As stated earlier, undergraduate research experiences have been shown to increase participating students' collaboration (Lopatto, 2006, 2008; Corwin *et al.*, 2015a), confidence, and development of meaningful relationships with peers and instructors (Shaffer *et al.*, 2010, 2014; Harsh *et al.*, 2011; Hanauer *et al.*, 2012; Alkaher and Dolan, 2014), as well as their educational aspirations (Eagan *et al.*, 2013; Hathaway *et al.*, 2002; Lopatto, 2007, 2008; Nevill and Chen, 2007; Carter *et al.*, 2009; Junge *et al.*, 2010; Rodenbusch *et al.*, 2016; Carpi *et al.*, 2017). Therefore, the purpose of the present study was to assess the impact on student outcomes of the cross-disciplinary CURE program in a community college setting, specifically the development of research skills, student confidence, connections with peers and instructors, and educational aspirations. Collectively, these student outcomes are important indicators of academic persistence and success (Hathaway *et al.*, 2002; Corwin *et al.*, 2015a). Thus, we examined the following research questions: 1) Did the integration of CUREs into introductory-level courses across disciplines in a community college setting result in student outcomes consistent with literature for CUREs (i.e., research skills, self-confidence, and connections with peers and instructors)? If so, what factors were associated with these outcomes? 2) Do research experiences at a community college increase the likelihood that students seek a higher degree from pre- to post-CURE experiences? If so, what factors were associated with this change?

METHODS

Undergraduate Research Program Development

In 2018, we sought to build a multidisciplinary undergraduate research program at our community college. A small group of faculty were involved in the creation of a campus action plan, which included the development of CUREs for implementation into introductory-level or majors-level courses in five different departments (Anthropology, Biology, Chemistry, Psychology, and Political Science). Supplemental Table 1 includes a description of each of the CUREs. This group worked with the college's research librarian to develop research literacy modules for integration into many of the CUREs. Participating faculty formed a community of practice that met regularly to support one other and problem solve as they were implementing these CUREs. The faculty were also involved in the creation of pre- and post-survey assessments to measure the impact of this intervention on student success. To create a sustainable and supportive undergraduate research program, faculty worked with the Research, Innovation, Service Learning and Experiential Learning Division on campus to establish a quarterly campus-wide research symposium. Following the initial establishment of the research program, we have made efforts to scale and sustain this program through the creation of faculty learning communities, regular professional development offerings, and expanded collaborations with other community colleges and universities in the area.

Participants

The study was conducted at a large community college in the Pacific Northwest (student population of 34,000). The student population is diverse (Asian/Pacific Islander: 20.3%, African American: 6.1%; Native American: 1.1%; multiracial: 3.4%; White: 69.1%), 55% of students are full-time, 65% of our students are employed, and 22% have dependents. More than half of the credit students (55%) are completing a transfer degree before transferring to a 4-year program.

A total of 762 students enrolled in introductory-level courses containing a CURE completed both the pre and post surveys. Of these, 189 students completed the undergraduate research experience in the online setting during the pandemic (Spring 2020 to Winter 2021). The pre-pandemic data set (n = 573) includes a relatively even distribution of courses in the social and natural sciences (anthropology, chemistry, life sciences, political sciences, and psychology). The distribution of courses represented during the pandemic was slightly different, because some of the lab science faculty were not able to convert their undergraduate research experiences to the online setting.

Procedure

Student Survey. To assess the impact of undergraduate research experiences in introductory-level courses within the community college setting, a group of faculty developed a pre- and post-survey assessment for students to complete. This study was determined to be exempt by the Institutional Review Board. The survey was administered over the course of seven academic quarters (Winter 2019 to Winter 2021) to students participating in introductory-level courses that included an undergraduate research experience. The pre survey was given within the first 3 weeks of the quarter, and the post survey was assigned within the last 2 to 3 weeks of the quarter. Most faculty offered extra credit or a small number of points for participation in the survey. The pre- and post-survey responses were paired and de-identified by removing student names, instructor names, and course names from the data set.

Measures

Student Survey. The pre- and post-survey student assessments were developed by a cross-disciplinary team of faculty using a combination of previously validated instruments and customized questions (Brownell *et al.*, 2015; Corwin *et al.*, 2015b; Hathaway *et al.*, 2002) to assess overall experiences in a

research-based course and to measure whether students experienced the design features of CUREs. The survey development process was participatory and cross-disciplinary to make a standard instrument for all CUREs across the campus.

Research Skills. Research skills were assessed in the post survey. Upon completion of the research-based course, students were asked to self-report questions from the American Association of Colleges and Universities (AACU) VALUE Rubric for Inquiry and Analysis (Rhodes, 2010). This rubric was created using the AACU Critical Thinking VALUE Rubric.[1] The inquiry and analysis questions were intended to measure self-reported gains in key skill areas. Students were asked, "How often did the following things occur in this course?," and rated various research skills (e.g., "I contributed my ideas during class discussions," "I sought input on how to address problems that I encountered during my investigation."). Each item was on a four-point frequency Likert scale (never, one or two times, three or four times, or weekly).

The remainder of the research skill assessment questions were custom developed by the team of faculty. Students were asked, "Having completed this course and your research project, how much did you improve in the following areas?," and rated the following research skills: interpreting results, analyzing data, collecting data, reading primary literature, communicating research results, and troubleshooting in the research process on a five-point frequency Likert scale (none, little, some, much, or extensive).

Students were also asked qualitative, open-ended questions on: 1) a personal strength or skill they used to be successful in the research portion of the course (i.e., "What is a personal strength or skill that you used to be successful in the research portion of this course? Please describe that strength or skill in 2–3 sentences.") and 2) whether doing research was a useful way to learn about the subject matter (i.e., "Was doing research a useful way to learn about the subject of your course? Why or why not? Please explain in 2–3 sentences.")

Student Confidence. Pre and post survey, students were asked to rate the statement "I can do well in research-based courses" on a four-point Likert scale (strongly disagree to strongly agree; Corwin *et al.*, 2015b). Students were also asked post survey, "Having completed this course and your research project, how much did you improve in the following areas?," and rated their "self-confidence in doing research" on a five-point frequency Likert scale (none, little, some, much, or extensive).

Working with Peers. Peer connection was assessed with a single item post survey. Students rated "I worked closely with my peers while conducting my research project" on a four-point frequency Likert scale (never, one or two times, three or four times, or weekly).

Relationship with Instructor. Instructor connection was assessed with two items post survey. These items were: "I felt supported by the instructor" and "I felt I built a meaningful relationship with the instructor during this course." All of these items were also rated on a four-point Likert scale.

[1]Retrieved from www.aacu.org/value-rubrics.

Educational Aspirations. Pre and post survey, students were asked, "What is the highest degree you intend to earn?" (Hathaway *et al.*, 2002). Students were also asked about seeking additional research opportunities. Post survey, students were asked, "What is the likelihood that you will seek out research opportunities or research-based courses again?," rated on a five-point Likert scale (extremely likely, somewhat likely, neither likely nor unlikely, somewhat unlikely, or extremely unlikely).

Data Analysis Plan

Quantitative Analyses. All quantitative analyses were conducted in SPSS v. 28. Bivariate correlations were conducted to examine the relationships between all quantitative variables (i.e., research skills, self-confidence, relationships with peers, and relationship with instructor). To examine the impact of participating in a CURE on student confidence in research-based courses and seeking a higher degree, paired-sample *t* tests were conducted. Chi-square analyses were conducted to further explore the proportion of students who sought a higher degree after taking a research-based course. Independent-sample *t* tests were conducted to examine group differences between students who did or did not work closely with their peers, as well as differences between students who did or did not have supportive and meaningful relationships with their instructors and the effect on their research skill development and educational aspirations. PROCESS, an observed variable ordinary least squares and logistic regression path analysis modeling tool (Hayes, 2017), was used to conduct mediation analyses to determine factors, both direct and indirect, that influenced educational aspirations (i.e., student confidence, seeking additional research opportunities, working with peers, and relationship with instructor). For example, we tested whether student confidence influenced educational aspirations and whether the relationship with the instructor was a mechanism for this change (student confidence → relationship with instructor → educational aspiration).

Qualitative Analyses. The qualitative analysis tool Dedoose (Dedoose.com) was used to code and categorize student responses to the question concerning the types of skills they reported after taking their research-based courses. No response received the same code more than once. Descriptive coding was conducted for first-cycle coding. Once the first-cycle codes were created, the research team conducted axial coding for second-cycle coding (Saldaña, 2021).

RESULTS

Part I

Did the integration of CUREs into introductory-level courses across disciplines in a community college setting result in student outcomes consistent with literature for CUREs (i.e., research skills, self-confidence, and connections with peers and instructors)? If so, what factors were associated with these outcomes?

Student Research Skill Development

Quantitative Results. A subset of the survey questions was aimed at measuring whether students were experiencing the design features of CUREs (i.e., interpreting results, analyzing data, collecting data, reading primary literature, communicating research

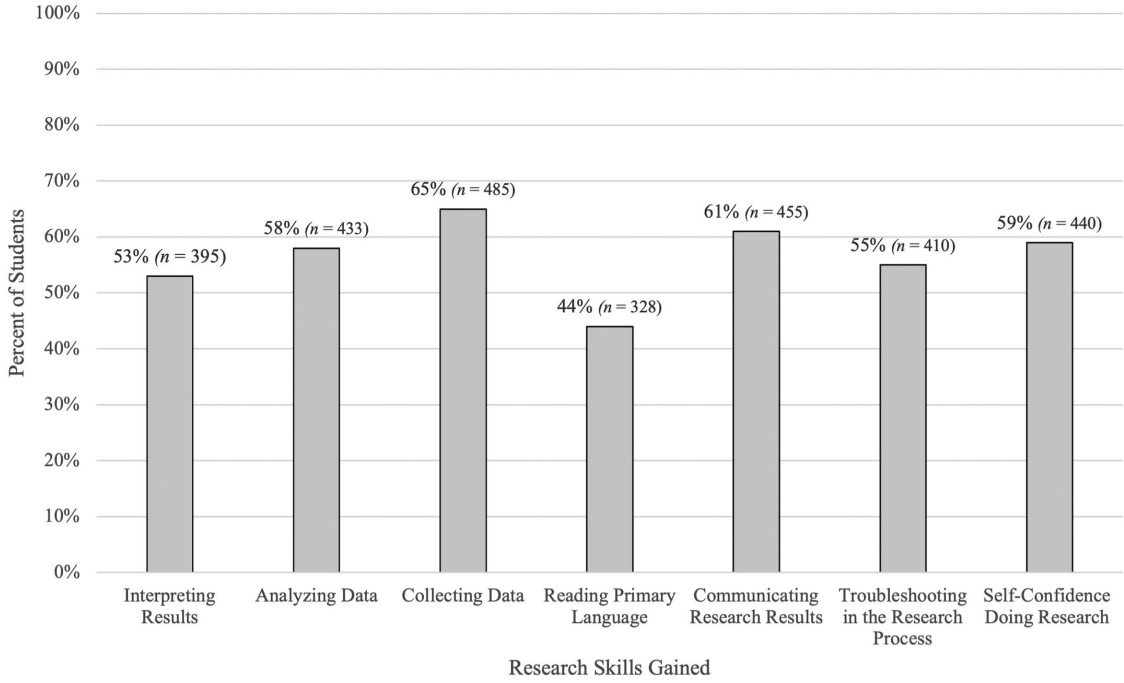

FIGURE 1. Students reporting research skill development. Students were asked to indicate the extent to which they had improved in each of the research skills. The percentage of students indicating "much" or "extensive" improvement is plotted in the graph.

results, troubleshooting in the research process, and feeling self-confident when doing research). More than half of all students reported improvement in all areas (self-reported "much" or "extensive" in improvement), except in reading primary literature, after taking a research-based course; see Figure 1.

Qualitative Results. Students were also asked to self-report what personal strength or skill they used to be successful in the research portion of the course. Dedoose identified 20 codes for the first cycle. Through axial coding, we connected the 20 codes and organized them into four codes, based on similar themes and concepts: 1) Life Application (i.e., open-mindedness/listening, creativity, logic/problem solving, adapting, passion, patience, and previous knowledge/skills), 2) Communication/Collaboration (i.e., communication with classmates, communication with respondents, and communication with teacher), 3) Research Skills (i.e., observation, curiosity/asking questions, data analysis/management, critical thinking, reading/writing/note-taking, and using sources), and 4) Responsibility/Initiative (i.e., organization, independence, focus/diligence, time management/efficiency). See Figure 2 for the percentages of students who reported each of the above four skills.

Student Confidence. Students showed increased confidence in being able to do well in a research-based course as a result of taking an undergraduate research–based course ($t(756) = -3.48$, $p = 0.001$); see Figure 3. Students were asked in a post survey if they learned skills through doing research that were useful in other areas of life. Student confidence in a research-based course was significantly postively correlated with the skills they learned while conducting their research projects that apply to other areas of life ($r = 0.47$, $p < 0.001$). That is, the more confident students were in CUREs, the more likely they were able to apply what they learned in their everyday lives.

Factors Associated with Student Development in Research and Outcomes

Working with Peers. Working closely with peers was significantly positively correlated with the highest degree students intend to earn at pre ($r = 0.11$, $p < 0.01$) and post survey ($r = 0.15$, $p < 0.01$). Working closely with peers also significantly predicted intent to seek a higher degree at post survey ($B = 0.16$, SE = 0.04, $p < 0.001$). All research outcomes were significantly positively correlated with working closely with peers while conducting their research projects: 1) interpreting results ($r = 0.19$, $p < 0.001$), 2) analyzing data ($r = 0.17$, $p < 0.001$), 3) collecting data ($r = 0.13$, $p < 0.001$), 4) reading primary literature ($r = 0.14$, $p < 0.001$), 5) communicating research results ($r = 0.19$, $p < 0.001$), 6) troubleshooting in the research process ($r = 0.17$, $p < 0.001$), 7) self-confidence in research ($r = 0.12$, $p < 0.001$), and 8) likelihood of seeking out research-based courses again ($r = 0.17$, $p < 0.001$). Additional important parts of the research process were also significantly positively correlated with working closely with peers. Seeking input on how to address problems that they encountered during their investigations was significantly positively correlated with working closely with peers ($r = 0.39$, $p < 0.001$). Revising and repeating work to account for errors or fix problems was significantly positively correlated with working closely with peers ($r = 0.24$, $p < 0.001$)

Relationships with peers increased research skill improvements. To examine differences between students who worked

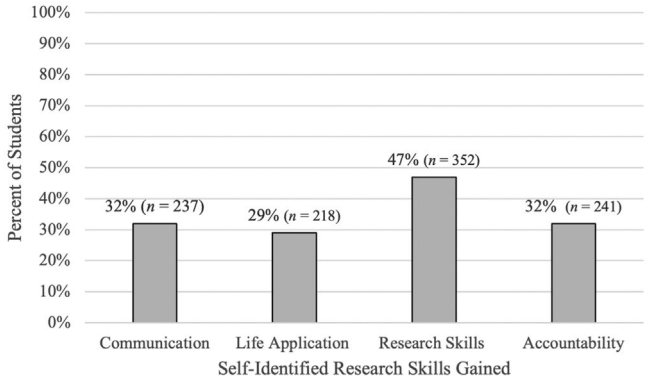

FIGURE 2. Students reporting self-identified research skills. The X axis shows the four categories identified in student responses to the question "What is a personal strength or skill you used to be successful in the research portion of the class?" Student responses were coded by the Dedoose software program. The percentage of students with responses that fell into each category is plotted. *n* = number of student responses including codes in each of these categories, where *N* = 746.

closely with peers on research skill development and those who did not, two groups were created. Students who responded "strongly agree" or "agree" to the question about working with peers (n = 562) were put into one group. Students who responded "disagree" or "strongly disagree" were put into a second group (n = 201). Independent-sample t test results demonstrated that students who worked closely with peers were significantly more likely to self-report improvements in all areas of research ($p < 0.001$) and were more likely to feel like they belonged in a research-based course. These students were also more likely to seek out research opportunities again ($p < 0.001$).

Relationship with Instructor. Almost half of all students (49.27%) visited their instructors at least one to two times during their CUREs. An additional 22.46% of students visited their instructors three to four times (14.71%) or weekly (7.75%). Building a meaningful relationship with the instructor was significantly correlated with all research skill outcomes: 1) interpreting results ($r = 0.35$, $p < 0.001$), 2) analyzing data ($r = 0.30$, $p < 0.001$), 3) collecting data ($r = 0.31$, $p < 0.001$), 4) reading primary literature ($r = 0.24$, $p < 0.001$), 5) communicating research results ($r = 0.32$, $p < 0.001$), 6) troubleshooting in the research process ($r = 0.37$, $p < 0.001$), 7) self-confidence in research ($r = 0.38$, $p < 0.001$), and 8) likelihood of seeking out research-based courses again ($r = 0.26$, $p < 0.001$). Additionally, contributing ideas during class discussions was significantly positively correlated with building a meaningful relationship with the instructor ($r = 0.27$, $p < 0.001$). Visiting the instructor's office hours or meeting with the instructor outside class was also significantly positively correlated with building a meaningful relationship with the instructor ($r = 0.22$, $p < 0.001$). A meaningful relationship with the instructor was also significantly positively correlated with students feeling like they belonged in a research-based course, and this correlation increased from pre ($r = 0.18$, $p < 0.001$) to post survey ($r = 0.32$, $p < 0.001$). However, building a meaningful relationship with the instructor was not significantly correlated with students seeking a higher degree in both the pre- and post-survey responses.

In addition to being asked if they had a meaningful relationship with the instructor, students were asked if they felt supported by the instructor. Students were divided into two groups according to their responses to whether they felt supported by their instructors. Those who reported that they felt supported by their instructors ("strongly agree" or "agree"; n = 425) were put into one group, and those who reported that they did not feel supported by their instructors ("strongly disagree" or "disagree"; n = 104) were put into a second group. Students who felt they were supported by their instructors were significantly more likely to feel that they improved in collecting data ($t(525) = -2.33$, $p = 0.02$) and communicating results of their project ($t(525) = -2.06$, $p = 0.04$). They were also significantly more likely to have self-confidence in research ($t(525) = -2.45$, $p = 0.01$) compared with students who did not feel supported by faculty. Furthermore, students' self-confidence in doing research after taking a research-based course also showed a significant positive correlation with their likelihood of seeking out research-based courses or research opportunities in the future ($r = 0.36$, $p < 0.001$).

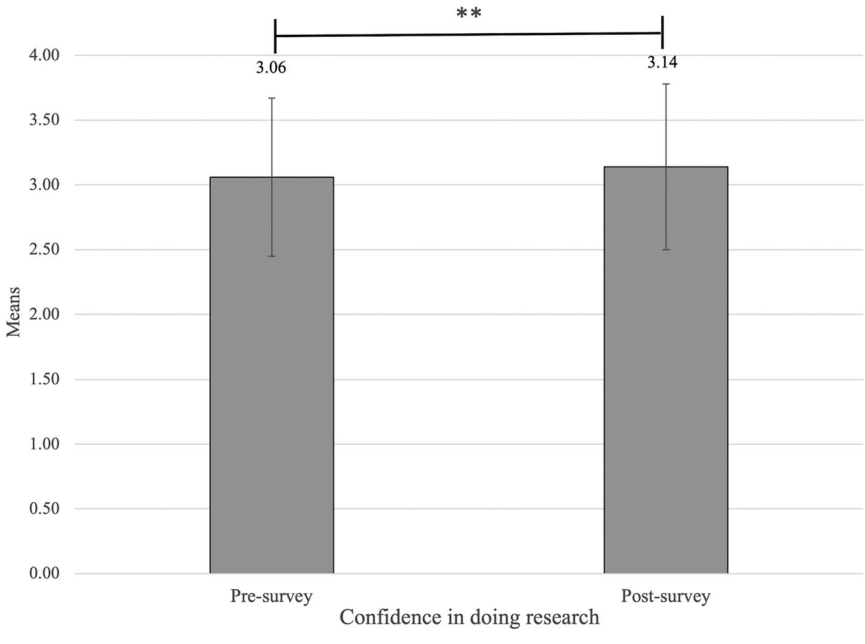

FIGURE 3. Mean score comparison of student confidence to do well in research-based courses, pre and post survey. Students were asked in both the pre and post surveys if they agreed with the statement "I can do well in a research-based course." Mean scores of their responses from the pre and post surveys are plotted. The asterisk (*) indicates a significant difference between conditions ($p = 0.001$). Error bars indicate standard errors of the mean.

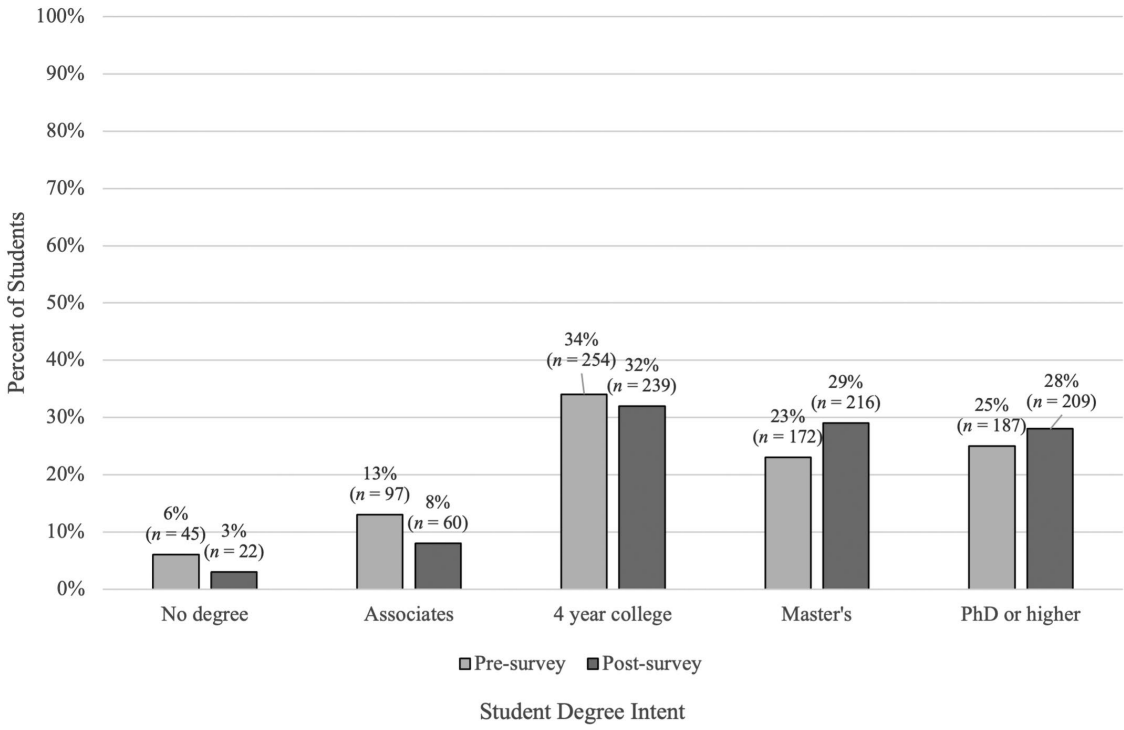

FIGURE 4. Comparison of the percentage of students intending to earn a higher degree pre and post survey. Students were asked in the pre and post surveys to indicate the highest degree they intended to earn. The percentage of students indicating each degree is plotted. There was a significant change in aspirations from pre to post survey ($p < 0.001$).

Part II

Do research experiences at a community college increase the likelihood that students seek a higher degree from pre- to post-CURE experiences? If so, what factors were associated with this change?

Impact of a Research-Based Course on Educational Aspirations. A considerable number of students, 211 (28%, $n = 758$), reported wanting to pursue higher degrees after participating in the CURE. Further, 63 students (8%, $n = 758$) reported pursuing a lower degree in the post survey, and 484 students (64%, $n = 758$) reported pursuing the same degree pre and post survey.

After completing the CURE, students overall showed a significant increase in their intention to seek a higher degree ($t(756) = 5.39$, $p = 0.001$); see Figure 4. Notably, there was also a significant shift in the number of students who are seeking a higher degree after their research experience ($x^2(16) = 694.04$, $p < 0.001$).

Factors That Influence Factors Associated with Change in Student Educational Aspirations

Confidence in Research-Based Courses. Change scores were calculated for both educational aspirations (pre to post) and confidence in research-based courses (pre to post) by subtracting the post score from the pre score. A higher change score meant students increased in both educational aspirations and confidence from pre- to post-CURE. Those with a high score represented larger changes in educational aspirations. The change in education aspiration from pre- to post-CURE was significantly correlated with a positive change in confidence ($r = 0.07$, $p < 0.05$). That is, those who changed their aspirations to a higher degree reported a significant positive change in confidence from pre to post.

Seeking More Research Opportunities. The change in education aspiration from pre to post was significantly correlated with the likelihood that students will seek out research opportunities or research-based courses again ($r = 0.09$, $p < 0.05$). That is, those who changed their aspirations to a higher degree reported that they were more likely to seek out more research opportunities.

Working with Peers. Students who responded "strongly agree" or "agree" to the question about working with peers ($n = 558$) were put into one group. Students who responded "disagree" or "strongly disagree" were put into a second group ($n = 200$). Independent-sample t test results showed there was no difference between students who worked closely with peers and those who did not on the change in educational aspiration ($t(525) = -2.45$, $p = 0.01$).

Relationship with Instructor. Those who reported that they felt supported by their instructors ("strongly agree" or "agree"; $n = 424$) were put into one group, and those who reported that they did not feel supported by their instructors ("strongly disagree" or "disagree"; $n = 104$) were put into a second group. There was no difference between students who felt supported by their instructors and those who did not on the change in educational aspiration ($t(526) = -0.40$, $p > 0.05$). The same results were found for whether students felt they had a meaningful relationship with the instructor ($t(718) = 0.63$, $p > 0.05$).

We also examined both direct and indirect effects of students' change in educational aspiration. We did not find direct effects of factors, such as self-confidence and building a meaningful relationship with the instructor, on the change in educational aspirations. However, we did find an indirect effect: Building a meaningful relationship with the instructor significantly mediated the relationship between the change in confidence and change in educational aspiration ($p < 0.05$). That is, the change in confidence predicted a change in educational aspiration when there was a meaningful relationship with the instructor (student confidence → relationship with instructor → educational aspiration).

DISCUSSION

The purpose of the current study was to assess the impact of a CURE program in a community college setting. Overall, the current research program was shown to be successful in many areas. Students reported improvement in research skills, including interpreting results, communicating results, and self-confidence in research-based courses. In open-ended responses, students reported acquiring important practical skills due to taking part in CUREs, such as life application (e.g., patience, passion) and accountability (e.g., responsibility, time management). The majority of students (85%) also felt that research was valuable to their learning experience. Our findings confirm previous research on the benefits of undergraduate biology research experiences in a community college setting (Wolkow *et al.*, 2014). The present study findings add to previous literature by demonstrating the positive impact of a CURE program established across various disciplines (i.e., anthropology, chemistry, life sciences, political sciences, and psychology) in a racially diverse community college setting. Consistent with benefits that have been previously established in the CURE literature in 4-year universities, this cross-disciplinary CURE program increased student research skills, and increased student confidence.

The study sample was recruited from a large community college, with more than half of the student population identifying as Asian Pacific Islander, African American, Native American, Latinx, or multiracial. The college has an opportunity to increase retention and transfer of students who are often underserved in higher education and lack access to high-impact practices like undergraduate research. Community colleges provide an opportunity to involve a large and diverse set of students in undergraduate research experiences at an early stage of education (Hewlett, 2018). Numerous benefits of research experiences in underrepresented students have been well documented in previous research (O'Donnell *et al.*, 2015). The fact that this research program was shown to be both feasible and successful in a community college setting is promising for empowering transfer and underrepresented students to further their education beyond a 2-year degree.

Factors That Influence Student Development in Research

A significant finding was that students who both felt that they had built a meaningful relationship with the instructor and felt supported by the instructor reported more gains in research skills in the post survey. One of the key design elements of a CURE is a restructuring of the student–instructor relationship, as the instructor becomes a collaborator and facilitator, rather than an authority figure. Strengthened student–instructor relationships have been shown to be key predictors of student success in life and work after college (Ray & Markham, 2014). CUREs also facilitate peer interactions, as participants become collaborators in the discovery-based and iterative process of research. In our study, working closely with peers was also strongly related to skill building by the end of the course. Based on these findings, a key outcome of a CURE may be the development of strong student–instructor relationships and peer interactions, which are key predictors of academic persistence and success. Therefore, "encouraging use of office hours, research group activities, either group or one-on-one engagement with the instructor, and opportunities to work closely with peers is vital to the success of students in these CUREs and may contribute to their success beyond the course.

Student Confidence

Results revealed that community college students who participated in CUREs in various disciplines showed increased confidence in being able to do well in a research-based course in the future. The literature shows that incorporating research helps students develop independent critical-thinking skills that instill confidence in students to form their own conclusions based on evidence (Petrella and Jung, 2008). Getting hands-on experience by conducting original research permits students to make important decisions on designing sound inquiries and methodologies, implementing a variety of techniques, and developing skills in analyzing and interpreting results. This experience appears to translate into confidence to enroll in research-based courses and prompts the recognition of the kind of work students enjoy.

Student confidence in a research-based course also positively correlated with the skills they developed that apply to other areas of life. These findings highlight and confirm research experiences as a high-impact practice (Davidson, 2018) and indicate that it is just as beneficial, if not more, for students to start participating in research as early as their first 2 years of college. Undergraduate research helps develop transferable skills that have a broad array of applications, among them teamwork, critical thinking, communication, problem solving, and the ability to deal with struggle, all of which were reported by students in the study. Our findings confirm previous findings that students enrolled in undergraduate research–based courses report higher levels of independent thinking, are more willing to take on an active role in learning, and are intrinsically motivated (Lopatto, 2007).

Impact of a Research-Based Course on Pursuit of Educational Degree

There was a significant increase in students seeking out higher degrees upon completion of a CURE. Although a significant number of students had already reported wanting to pursue higher degrees before the research experience, 211 students (28%) reported wanting to pursue higher degrees after participating in the CURE. This included a substantial increase in the number of students wishing to pursue a master's, doctoral, or other higher degrees after taking a research-based course. Furthermore, 8% of students reported pursuing a lower degree in the post survey versus 28% reported pursuing a higher degree in the post survey. These findings are in line with previous higher education literature, which shows participation in

research projects at an undergraduate level plays a significant role in aspirations to pursue a postbaccalaureate degree, including professional, master's, and PhD programs (Hathaway *et al.*, 2002). Further, we found that this increase in educational aspirations was due to increased confidence in research-based courses, and this increase in confidence led to a more meaningful relationship with the instructor. Therefore, focusing on confidence levels throughout the course (e.g., a weekly check-in to assess areas in which the students may feel frustrated or confused) may help students' self-motivation in research.

Limitations

There were limitations in the present study. We did not collect data from students who did not participate in CUREs to use as a control group. Therefore, it is difficult to determine whether the skills gained were specifically due to CUREs. While it would have been ideal to have the same instructor teach two sections (one with the intervention of the CURE program and one without), this was not feasible with course scheduling. Additionally, we were not able to control for any classroom or instructor differences, which would have allowed us to take into account the various types of student experiences. Further, to ensure students were able to complete the survey in a reasonable amount of time, the assessment of many of the constructs measured consisted of only one question (e.g., student confidence, as stated earlier). Our CURE program also involved courses in both social sciences and natural sciences; thus our assessments had to be applicable across various disciplines. Therefore, we were unable to analyze the reliability and validity data of the assessments created for the student survey. Additionally, to assess change in educational aspirations, a change score was calculated. Due to ceiling effects, students who started with high educational aspirations received a lower change score. To highlight all students who reported any change, we also reported the number of students who increased their educational aspirations, as stated earlier.

CONCLUSIONS

Despite the challenges and limitations of the study, our findings are encouraging to faculty at community colleges who have similar goals of implementing student research programs on their campuses. We sought to create an CURE program at a large community college by taking a multi-pronged approach to 1) support faculty development of CUREs across multiple disciplines, 2) establish a supportive campus culture that values and celebrates this practice, and 3) assess the impact of this initiative on students. Implementation of this practice increased student research skills and student self-confidence, improved student–instructor relationships, facilitated peer interactions, and ultimately increased students' educational aspirations. As stated earlier, these outcomes are important indicators of academic persistence and success (Hathaway *et al.*, 2002; Corwin *et al.*, 2015a).

The successful implementation of this undergraduate research program required multiple levels of support for students and faculty, including a community of practice and faculty professional development offerings, as well as elements to create a campus culture that celebrates and prioritizes undergraduate research. Within the community college setting, CUREs offer a promising opportunity to increase access to undergraduate research experiences for traditionally underrepresented student populations early in their college careers. Our findings indicate that this practice positively impacts student outcomes that are indicators of academic persistence and success.

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