Broadening Access to STEM through the Community College: Investigating the Role of Course-Based Research Experiences (CREs)

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ABSTRACT

Broadening access to science, technology, engineering, and mathematics (STEM) professions through the provision of early-career research experiences for a wide range of demographic groups is important for the diversification of the STEM workforce. The size and diversity of the community college system make it a prime educational site for achieving this aim. However, some evidence shows that women and Black, Latinx, and Native American student groups have been hindered in STEM at the community college level. One option for enhancing persistence in STEM is to incorporate the course-based research experiences (CREs) into the curriculum as a replacement for the prevalent traditional laboratory. This can be achieved through the integration of community colleges within extant, multi-institutional CREs such as the SEA-PHAGES program. Using a propensity score–matching technique, students in a CRE and traditional laboratory were compared on a range of psychosocial variables (project ownership, self-efficacy, science identity, scientific community values, and networking). Results revealed higher ratings for women and persons excluded because of their ethnicity or race (PEERs) in the SEA-PHAGES program on important predictors of persistence such as project ownership and science identity. This suggests that the usage of CREs at community colleges could have positive effects in addressing the gender gap for women and enhance inclusiveness for PEER students in STEM.

INTRODUCTION

Broadening access to science, technology, engineering, and mathematics (STEM) careers is a long-standing national priority (President's Council of Advisors on Science and Technology, 2012) and the size and diversity of the community college system make it a prime educational site for achieving this aim (National Governors Association, 2011; Schinske *et al.*, 2017). Compared with other institution types, community colleges are more accessible with fewer application barriers; comparatively affordable tuition costs; and accessible locations, including rural and inner-city areas (Hoffman *et al.*, 2010; Ginder *et al.*, 2014). Importantly, the accessibility of community colleges translates into a large and diverse population of students representing a third of all beginning undergraduate students in the United States and, relative to 4-year institutions, includes higher frequencies of women, first-generation college students, low-income students, and persons from historically STEM-excluded ethnic and racialized groups (PEERs; Asai, 2000) that include Blacks, Latinx, and Native Americans (American Association of Community Colleges, 2017). These features make community colleges an important educational context with the potential to diversify the STEM professions.

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There are, however, some clear challenges to community colleges fulfilling this potential. Research has suggested that 50% of incoming community college students do not have sufficient educational background in science and require remedial courses (Van Noy and Zeidenberg, 2017). In addition, full-time enrollment and continual attendance at community colleges is atypical, with 50% of students having at least one 4-month break in their educations (Van Noy and Zeidenberg, 2017). Community colleges are predominantly publicly funded institutions, and their budgets can be unpredictable and dependent on the goodwill of legislators and the state of the economy, which frequently leads to underfunding of these institutions (Dowd and Cheslock, 2006). Ultimately, these factors contribute to timelines for the majority of STEM students in the community college of at least 6 years to bachelor's degree completion, with only one-third of students who initially enrolled in STEM completing a degree (Van Noy and Zeidenberg, 2017).

Furthermore, studies suggest that community colleges contribute to rather than resolve the gender gap and inequality in STEM (Costello, 2012; Perez-Felkner *et al.*, 2019; Marco-Bujosa and Sorrentino, 2020). While there are more women than men in the community college system, only 5% of associate STEM degrees were awarded to women compared with 15% for men (Snyder *et al.*, 2016). Between 2007 and 2012, the proportion of women who received associate degrees in STEM dropped 6.3%. More specific analyses of the issues faced by women in STEM at various institutions of higher education, including the community college, suggest that women have to contend with negative stereotypes, gender biases, and a hostile climate in the STEM classroom (Starobin and Laanan, 2008; Lester *et al.*, 2017; Shadduck, 2017; Perez-Felkner, 2019). Women, and other underrepresented groups at the community college, may have a sense of not fitting in socially within STEM (Wickersham and Wang, 2016). Thus, while the size and diversity of community colleges have the potential to address demographic disparities in STEM, this potential is currently not being fulfilled and actually may be hindered in this setting.

Course-Based Research Experiences and Persistence

One approach to improve community college student persistence in science is to address the curriculum directly. For community college students to persist and succeed in science, early course experiences are crucial. In an analysis of course selection patterns for first-year community college students, Wang (2016) found that early exposure to science courses resulted in increased upward transfer into 4-year STEM programs and enhanced the desire to choose a STEM career. In particular, science laboratory courses that focus on the application of knowledge, collaboration, and authenticity can provide early experiences that promote persistence in the sciences among community college students (Hurtado *et al.*, 2010; Evans *et al.*, 2020). This has been shown to be particularly important for demographic groups that have not been well represented in the sciences. Estrada *et al.* (2018), in a longitudinal analysis of the persistence of PEERs into STEM careers, found research experiences and quality mentorship played a positive role in supporting a STEM career trajectory.

At a range of institution types, the role of authentic research experiences in enhancing early-career undergraduate persistence in the sciences has been well documented (Graham *et al.*, 2013; Auchincloss *et al.*, 2014; Hanauer *et al.*, 2017; Hernandez *et al.*, 2018). Commonly termed "course-based research experiences" (CREs[1]), courses of this type have as their central educational design feature the intention of students conducting authentic scientific research that is of value and significance beyond the course (Hanauer *et al.*, 2006, 2012, 2016, 2017; Hanauer and Dolan, 2014; Graham *et al.*, 2013; Auchincloss *et al.*, 2014; Brownell and Kloser, 2015; Rowland *et al.*, 2016; Shortlidge *et al.*, 2017). The core aspect of this type of course and the aspect that makes it an authentic research experience is that students generate data that are used by scientists for ongoing shared research and publication (Auchincloss *et al.*, 2014; Hanauer *et al.*, 2017). A CRE makes a direct connection between the scientific lab work and associated scientific products of the student and the scientific community (Auchincloss *et al.*, 2014; Hanauer *et al.*, 2017). The data and analyses that undergraduate students conduct with the CRE lab course are part of a broader research agenda of an active scientist or community of scientists (Hanauer *et al.*, 2006, 2012, 2016, 2017; Hanauer and Dolan, 2014; Graham *et al.*, 2013; Auchincloss *et al.*, 2014). The benefits of the CRE when compared with the traditional laboratory, which focuses on performing well-known exercises, include enhanced persistence in the sciences, an increased sense of ownership over the research, higher levels of science identity, appreciation for the scientific community values, and a sense of belonging in a scientific community (Russell *et al.*, 2007; Bangera and Brownell, 2014; Corwin *et al.*, 2015; Hanauer *et al.*, 2016, 2017; Rodenbusch *et al.*, 2016).

While the CRE offers the opportunity of enhancing persistence in the sciences for a wide range of different demographic groups, integrating a CRE into the community college system is not simple, given the often-limited research infrastructure and time for faculty to develop and implement their own research activities at community colleges. The challenge for the community colleges is to find effective ways to engage in authentic research while fulfilling their primary mission of maintaining broad access to higher education and to teaching and training students.

A CRE does not have to stand alone at one institution but can be delivered as part of a larger multi-institutional program with common scientific and educational goals and programming. Such inclusive research and education communities (iRECs) enable full participation of institutions, faculty, and students in authentic research experiences, with resources and training provided centrally within the program (Hanauer *et al.*, 2017). Joining an iREC community has a much lower demand of resources and design than de novo CRE development, a crucial factor for participation of institutions that do not emphasize faculty research, including many community colleges.

The iREC studied here is the SEA-PHAGES program. This is a large CRE program with more than 160 member institutions in which more than 5000 students participate each year, most of them in their first or second year of college. The SEA-PHAGES program is a yearlong CRE in which students identify and characterize novel bacteriophages, viruses of bacteria

[1]We are using the acronym CRE for course-based research experience. This course type is also referred to as a CURE (course-based undergraduate research experience).

(Hanauer *et al.*, 2017). The scientific output of student and faculty researchers includes submission of viral genome sequences to public databases such as PhagesDB (https://phagesdb.org) and GenBank (www.ncbi.nlm.nih.gov/genbank), publication of peer-reviewed manuscripts, and support of therapeutic applications (e.g., Dedrick *et al.*, 2019). Prior educational research on the SEA-PHAGES program has shown that it has a positive effect on student persistence and functions across a wide range of demographic groups (Hanauer *et al.*, 2017), including students at community colleges.

Psychosocial Processes and Persistence

The iREC structure of the SEA-PHAGES program offers the opportunity of bringing CRE lab courses to the community college by overcoming many of the practical challenges of CRE implementation and has documented ability to increase persistence in a broad range of institution types (Hanauer *et al.*, 2017; Estrada *et al.*, 2018). However, the question still remains as to whether or not the psychosocial processes that lead to persistence for students studying in these types of courses will be effective for the various demographic groups within the community college setting.

A CRE has the ability to be an influencing agent that enhances a student's sense of ability and belonging. Using Kelman's (2006) theory of social integration, Estrada *et al.* (2018) propose that the pathway of enhanced persistence in STEM consists of compliance, identification, and internalization. Compliance involves the development of the belief that the student can complete the tasks involved in STEM; identification involves the development of a sense of belonging and identity in STEM; and finally, internalization involves the adoption of the values of the social system. In operational measurement terms, compliance, identification, and internalization are measured as the variables of self-efficacy, science identity, and scientific community values, respectively. The longitudinal analyses conducted by Estrada *et al.* (2018) show that higher levels of measured science identity and scientific community values are predictive of a STEM career pathway following graduation. Simply put, the idea of social integration as applied to STEM is that if students have the belief that they are capable of being a scientist, believe that they are a scientist, and believe in the value of science, there is a greater chance that they will persist in the sciences.

More recent work on what characterizes CRE instruction offers further insight into the way this educational approach may support persistence for PEER students (Hanauer *et al.*, 2022). In a CRE, faculty work together with students who function as novice researchers. This shared research responsibility changes the relationship with the student and changes the student's own positionality. The students take on the ownership and responsibility for their work and the instructor functions as a mentor, provides emotional support, and acts as a fellow researcher. Importantly, as with the SEA-PHAGES program, where the Hanauer *et al.* (2017) data on CRE instruction were collected, both student and instructor are members of a large research community that regularly holds student and faculty cross-institutional meetings and publishes results with students. The presence of the scientific community and the student's membership in that community are key to the SEA-PHAGES CRE and the multi-institutional iREC structure.

In relation to persistence, several psychosocial components are salient in the description of the instructional characteristics of a CRE. CRE instruction concretely manifests a sense of belonging for its student members and fosters a sense of achievement and ability. The student has ownership over the research and scientific outputs (Hanauer *et al.*, 2012; Hanauer and Dolan, 2014). This counters stereotype threats to legitimate participation in STEM and offers the experience of belonging and competence (Fouad and Santana, 2017). Persistence is facilitated by instructor mentorship and by revising student status and position as a scientist. The CRE does not prepare you to be a scientist in some future scenario but rather positions you as a researcher contributing to a scientific community in the present. The actual research experience has the potential to be a transformative experience for students who may have not felt included in the sciences beforehand. Operationally, belonging, responsibility, and ownership are measured using the variables of networking and project ownership (Hanauer *et al.*, 2016). As such, the simple idea behind the CRE instructional approach is that being an active, productive member of a research community in a mentored educational context will provide the student with the personal experience of being a novice scientist. The student has the experience and as such, questions relating to ability, identity, and legitimacy as a future STEM professional are alleviated and persistence for the student is enhanced.

Design, Research Questions, and Measurement

As reviewed earlier, CREs have the potential to enhance diversity and inclusivity in STEM by promoting persistence in the sciences across various student demographic groups. This is achieved through a transition of the student's psychosocial positionality and may be particularly important for students who have historically been marginalized within STEM. As such, the research into the value of CRE in the community college setting conducted here involves three different design components:

1. The CRE needs to be compared with an appropriate course in the community college setting; one that is at a comparable level and size and has comparable class activities. The traditional introductory science laboratory course that is dedicated to the development of competence in particular procedures used in science is such a course. Given the ubiquity of this course, if there are positive differences between the CRE and the traditional lab, our argument would be that, as a practical approach, the traditional lab should be replaced with a CRE course.
2. The analysis needs to take into account both gender and ethnicity in order to consider whether the CRE has particular value for women and PEER students. As such, comparisons need to be made between course types for specific demographic groups or subgroups of students in order to see the relative value of a CRE as opposed to a traditional lab in the community college setting.
3. Measurement needs to address the psychosocial variables that have been shown to be predictive of persistence. In the theoretical review presented earlier, the active components of a CRE that have potential to enhance persistence and inclusivity in the sciences consisted of variables that address responsibility, ownership, belief in one's ability, science-related identity, belief in the values of science, and a sense of belonging in the scientific community. A

developed and psychometrically validated survey tool that covers these psychosocial variables is the Persistence in the Sciences (PITS) survey (Hanauer *et al.*, 2016). By focusing on the psychosocial variables that predict persistence it is possible to compare the relative value of different courses in enhancing persistence and providing a quality research experience.

Here, we explore the value of a CRE in the community college setting by comparing the SEA-PHAGES program with traditional non-research lab courses at the same schools, using the PITS survey for measurement purposes, and focusing on how different demographic subgroups of students defined by gender and ethnicity fare in this comparison. Our hypothesis is that the SEA-PHAGES program will outperform the traditional laboratory on the PITS survey variables and that this may have a particularly pronounced effect for women and PEERs. This hypothesis is based on prior research that has shown advantages for CREs in other institutional settings and the characteristics of CRE instruction that foster belonging, competence and identification with STEM (Hanauer *et al.*, 2017; Estrada *et al.*, 2018). Our specific research questions are as follows:

1. Are there differences in the persistence potential as measured on the PITS survey of students studying in the SEA-PHAGES course and traditional laboratory courses at community college institutions?
   - 1.1. Are there differences in participant ratings on the PITS survey variables of project ownership, self-efficacy, science identity, scientific community values, and networking between participants who study in SEA-PHAGES and students who study in a traditional laboratory course at community college institutions?
   - 1.2. Are there differences in participant ratings of their likelihood of staying in the sciences (persistence) between participants who study in SEA-PHAGES and students in a traditional laboratory course at community college institutions?
   - 1.3. Are there differences on the PITS survey variables for student groups defined by gender and ethnicity who study in SEA-PHAGES or a traditional laboratory course at community college institutions?
   - 1.4. Are there differences in participant ratings of their likelihood of staying in the sciences (persistence) for student groups defined by gender and ethnicity who study in SEA-PHAGES or a traditional laboratory course at community college institutions?

METHODS

Participants

Participants for this study consisted of students studying at community colleges in either a SEA-PHAGES course or a traditional microbiology laboratory course. The SEA-PHAGES course is an established, large-scale community-based undergraduate research experience course. A traditional lab was defined as an introductory laboratory course whose main emphasis in the curriculum consisted of teaching students a series of specific laboratory procedures without these being used as part of an authentic data-collection process related to a current ongoing research project. To check the validity of the comparison of these two courses at each community college, we checked the setup and access processes for potential biasing factors. As reported by the institutions, no explicit recruiting was conducted for the SEA-PHAGES course, and students could choose either of the two courses. However, when choosing the SEA-PHAGES course, students were informed that this was a research-based course, and instructors reported that there was a process of peer-to-peer word-of-mouth promotion of the SEA-PHAGES course. As such, it is possible that some students joined the SEA-PHAGES course primarily because they had an interest in conducting research. But this was not the result of any systematic streaming of high-performing students into the SEA-PHAGES section and lower-performing students into the traditional laboratory section.

Data were collected from both course types concurrently in the same semester in the Fall and Spring semesters of the 2017–2018 academic year from 18 different SEA-PHAGES courses and 24 traditional laboratory courses from nine different community colleges across the United States. Overall, 631 students from SEA-PHAGES courses and 1013 students from traditional laboratory courses completed the PITS survey and participated in this study. PITS participation rates (based on number of enrolled students) were 63.7% for the SEA-PHAGES course and 76.1% for the traditional lab. The demographic characteristics of the two groups are presented in Table 1. As can be seen in Table 1, chi-square analyses reveal significant differences between the groups on the variables of grade point average (GPA), parents' educational levels, and class level. The ethnic composition of the PEER category in Table 1 (and subsequent analyses presented later) consisted of the following ethnic groups: Black (15%), Latinx (45%), Native American (1%), multi-ethnic (31%), Hawaiian and Pacific Islander (1%), and other (7%). These proportions of ethnic dispersion were equitable across the SEA-PHAGES and traditional lab course. All data were collected in accordance with the ethical requirements of the Indiana University of Pennsylvania Institutional Review Board (no. 14-302).

Instrument

Data were collected using the PITS survey instrument (Hanauer *et al.*, 2016, 2017) situated on the Web-based platform Qualtrics. The survey has the following variables:

- **Project Ownership—Content:** 10 rating scales dealing with dealing with the degree of ownership the student feels over the laboratory research work (Hanauer and Dolan, 2014)
- **Project Ownership—Emotion:** 5 rating scales dealing with specified positive emotive responses to the laboratory research experience (Hanauer *et al.*, 2012; Hanauer and Dolan, 2014)
- **Science Self-Efficacy:** 6 rating scales dealing with participants' confidence in functioning as a scientist (Chemers *et al.*, 2011; Estrada *et al.*, 2011)
- **Science Identity:** 5 rating scales dealing with ways in which the participant thinks about her/himself as a scientist (Chemers *et al.*, 2011; Estrada *et al.*, 2011)
- **Scientific Community Values:** 4 rating scales dealing with the participants' affinity to values in the scientific community (Estrada *et al.*, 2011)

TABLE 1. Demographic information and Pearson χ^2 for sample of traditional laboratory and SEA-PHAGES ($n = 1643$)

Demographic category	SEA-PHAGES (n = 631)		Traditional lab (n = 1013)		Pearson χ^2	
	%	n	%	n	(df)	Sig.
Gender						
Men	54	338	51	521	2.65	0.62
Women	38	243	33	331	(4)	
Missing	8	50	16	161		
Ethnicity						
PEER	56	354	57	573	0.03	0.85
White/Asian	44	277	43	440	(1)	
Missing	—	—	—	—		
GPA						
Below 2.5	3	21	5	48	27.47	0.0001
2.6–3.0	17	107	23	228	(4)	
3.1–3.5	34	216	27	276		
3.6–4.0	36	227	24	248		
4.1 and higher	0.3	2	1	9		
Missing	9	58	20	204		
Parents' education						
No college degree	35	220	31	309	14.02	0.03
Bachelor's degree	13	80	17	168	(6)	
Associate's degree	25	159	20	207		
Master's degree	12	77	8	83		
Doctorate or professional degree	5	33	4	40		
Missing	10	62	20	207		
	—	—	—	—		
Parents' Occupations						
Unskilled labor	7	45	7	75	5.8	0.33
Skilled labor	24	152	21	212	(5)	
Clerical	5	30	3	34		
Service	10	65	10	96		
Managerial	12	77	14	137		
Professional	32	202	25	254		
Missing	10	60	20	205		
Class level						
Freshman	15	94	23	237	48.27	0.0001
Sophomore	39	247	34	345	(5)	
Junior	13	81	12	123		
Senior	13	85	8	82		
Missing	20	124	22	226		

- **Networking:** 5 rating scales dealing with types of people who students talk to concerning their participation in a laboratory course (these scales differentiate between personal and professional discussion partners; Hanauer and Hatfull, 2015)
- **Future Intent:** 4 rating scales dealing with short-, mid-, and long-term intentions to stay in the sciences

The PITS survey has been psychometrically evaluated and used with community college populations in previous studies (Hanauer *et al.*, 2016, 2017). It is used to evaluate the outcomes of a research experience (see Supplemental Material for full copy of the PITS survey).

Procedure

To collect data for this study, we sent SEA-PHAGES instructors at community colleges an open letter inviting them to participate in this study and to help identify parallel traditional laboratory courses that were concurrently offered at their institutions. Instructors from both SEA-PHAGES and traditional laboratories were contacted and sent a survey link to forward to students from their classes. Data were collected during the last 2 weeks of their courses in each of the different community college settings. After completing the informed consent form, students completed the online PITS survey.

Analytical Approach

While all data were collected at the same institutions and from students in concurrent sections, comparability of the demographic groups cannot be guaranteed through this approach, raising the issue of differing student characteristics possibly confounding the results. Simple comparison between courses is

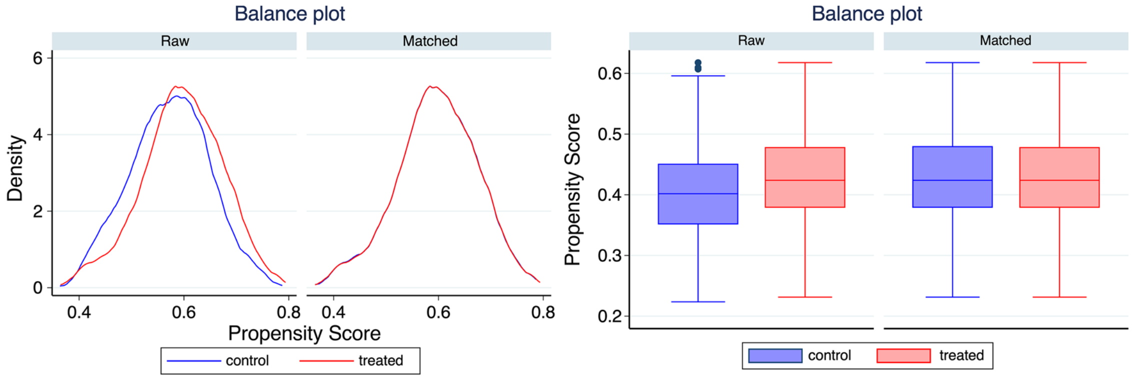

FIGURE 1. Density plot and balance box plot of raw and matched samples of traditional and SEA-PHAGES participants from the nine Community Colleges (*n* = 1644).

not a valid option for exploring the outcomes of two different course types. Accordingly, a participant matching approach was used for this comparison. For matching purposes, a propensity score–matched average treatment effect on the treated was calculated. This procedure was performed on all of the PITS variables (Project Ownership Content, Project Ownership Emotion, Self-Efficacy, Science Identity, Scientific Community Values, and Networking) and on scales designed to measure persistence potential (future intent to stay in the sciences). The propensity score–matching technique used here compared the outcome for each student in the SEA-PHAGES group with the average outcome of a student deemed similar using propensity scores from the traditional group. Participants were matched on the variables of gender, class level, ethnicity, GPA, parents' educational levels, and parents' occupations. Because multiple tests were conducted Bonferroni-Holm corrections were applied to the significance levels (Holm, 1979).

To understand the specific relations between gender, ethnicity, and course type, we conducted a series of propensity score–matched group comparisons. Originally, the intent was to use a multivariate analysis of covariance (MANCOVA) approach to these data in order to directly address potential interactions between variables while controlling for covariates. However, initial exploration of the assumptions of such an analysis found that the data violated both the multivariate normality assumption as well as the homogeneity of regression lines assumption. Accordingly, it was decided to conduct the analysis using a series of point-to-point propensity score–matched average treatment effect on the treated for specific group comparisons. The comparisons conducted covered gender, ethnicity, class level, and program type and addressed the specific research questions presented earlier. For each of these analyses, random groups of 200 participants matching required specifications (such as PEER men in the SEA-PHAGES course; or PEER women in the SEA-PHAGES course) were selected from the full data set. Prior research has shown that this is an appropriate matching technique for sample sizes of 200 (Howarter, 2015). Groups were matched for class level, GPA, gender, parents' educational levels, and parents' occupations. Before any analyses on the matched participants were conducted, the quality of the actual matching was analyzed. A balance density plot of propensity scores for matched and unmatched samples was generated. To evaluate the quality of the propensity score matching, we generated standardized differences and variance ratios for the matched groups. For each of the covariates, standardized differences were close to 0 (±0.06) and variance ratios were close to 1 (±0.10), suggesting appropriate matching had occurred. Figure 1 presents the density plot and balance box plot of raw and matched samples of traditional and SEA-PHAGES participants from the nine community colleges. All analyses were conducted using the statistical package STATA v. 14.

RESULTS

To evaluate the effect of the SEA-PHAGES education program in the community college settings on the outcomes of the psychological measures of research experiences, we employed a propensity score group matching approach comparing SEA PHAGES students with students who studied in a traditional (non-research) laboratory. Table 2 presents the mean, standard deviation, and average treatment effect on the treated for traditional laboratory and SEA-PHAGES courses on all PITS survey variables (project ownership content, project ownership emotion, self-efficacy, science identity, scientific community values, and networking). As can be seen in the descriptive data in Figure 2 and Table 2, participants from the SEA-PHAGES course gave higher self-ratings on all of the PITS survey variables, with a range of 0.25 to 0.48 higher on five-point scales representing a higher mean of 8% for SEA-PHAGES students over traditional lab students. Using the propensity score–matching technique, five of the six PITS survey variables were found to be significantly different (project ownership content, project ownership emotion, science identity, scientific community values, and networking). In this analysis, self-efficacy was not significantly different between the groups. Overall, the results for the PITS variables show significant differences, with the SEA-PHAGES program exhibiting higher ratings over the traditional laboratory.

To further understand the results of the SEA-PHAGES and traditional lab comparisons, we disaggregated the results according to gender. As can be seen in Table 2 and Figure 2, B and C, men in the SEA-PHAGES program have higher ratings across all PITS variables than their counterparts in traditional lab; however, after application of the Bonferroni-Holm correction, none of the PITS variables were significantly different for men. In contrast, all of the variables were significantly higher for women in the SEA-PHAGES program when compared with

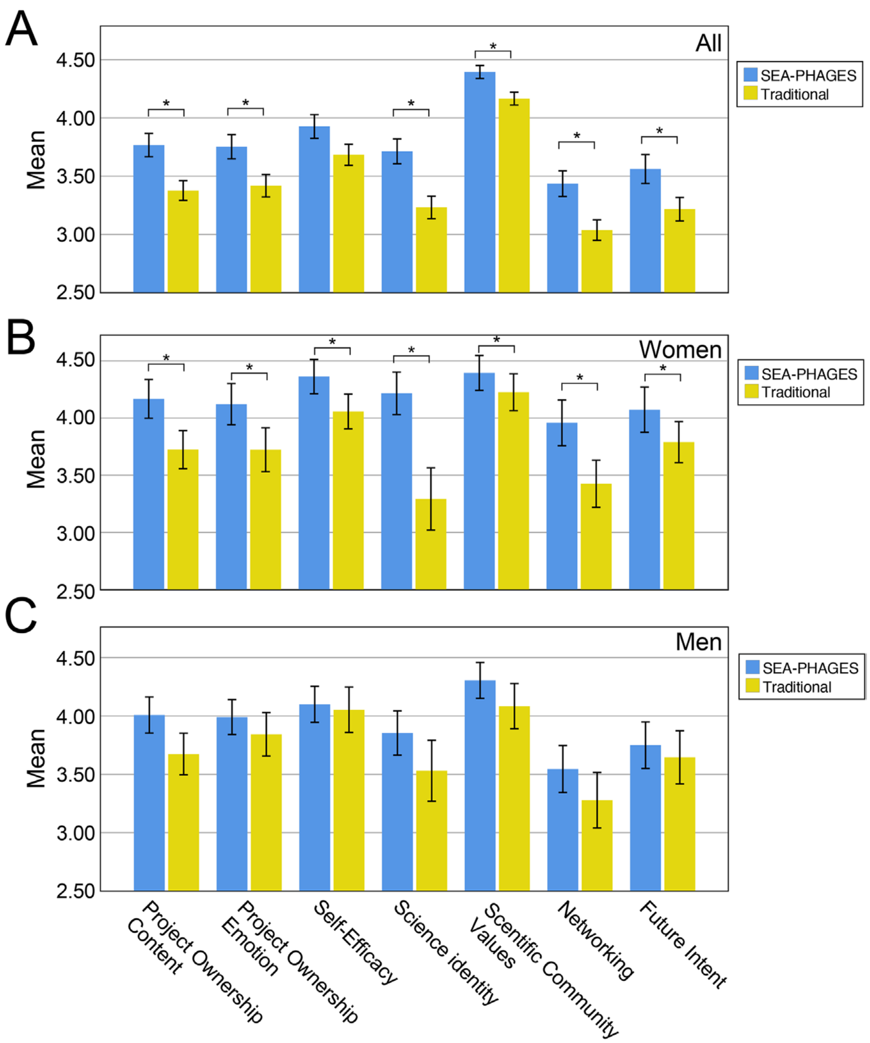

FIGURE 2. Bar graph comparison of SEA-PHAGES and traditional students (blue and yellow bars, respectively) on the PITS survey variables and future intent to persist in the sciences. (A) Course comparison for SEA-PHAGES and traditional laboratory. (B) Disaggregated course comparison (SEA-PHAGES and traditional lab) for women. (C) Disaggregated course comparison (SEA-PHAGES and traditional lab) for men. Equally sized random student groups by course type were propensity score matched and compared on average treatment effect on the treated (ATET). Significant differences following a Holm-Bonferroni correction are indicated (*$p < 0.05$). PITS survey ratings are from 1 (strongly agree) to 5 (strongly disagree) for all measures except scientific community values, which had a 1 (not like me at all) to 6 (very much like me); scientific community values rating was proportionally rescaled to 1–5 for this figure.

women in the traditional laboratory. This suggests that the positive effects seen for the whole program comparison resulted from advantages of the SEA-PHAGES course for women.

To evaluate the persistence potentials of each of these courses, we used a similar analytical matching approach for the variable of future intent to stay in the sciences (which is part of the PITS survey and deals with short-, mid-, and long-term intentions to stay in the sciences). Table 3 presents the mean, standard deviation, and average treatment effect on the treated for traditional laboratory and SEA-PHAGES courses on the variable of future intent to stay in the sciences. Figure 2A and the descriptive data for this variable show that participants in the SEA-PHAGES course scored 0.35 higher than the traditional lab participants, representing a 7% higher persistence intention. The propensity score–matched average treatment effect on "treated all" showed significant differences between participants from the two courses. To further explore the persistence potential of these courses, we addressed one of the items that constitutes the construct of intent to stay in the sciences individually. This item—"I intend to complete a science related undergraduate degree"—directly addresses the issue of intent to complete an undergraduate degree in the sciences. Our aim was to directly consider persistence in an undergraduate STEM degree. As seen in Table 3, the scores of SEA-PHAGES course participants were 0.3 greater than those of students of the traditional lab. The inferential statistic of the propensity score–matched average treatment effect on the treated showed significant differences between participants from the two courses. The results relating to the persistence potential of these two courses suggest that participants completing the SEA-PHAGES course had higher intent to stay in the sciences and complete a science-related undergraduate degree.

To further understand the results of the program comparison on future intent, we disaggregated the results according to gender. As can be seen in Table 3 and Figure 2, B and C, after application of the Bonferroni-Holm correction, there was a significant difference for women on the future intent to stay in science, but not for men. This result suggests that the overall program difference between the programs can be attributed to the women.

The next set of analyses that were conducted aimed to look at the value of the SEA-PHAGES course for the intersection of specific student populations who had in the past been seen to be particularly at risk for not completing their studies. Three variables are of particular interest for the current set of comparisons: gender, ethnicity, and course types. As described earlier, the qualities of the data set did not allow an integrative MANCOVA approach; accordingly, specific group comparisons were conducted using a propensity score–matching approach applied to randomly selected subsamples of participants. Random samples were elicited to avoid course-based nesting with program type. A propensity score–matching approach was used to make sure that underpinning demographic variables did not confound any of the comparative results. Table 4 summarizes the mean, standard deviation, and average treatment effect on the treated (ATET propensity score

TABLE 2. Mean, standard deviation, and average treatment effect on the treated (ATET propensity score matching) for traditional laboratory and SEA-PHAGES courses combined men and women and disaggregated by gender ($n = 1632$)

Estimation method		Project ownership content	Project ownership emotion	Self-efficacy	Science identity	Scientific community values	Networking
Traditional lab		**3.37 (1.37)**	**3.41 (1.48)**	**3.68 (1.46)**	**3.23 (1.56)**	**4.36 (1.88)**	**3.03 (1.41)**
SEA-PHAGES		**3.77 (1.27)**	**3.75 (1.32)**	**3.93 (1.29)**	**3.71 (1.35)**	**4.75 (1.71)**	**3.43 (1.4)**
ATET propensity score matching	Coeff.	0.29	0.16	0.11	0.48	0.24	0.39
	SE	0.06	0.07	0.06	0.09	0.09	0.07
	z	4.65	2.31	1.82	5.04	2.57	5.0
	Sig.	0.0001*	0.02*	0.07	0.0001*	0.01*	0.0001*
Men only							
Traditional lab		**3.27 (1.39)**	**3.42 (1.46)**	**3.61 (1.53)**	**3.15 (1.6)**	**4.27 (1.91)**	**2.92 (1.47)**
SEA-PHAGES		**3.83 (1.05)**	**3.8 (1.04)**	**3.94 (1.06)**	**3.67 (1.17)**	**4.75 (1.62)**	**3.39 (1.14)**
ATET propensity score matching	Coeff.	–0.24	–0.1	–0.03	–0.42	–0.38	–0.36
	SE	0.11	0.11	0.11	0.18	0.22	0.16
	z	–2.22	–0.92	–0.27	–2.28	–1.65	–2.18
	Sig.	0.02	0.36	0.79	0.02	0.09	0.03
Women only							
Traditional lab		**3.46 (1.23)**	**3.46 (1.31)**	**3.77 (1.26)**	**3.27 (1.37)**	**4.68 (1.59)**	**3.19 (1.3)**
SEA-PHAGES		**4.09 (0.81)**	**4.08 (0.82)**	**4.35 (0.61)**	**4.19 (0.75)**	**5.24 (0.79)**	**3.97 (0.88)**
ATET propensity score matching	Coeff.	–0.57	–0.54	–0.54	–0.78	–0.44	–0.77
	SE	0.17	0.16	0.14	0.14	0.17	0.17
	z	–3.47	–3.42	–3.82	–5.49	–2.57	–4.63
	Sig.	0.001*	0.001*	0.0001*	0.0001*	0.01*	0.0001*

*Significant at 0.05 level following a Holm-Bonferroni correction.

matching) for gender and ethnic groups in traditional laboratory and SEA-PHAGES courses.

Men, Ethnicity, and Program Comparisons

The first set of comparisons dealt with men and ethnicity in the SEA-PHAGES and the traditional lab. PEER men in the SEA-PHAGES program were compared with their White/Asian counterparts. As seen in Table 4, descriptive data for the comparison of PEER and White/Asian men in the SEA-PHAGES program show that White/Asian men have higher ratings than the PEER men across the six PITS variables. However, when the two groups are matched using a propensity score–matching approach, none of the PITS variables are significantly different between the groups. As such, the data show no systematic differences in results on the PITS variables for White/Asian and PEER men in the SEA-PHAGES program.

The second analysis compared PEER men in the SEA-PHAGES and in the traditional lab. As can be in the descriptive data in Figure 3A and Table 4, PEER men in the SEA-PHAGES program had higher ratings than the PEER men in the traditional lab for all six PITS variables. Propensity score–matched group data reveal that project ownership content and scientific identity are significantly different between PEER men in the SEA-PHAGES and traditional labs, with an advantage for the SEA-PHAGES students. The results suggest that the SEA-PHAGES course has a positive effect on PEER men in relation to a sense of project ownership and scientific identity.

The third set of analyses presented in Table 4 compares the PEER men and White/Asian men in the traditional laboratory. As can be seen in the descriptive data, White/Asian men have higher ratings than PEER men. The propensity score–matching analyses did not find any significant differences between the groups. Accordingly, there were no systematic differences for men with different ethnicities in the traditional laboratory.

Women, Ethnicity, and Program Comparisons

The next set of analyses presented in Table 4 addressed women participants in the SEA-PHAGES and traditional lab. PEER women were compared with White/Asian women in the SEA-PHAGES program. As can be seen in the descriptive data in Table 4, the ratings of the two groups are very similar. The matched group propensity score analysis reveals that there are no systematic differences between women students of different ethnicities on any of the PITS variables in the SEA-PHAGES program.

PEER women were compared in the SEA-PHAGES and traditional programs. As seen in descriptive data in Figure 3B and Table 4, PEER women in the SEA-PHAGES program have higher ratings than PEER women in the traditional lab for all of the PITS variables. Matched-group propensity score comparisons reveal significant differences for three of the six PITS variables: project ownership content, self-efficacy, and science identity. The results suggest that the SEA-PHAGES program elicits significantly higher ratings for PEER women when compared with PEER women in the traditional labs.

PEER women and White/Asian women were compared in the traditional lab. White/Asian women had higher ratings for five of the six PITS variables. However, the matched-group propensity score comparisons did not reveal any significant differences between the groups of women. As such, the data suggest there are no systematic differences between women of different ethnicities in the traditional lab.

TABLE 3. Mean, standard deviation, *t* test, average treatment effect on the treated (ATET propensity score matching) for traditional laboratory and SEA-PHAGES courses for future intent to stay in the sciences courses combined men and women and disaggregated by gender ($n = 1632$)

Estimation method		Future intent	Intent to complete science degree
Traditional lab		**3.21 (1.54)**	**4.04 (1.12)**
SEA-PHAGES		**3.56 (1.46)**	**4.34 (0.94)**
ATET propensity score matching	Coeff.	0.19	0.26
	SE	0.08	0.09
	z	2.6	2.85
	Sig.	0.009*	0.004*
Men only			
Traditional lab		**3.24 (1.52)**	**4.13 (1.06)**
SEA-PHAGES		**3.59 (1.19)**	**4.16 (1.05)**
ATET propensity score matching	Coeff.	−0.22	−0.29
	SE	0.18	0.24
	z	−1.22	−1.21
	Sig.	0.23	0.23
Women only			
Traditional lab		**3.52 (1.28)**	**4.21 (0.97)**
SEA-PHAGES		**4.07 (0.85)**	**4.49 (0.76)**
ATET propensity score matching	Coeff.	−0.54	−0.29
	SE	0.22	0.16
	z	−2.4	−1.86
	Sig.	0.02*	0.06

*Significant at 0.05 level following a Holm-Bonferroni correction.

Men and Women and the Program

The final set of analyses presented in Table 4 compared men and women in the two different programs. As can be seen in descriptive data in Figure 3C and Table 4, women in the SEA-PHAGES program have higher ratings than the men in the same program. Propensity score–matching analyses show that three of the PITS variables (self-efficacy, science identity, and networking) are significantly different, with higher ratings for women. As seen in the descriptive data in Figure 3D and Table 4, the comparison of men and women in the traditional laboratory course reveals relatively close ratings between the groups in the traditional labs. Propensity score–matching analyses reveal that only the variable project ownership emotion was significantly different. All other variables were not significant.

Future Intent to Stay in the Sciences

Table 5 presents the descriptive and inferential analyses of different subgroups on the variables of future intent to stay in the sciences and to complete an undergraduate degree in the sciences. In the comparison between PEER men and White/Asian men in the SEA-PHAGES program, there were no significant differences between the groups for either future intent to stay in the sciences or the intent to complete a science undergraduate degree. Similar results were found for PEER men and White/Asian men in the traditional laboratory course, with no significant differences between the groups. As seen in Table 5 and Figure 3A, there were also no significantly higher ratings for PEER men in the SEA-PHAGES program as compared with PEER men in the traditional course in their intent to stay in the sciences.

However, as seen in Table 5 and Figure 3B, there were significantly higher ratings for PEER women in the SEA-PHAGES program over PEER women in the traditional lab for future intent to stay in the sciences. There were no significant differences between the women from different ethnicities within the SEA-PHAGES program or within the traditional laboratory. As seen in Figure 3, C and D, women in the SEA-PHAGES program had a significantly higher degree of intent to stay in the sciences than their male counterparts. Overall, the results suggest that the SEA-PHAGES program had significantly higher ratings for the intent to stay in the sciences for women (and PEER women) when compared with the traditional lab.

DISCUSSION

The aim of this study was to investigate the value of incorporating a CRE into the community college curriculum with a specific focus on how this course type performs for demographic groups defined by gender and ethnicity. Our hypothesis was that participation in a CRE should have a positive effect for women and PEER students when compared with the prevalent traditional laboratory at the community college. This hypothesis was based on existing scholarship showing that a CRE can enhance belonging, competence, and identification within STEM (Hanauer *et al.*, 2017; Estrada *et al.*, 2018) and was measured using the PITS survey, which includes the psychosocial variables of project ownership, self-efficacy, science identity, scientific community values, and networking.

The results of this study partially support our hypotheses. Overall, participation in the SEA-PHAGES program results in significantly higher levels of rating for project ownership content, project ownership emotion, science identity, scientific community values, and networking, and these higher levels translate into a significantly higher intent to stay in the sciences. If the data are disaggregated for gender, it is clear that

TABLE 4. Mean, standard deviation, average treatment effect on the treated (ATET propensity score matching) for research experiences gender and ethnic groups in traditional laboratory and SEA-PHAGES courses (n = 200)

Estimation method		Project ownership content	Project ownership emotion	Self-efficacy	Science identity	Scientific community values	Networking
			Men PEER				
Are there differences in the research experiences of excluded because of ethnicity or race (PEER) and White/Asian male students in the SEA-PHAGES program?							
SEA-PHAGES							
Men PEER		**3.78 (1.18)**	**3.77 (1.18)**	**3.83 (0.11)**	**3.58 (0.13)**	**4.68 (0.16)**	**3.43 (0.12)**
Men White/Asian		**3.99 (0.71)**	**3.98 (0.78)**	**4.23 (0.07)**	**3.98 (0.08)**	**5.2 (0.09)**	**3.69 (0.08)**
ATET propensity score matching	Coeff.	−0.1	−0.05	0.06	0.05	−0.1	0.06
	SE	0.12	0.12	0.12	0.17	0.16	0.21
	z	−0.86	−0.04	0.51	0.27	−0.63	−0.29
	Sig.	0.39	0.68	0.61	0.78	0.52	0.77
Are there differences in the research experiences of excluded because of ethnicity or race (PEER) male students in the SEA-PHAGES program and the traditional laboratory?							
PEER men							
SEA-PHAGES		**3.78 (0.11)**	**3.77 (0.11)**	**3.83 (0.11)**	**3.58 (0.13)**	**4.68 (0.16)**	**3.43 (0.12)**
Traditional lab		**3.34 (0.14)**	**3.5 (0.15)**	**3.55 (0.16)**	**3.07 (0.16)**	**4.29 (0.19)**	**3.02 (0.15)**
ATET propensity score matching	Coeff.	−0.37	−0.12	−0.2	−0.53	−0.33	−0.25
	SE	0.13	0.13	0.14	0.17	0.2	0.16
	z	−2.76	−0.95	−1.42	−3.02	−1.62	−1.53
	Sig.	0.006*	0.34	0.15	0.003*	0.1	0.13
Are there differences in the research experiences of persons excluded because of ethnicity or race (PEERs) and White/Asian male students in the traditional laboratory?							
Traditional							
Men PEER		**3.34 (0.14)**	**3.5 (0.14)**	**3.55 (0.16)**	**\3.08 (0.16)**	**4.28 (0.19)**	**3.02 (0.15)**
Men White/Asian		**3.69 (0.07)**	**3.77 (0.08)**	**4.14 (0.06)**	**3.43 (0.12)**	**4.83 (0.12)**	**3.35 (0.09)**
ATET propensity score matching	Coeff.	−0.03	−0.2	−0.04	0.002	−0.16	−0.05
	SE	0.16	0.13	0.15	0.19	0.2	0.18
	z	−0.16	−1.54	−0.31	0.01	−0.77	−0.29
	Sig.	0.8	0.12	0.76	0.99	0.43	0.77
			Women PEER				
Are there differences in the research experiences of excluded because of ethnicity or race (PEER) and White/Asian female students in the SEA-PHAGES program?							
SEA-PHAGES							
Women PEER		**4.07 (0.08)**	**4.02 (0.1)**	**4.27 (0.06)**	**4.06 (0.08)**	**5.08 (0.1)**	**3.79 (0.11)**
Women White/Asian		**4.18 (0.07)**	**4.12 (0.08)**	**4.33 (0.07)**	**4.19 (0.07)**	**5.24 (0.09)**	**3.95 (0.09)**
ATET propensity score matching	Coeff.	−0.007	0.08	−0.04	0.04	0.06	0.02
	SE	0.12	0.14	0.1	0.12	0.14	0.16
	z	−0.06	0.61	−0.34	0.33	0.46	0.15
	Sig.	0.95	0.54	0.73	0.74	0.65	0.88
Are there differences in the research experiences of excluded because of ethnicity or race (PEER) female students in the SEA-PHAGES program and the traditional laboratory?							
PEER Women							
SEA-PHAGES		**4.07 (0.08)**	**4.02 (0.1)**	**4.27 (0.06)**	**4.06 (0.08)**	**5.08 (0.1)**	**3.79 (0.11)**
Traditional lab		**3.57 (0.11)**	**3.66 (0.12)**	**3.79 (0.12)**	**3.31 (0.14)**	**4.54 (0.16)**	**3.2 (0.12)**
ATET propensity score matching	Coeff.	−0.47	−0.37	−0.51	−0.63	−0.45	−0.34
	SE	0.16	0.18	0.16	0.2	0.22	0.22
	z	−2.92	−2.06	−3.1	−3.14	−2.05	−1.6
	Sig.	0.003*	0.04	0.002*	0.002*	0.04	0.11

(*Continues*)

TABLE 4. Continued

Estimation method		Project ownership content	Project ownership emotion	Self-efficacy	Science identity	Scientific community values	Networking
Are there differences in the research experiences of persons excluded because of ethnicity or race (PEERs) and White/Asian female students in the traditional laboratory?							
Traditional							
Women PEER		**3.62 (1.0)**	**3.87 (1.07)**	**3.94 (1.04)**	**3.28 (1.49)**	**4.75 (1.41)**	**3.24 (1.1)**
Women White/Asian		**3.73 (0.99)**	**3.79 (1.02)**	**4.07 (0.87)**	**3.46 (1.34)**	**4.94 (1.22)**	**3.36 (1.09)**
ATET propensity score matching	Coeff.	0.08	0.08	0.24	0.002	0.13	0.12
	SE	0.25	0.23	0.25	0.32	0.32	0.24
	z	0.31	0.36	0.95	0.01	0.42	0.51
	Sig.	0.76	0.72	0.34	0.99	0.68	0.61
Gender							
Are there differences in the research experiences of male and female students in the SEA-PHAGES program?							
SEA-PHAGES							
Men		**3.83 (0.1)**	**3.8 (0.1)**	**3.94 (0.1)**	**3.66 (0.12)**	**4.74 (0.16)**	**3.39 (0.11)**
Women		**4.09 (0.08)**	**4.08 (0.08)**	**4.35 (0.06)**	**4.19 (0.08)**	**5.24 (0.08)**	**3.97 (0.09)**
ATET propensity score matching	Coeff.	0.25	0.27	0.31	0.57	0.28	0.6
	SE	0.14	0.15	0.12	0.17	0.2	0.19
	z	1.81	1.84	2.54	3.3	1.4	3.06
	Sig.	0.07	0.06	0.01*	0.001*	0.16	0.002*
Are there differences in the research experiences of male and female students in the traditional laboratory course?							
Traditional							
Men		**3.26 (0.14)**	**3.42 (0.15)**	**3.61 (0.15)**	**3.15 (0.16)**	**4.27 (0.19)**	**2.92 (0.15)**
Women		**3.46 (0.12)**	**3.46 (0.13)**	**3.77 (0.13)**	**3.27 (0.14)**	**4.68 (0.16)**	**3.18 (0.13)**
ATET propensity score matching	Coeff.	–0.230	–0.39	–0.29	–0.28	0.15	0.22
	SE	0.15	0.15	0.18	0.2	0.29	0.24
	z	–1.560	–2.54	–1.6	1.36	0.49	0.88
	Sig.	0.1	0.01*	0.1	0.17	0.62	0.38

*Significant at 0.05 level following a Holm-Bonferroni correction.

these significantly higher ratings can be attributed to the effect of the SEA-PHAGES course for women. Women in the SEA-PHAGES program have significantly higher ratings for all of the PITS survey variables when compared with women in the traditional laboratory. For men in the SEA-PHAGES program, there are no significant improvements over the traditional laboratory. Furthermore, when men and women are compared in the SEA-PHAGES program, women have significantly higher ratings for science identity, scientific community values, and networking. Taken together, these results suggest that the SEA-PHAGES program and, by extension, a CRE at the community college have a positive effect on women but might not function in the same way for men.

These results are promising in terms of the potential way in which a CRE can help alleviate the gender gap in STEM. It should be noted that the current study was done in the context of microbiology education; however, CREs are increasingly present within a wide range of STEM fields, and it is plausible that participation in a different CRE would have similar outcomes for women. Prior research in the community college setting established that women face issues of negative stereotypes concerning their ability to function in STEM (Marco-Bujosa and Sorrentino, 2020), and have difficulty developing a sense of belonging or the feeling of a legitimate science identity (Buse *et al.*, 2013; Fouad and Santana, 2017). As measured on the PITS survey, participating in a CRE produced higher ratings for women for exactly these variables. As evidenced by increased self-efficacy, science identity, and scientific community values, when compared with women in the traditional lab, the women in the SEA-PHAGES program had higher ratings of their own competence, self-identification, and legitimacy in the field of STEM. Furthermore, as seen in the higher ratings for networking and project ownership when compared with the traditional laboratory, women in the SEA-PHAGES program felt ownership and belonging in the STEM. These results suggest a positive role for a CRE in addressing the gender gap at the community college.

Women in the SEA-PHAGES program had significantly higher ratings for future intent to stay in the sciences when compared with the traditional laboratory. This is important in light of the prior literature, which has suggested lower degree completion rates for women in STEM (Snyder *et al.*, 2016). We assume that the educational design features of the SEA-PHAGES CRE counter negative stereotypes and impostor phenomenon by providing women with a sense of belonging in STEM and proving their ability to be a researcher. Higher ratings for self-efficacy, science identity, and scientific community values for women in the SEA-PHAGES program when compared with women in the traditional laboratory would support this interpretation of the value of a CRE for women.

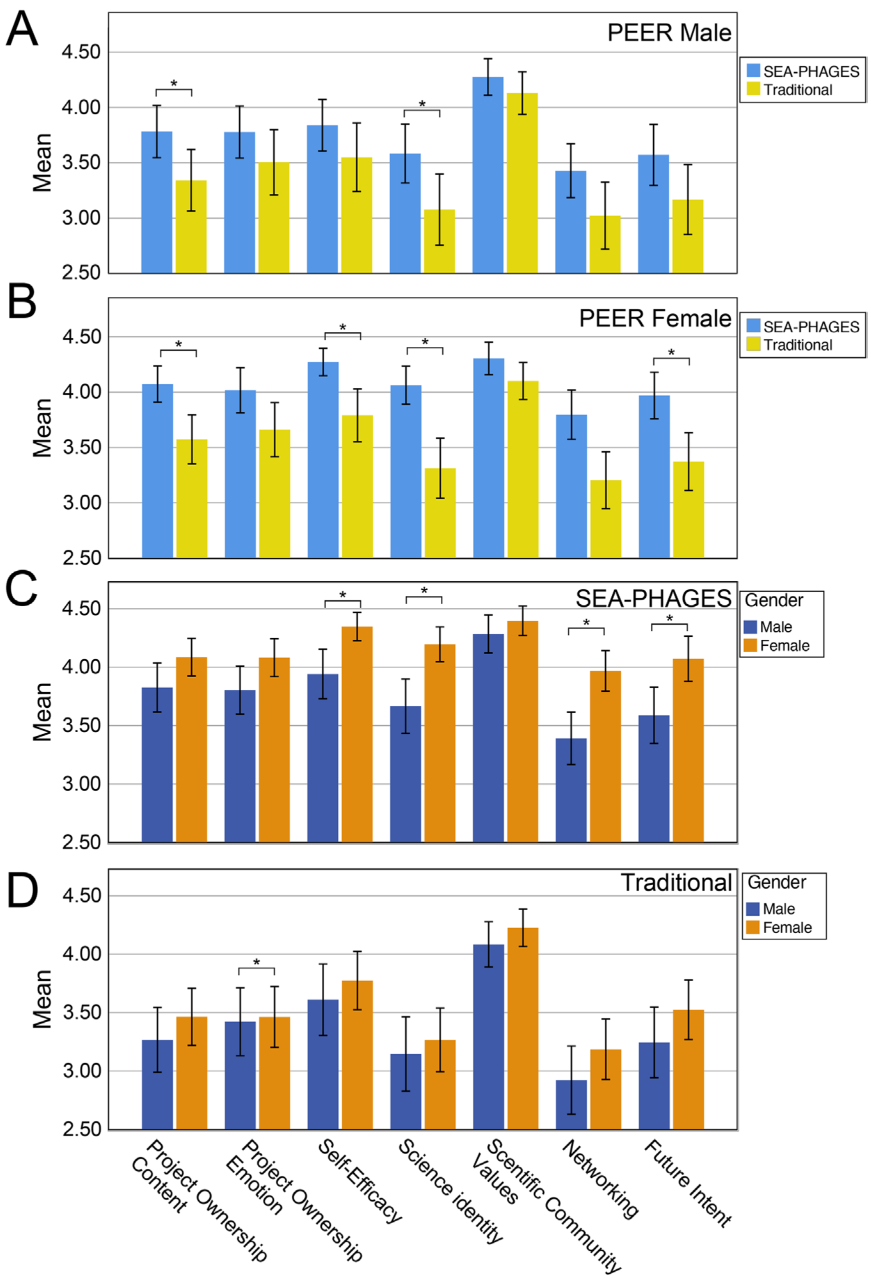

FIGURE 3. Bar graph comparison of SEA-PHAGES and traditional gender and ethnicity student groups on the PITS survey variables and future intent to persist in the sciences. (A) PEER male students in the SEA-PHAGES and traditional laboratory course (blue and yellow bars, respectively). (B) PEER female students in the SEA-PHAGES and traditional laboratory course (blue and yellow bars, respectively). (C) Male and female students in the SEA-PHAGES program (dark blue and orange bars, respectively). (D) Male and female students in the traditional lab (dark blue and orange bars, respectively). Equally sized random student groups by course type were propensity score matched and compared on average treatment effect on the treated (ATET). Significant differences following Holm-Bonferroni correction are indicated (*$p < 0.05$). PITS survey ratings are from 1 (strongly agree) to 5 (strongly disagree) for all measures except scientific community values, which had a 1 (not like me at all) to 6 (very much like me); scientific community values rating was proportionally rescaled to 1–5 for this figure.

There are also some encouraging results at the intersection of gender and ethnicity in relation to CRE participation. PEER women and PEER men in the SEA-PHAGES program have significantly higher ratings at the end of their CRE for project ownership and science identity than similar groups in the traditional laboratory. Project ownership and science identity in particular have been significant predictors of long-term career persistence for underrepresented student groups (Hanauer *et al.*, 2016; Estrada *et al.*, 2018). PEER women but not men also had higher ratings for self-efficacy. In terms of theory of social integration in STEM (Estrada *et al.*, 2018), PEER women who took part in the CRE program demonstrated higher levels of compliance and identification representing a belief in their ability to do science and to be a scientist than women in the traditional laboratory. For PEER men, science identity and project ownership were rated higher than for the traditional lab and suggest increased intent to persist for this group as well.

As described in the *Introduction*, our core argument is that the special educational characteristics of the CRE in conjunction with the broad range of student populations present in the community college could facilitate increased persistence in STEM by persons from underrepresented populations. The educational design of a CRE, with its repositioning of the student as a contributing scientist and member of scientific community, has the potential to counter many of the barriers to persistence in STEM. The results of the current study offer some evidence that the CRE has the potential to increase persistence in the STEM professions for women and PEER student participants. The results are particularly strong for women and in addressing the gender gap, which has been an issue in STEM at the community college and other institutions. The results also offer some positive outcomes for both men and women PEER students. Based on prior scholarship, our assumption here explaining these results is that the CRE provides in real time the experience of doing science, being a scientist, and being a member of the scientific community and that the authenticity of this experience alleviates self-doubt in terms of ability, legitimacy, and identification with STEM. It is important to find a

TABLE 5. Mean, standard deviation, treatment effect on the treated (ATET propensity score matching) for future intent for gender and ethnic groups in traditional laboratory and SEA-PHAGES courses (n = 200)

Estimation method		Future intent	Intent to complete science degree
	Men PEER		
Are there differences in the future intent because of ethnicity or race (PEER) and White/Asian male students in the SEA-PHAGES program?			
SEA-PHAGES			
Men PEER		**3.57 (1.32)**	**4.24 (0.98)**
Men White/Asian		**3.75 (1.07)**	**4.18 (1.09)**
ATET propensity score matching	Coeff.	0.03	–0.07
	SE	0.17	0.18
	z	0.18	–0.38
	Sig.	0.85	0.7
Are there differences in the future intent because of ethnicity or race (PEER) male students in the SEA-PHAGES program and the traditional laboratory?			
PEER men			
SEA-PHAGES		**3.57 (0.14)**	**4.24 (0.1)**
Traditional lab		**3.17 (0.16)**	**4.12 (0.11)**
ATET propensity score matching	Coeff.	0.31	–0.36
	SE	0.16	0.2
	z	–1.9	–1.78
	Sig.	0.05	0.08
Are there differences in the future intent because of ethnicity or race (PEER) and White/Asian male students in the traditional laboratory?			
Traditional			
Men PEER		**3.17 (0.15)**	**4.12 (0.11)**
Men White/Asian		**3.6 (0.1)**	**3.9 (0.13)**
ATET propensity score matching	Coeff.	–0.002	–0.09
	SE	0.15	0.17
	z	–0.02	–0.58
	Sig.	0.98	0.56
	Women PEER		
Are there differences in the future intent because of ethnicity or race (PEER) and White/Asian female students in the SEA-PHAGES program?			
SEA-PHAGES			
Women PEER		**3.96 (0.1)**	**4.33 (0.1)**
Women White/Asian		**4.06 (0.1)**	**4.57 (0.08)**
ATET propensity score matching	Coeff.	–0.009	0.17
	SE	0.19	0.16
	z	–0.05	1.03
	Sig.	0.96	0.3
Are there differences in the research experiences because of ethnicity or race (PEER) female students in the SEA-PHAGES program and the traditional laboratory?			
PEER women			
SEA-PHAGES		**3.97 (0.1)**	**4.32 (0.1)**
Traditional lab		**3.37 (0.13**	**3.97 (0.12)**
ATET propensity score matching	Coeff.	–0.71	–0.49
	SE	0.28	0.27
	z	–2.56	–1.81
	Sig.	0.01*	0.07
Are there differences in the future intent because of ethnicity or race (PEER) and White/Asian female students in the traditional laboratory?			
Traditional			
Women PEER		**3.61 (1.23)**	**4.11 (1.14)**
Women White/Asian		**3.7 (1.13)**	**4.10 (1.18)**
ATET propensity score matching	Coeff.	0.29	–0.33
	SE	0.28	0.22
	z	1.04	–1.54
	Sig.	0.3	0.13

(*Continues*)

TABLE 5. Continued

Estimation method		Future intent	Intent to complete science degree
		Gender	
Are there differences in the research experiences of male and female students in the SEA-PHAGES program?			
SEA-PHAGES			
Men		**3.58 (0.12)**	**4.16 (0.11)**
Women		**4.07 (0.09)**	**4.49 (0.09)**
ATET propensity score matching	Coeff.	0.39	0.49
	SE	0.15	0.19
	z	2.60	2.58
	Sig.	0.009*	0.01*
Are there differences in the research experiences of male and female students in the traditional laboratory course?			
Traditional			
Men		**3.24 (0.15)**	**4.13 (0.12)**
Women		**3.52 (0.12)**	**4.22 (0.1)**
ATET propensity score matching	Coeff.	–0.15	–0.29
	SE	0.2	0.14
	z	–0.73	–2.13
	Sig.	0.47	0.03*

*Significant at 0.05 level following a Holm-Bonferroni correction.

pathway for women and PEER students to persist in STEM. As evidenced here, an early CRE course may provide that initial push to stay in the field.

There are several limitations to the current study. The design underpinning this study consisted of a comparison between two course types (CRE and traditional lab) and the collection of end-point, psychosocial data. Students were matched; however, pre and post data were not collected for this study. The variables of project ownership content, project ownership emotion, and networking are end-point variables and should not be used in pre and post designs, as they only reflect the outcomes of having completed an educational experience. Self-efficacy, science identity, and scientific community values can be measured in a pre and post design. The lack of a pre and post design for these variables limits claims concerning changes within individual students on these variables. However, it is still valid to claim a difference between the course types at an end-point designation. A related limiting factor is that, while student groups were matched for gender, ethnicity, GPA, parents' educational backgrounds, and parents' occupations across the course types, they were not matched for majors or initial career intentions. As such, there are some missing data for the comparisons being made, and it is possible that major and initial career intention could have had an influence here.

The results of the current study suggest that there is value in having CREs in the science curriculum at the community college level. Comparisons of end-point outcomes for the SEA-PHAGES program and the traditional laboratory reveal higher ratings for women and PEER students on important predictors of persistence such as project ownership and science identity. This suggests that the usage of a CRE at the community college could have positive effects in addressing the gender gap for women and enhance inclusiveness for PEER students.

The technical difficulties of developing a CRE at a community college that might limit the implementation of a CRE can be overcome by joining an iREC like the SEA-PHAGES program. The SEA-PHAGES program provides a community college with an accessible route for CRE implementation through the provisions of an active scientific community, a defined scientific problem, vetted protocols, extensive instructor training, a network of schools that provides support, quality control checks on outputs, and various options for student and faculty interaction across institutions. Data from the SEA-PHAGES program demonstrated the viability of this approach for community colleges. Of 20 community colleges that have joined the SEA-PHAGES program, 19 (95%) community colleges are sustainably engaging cohorts of their undergraduates in the SEA-PHAGES research project each year, with five schools having sustained their participation for over 5 years (the remaining 14 joined after 2015), and the inaugural community college member, Queensborough Community College, for 10 years. This level of sustainability is comparable to that for 4-year colleges and universities (155/176; 88%) in the program. This is a practical approach that should allow a wide range of community college students to have the opportunity to participate in a CRE. While no single intervention can solve the broader problem of expanding inclusiveness in STEM, the integration of CREs at community colleges would seem to increase the chances that a broadening demographic of students has the opportunity to experience authentic research and thus increase their intent to persist in the sciences.

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HIGHLIGHT:

In a propensity score -matching design students in course-based research experiences (CREs; here SEA-PHAGES) and traditional laboratory courses at the same community colleges were compared on a range of psychosocial variables. End-point outcomes revealed significantly higher ratings in the SEA-PHAGES for women and PEER students on important predictors of persistence.