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| Research Article

Advanced biology students' individual conceptions of scientific researchers after participating in biomedically relevant CRE

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ABSTRACT While undergraduate research has been shown to be a high-impact educational practice, it is logistically impossible for all undergraduate biology majors to have long-term faculty-mentored research experience. Therefore, biology educators and researchers must devise opportunities to engage more students in undergraduate research outside of working directly in their labs. Course-Based Research Experiences (CREs), structured as authentic research experiences, are one such opportunity. In this work, we describe the effects of a CRE with biomedical relevance on students' research skills, attitudes toward science, and perceptions of scientific research and scientific researchers. Results demonstrate that students gained experience in independent research skills including designing their own research project, being accountable for part of a project, and writing a research proposal. Students' perceptions of scientific research and researchers, assessed by the Draw-A-Researcher Task, did not show changes among the whole group, but individual analysis yielded meaningful results related to students' personal changes in how they perceived research and researchers, including their perception of themselves as researchers. This work demonstrates the substantial impact of CREs on upper-level biology undergraduate and graduate students.

KEYWORDS Course-Based Research Experience, biology majors, molecular biology, biomedical research, Draw-A-Researcher Task

Course-Based Research Experiences

Undergraduate research is a high-impact educational practice emphasized as a major goal of biology education in national reports. However, at most institutions, it is not possible for all undergraduate biology students to engage in faculty-mentored research (1). In fall 2020, the average number of undergraduate biology majors among R2 universities was 823 (2). If we estimate that a biology department has approximately 25 faculty members with active research labs, each of whom mentors five undergraduate students, that only provides research opportunities for about 15% of biology majors. Therefore, biology departments need to create other opportunities for students to engage in undergraduate research.

One such opportunity is Course-Based Undergraduate Research Experiences (CUREs), in which students collaboratively engage in scientific practices to investigate a novel question that adds to the scientific body of knowledge (3). Implementing CUREs in undergraduate biology curricula can greatly increase the number of research opportunities available to students and extend the benefits of undergraduate research beyond students who typically participate in Research Experiences for Undergraduates, apply for research internships, and/or work in a faculty member's lab (1). Participating in CUREs has been shown to have several beneficial outcomes for students, including but not limited to persistence in STEM majors (4, 5), gains in students' self-efficacy and motivation to engage in science (5), and increases in students' scientific thinking and ability to analyze and interpret data (6).

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Recent research has expanded upon the specific practices within a CURE that may most strongly impact students' outcomes. It has been proposed that students' knowledge and skills are most strongly influenced by reading and evaluating scientific literature, collecting novel data, and analyzing results of that novel data; students' communication and collaboration skills are influenced by working collaboratively with peers and presenting work outside of class; and students' sense of ownership over a research project is influenced by collecting novel data and designing all or part of the data collection methods (7). In a study comparing the scientific identity and emotional ownership of the research project between a group of students who analyzed data collected by other scientists and another group of students who analyzed data that they collected themselves, the group analyzing their own data showed significantly greater gains in science identity and self-efficacy and developed greater emotional ownership over their project (8). Another study from the same research group assessed the impact of the type of data that students produced, with one group producing data that confirmed prior scientific knowledge and another group producing data that led to generation of novel scientific knowledge that was relevant to collective scientific knowledge (9). The latter group reported greater emotional ownership over their research projects and perceived that the work that they were doing was novel and relevant to the scientific community (9).

Biomedically relevant CREs

While CUREs have been widely studied, especially over the past decade, several aspects remain underexplored. Although biomedical science is a rapidly expanding field, very few studies have examined the impacts of CUREs using molecular techniques, with even fewer examining CUREs that are relevant to biomedical research. It has been suggested that this may be due to the lack of funding, low institutional support, and/or the complexity of procedures involved in molecular biology (10). One of the few studies on molecular biology CUREs took place in a large-enrollment cell and molecular biology course in which students used yeast to characterize mutations in the human p53 gene (11). This study engaged students in collaboration, data collection, data analysis, and public presentation of results, although the extent to which students had control over the experimental design and data collection was unclear (11). Other studies evaluating molecular biology CUREs reported greater understanding of how biomedical research is conducted (12), increases in students' attitudes about science and interest in pursuing graduate degrees in STEM (13), and greater retention in a biomedical science major (14).

It is worth noting that none of these studies took place in the context of a protein and cell biology techniques course nor did they explore scientific questions related to cellular immunology or assess students' perception of scientific researchers. Thus, using scientific questions related to cellular immunology and human disease provides a novel context for a biomedically relevant CURE emphasizing protein and cell biology techniques. In this study, we report on such a course and its effects on students' research skills, attitudes toward science, and perceptions of scientific researchers. This course is taken by both undergraduate and graduate students, so it will hereafter be referred to as simply a Course-Based Research Experience (CRE). We suggest that, in the context of a biomedically relevant CRE, students may demonstrate increased positive attitudes toward science, expand their concept of a scientific researcher, and recognize more extensive experience in research skills. Specifically, we hypothesize this CRE will support students' development in these areas due to the CRE's immunological focus, which provides a relevant biomedical framework for their investigations. Educational research shows that students are more likely to retain scientific content and applications if such content is relevant to their lives (15); the biomedical context of the CRE provides this relevance.

Research questions

After participating in a biomedically relevant CRE, how do students perceive

1. their experience in research skills?
2. the field of science and themselves within science classes?
3. a scientific researcher?

METHODS

Instructional setting

This study was conducted at an R2 university in the Midwestern United States. Data were collected in the spring semesters of 2021 and 2022 in a biotechnology course emphasizing molecular and cellular biology techniques co-taught by the first and last authors. This course is taken electively by junior- and senior-level undergraduates and is a required course for graduate students specializing in biotechnology. This lab course is designed to introduce students to experimental methods used in biotechnology focusing on cells and proteins, specifically experimental design, pipetting, and buffer preparation; protein extraction and quantification; protein gels (SDS-PAGE) and analysis; western blotting and analysis; immunohistochemistry, analysis, and microscopy; and fluorescence microscopy, with accompanying exercises facilitating students' application of the technique to address their research questions. Prior to this course being restructured as a CRE, the curriculum emphasized learning how to perform each technique, which lacked the relevance of the CRE and did not engage students in the full research process (e.g., writing research proposals, conducting experiments, and reporting results). Thus, the course was revised to introduce students to these techniques in the context of biomedically relevant immunological research using the *Drosophila*-parasitoid wasp system (16, 17). In both semesters, students engaged in the five dimensions of a CURE (3), detailed in Table 1. Students' research questions were determined collaboratively between students and the instructors to ensure that the research fits in the framework of biomedical relevance and was feasible to collect data during the semester.

Briefly, the immunological research in which students participated focused on analyzing the content of parasitoid wasp venom, which is a complex mixture of proteins, virus-like particles, microRNAs, small molecules, and ovarian fluids (18, 19). Venoms are already widely studied for their disease relevance. For example, honeybee venom has been suggested to be beneficial in the treatment of Parkinson's disease (20, 21), and wasp venoms have been shown to be useful in therapeutic and cancer applications (22). Parasitoid venoms provide a unique context to investigate potential biomedical treatments for human disease, since parasitoid venoms target conserved signaling pathways in hosts, and these same pathways are related to many human diseases (23–25).

TABLE 1 How dimensions of CREs are enacted in the present study[a]

Dimension of CRE	Dimension as described by Auchincloss et al. (3)	Method enacted in study
Iteration	Instructors' role is guidance and mentorship; inherent risk of generating "messy" data; iteration is expected	Instructors collaborated with students rather than directing them what to do; students investigated questions that generated data requiring organization and analysis
Collaboration	Collaboration occurs among students, teaching assistants, and an instructor in a course	Students worked in groups of 3–4, collaborating with each other and instructors to form research questions
Discovery	Purpose of the investigation is collaboratively defined by student and instructor; outcome is unknown	Students and instructors collaborated to form novel research questions
Scientific process	Students engage in multiple scientific practices; study design and methods are student driven	Students' novel research questions were answered using multiple cellular and protein techniques learned throughout the class
Broad relevance	Findings are novel are relevant beyond the course context, and provide opportunities for future research	Students' data may be used in future publications, students presented novel data, and data led to further research questions

[a]Dimensions as described by Auchincloss et al. (3).

In this CRE, students worked with a specific venom protein each semester: actin (Spring 2021) and neprilysin (Spring 2022). Both actin and neprilysin have been identified as conserved venom proteins in the parasitoid wasp species *Leptopilina boulardi*, *Leptopilina heterotoma*, and *Ganaspis hookeri* (Waring-Sparks et al., unpublished data). Neprilysin has been shown to regulate the clearance of amyloid β (Aβ) peptides, which aggregate to form β-amyloid plaques and contribute to Alzheimer's disease. Actin is a well-characterized protein that functions as an important comparison to neprilysin, which is still being characterized. For more information on this biomedical relevance, we refer readers to references (16, 17) and associated work. Throughout the semester, students carried out experiments in protein analysis, quantification, and characterization and collected quantitative (e.g., protein quantity) and qualitative (e.g., western blot images) data that will contribute to upcoming publications. All experiments complied with the ASM Guidelines for Biosafety in Teaching Laboratories. For their final project, student teams created a research proposal consisting of an introduction, hypothesis, objectives, methods including descriptions and purposes of specific procedures, expected results and interpretations, and future directions.

Participants

Twenty-five students in the course during the spring semesters of 2021 and 2022 consented to participate in this study (Illinois State University IRB #2021-11). The following demographics were collected via self-reported data: 48% (12/25) women and 48% men, with one participant declining to respond; 36% (9/25) third- or fourth-year undergraduate students, 48% masters' students, 4% (2/25) doctoral students, and 4% graduate students not enrolled in a degree program; 44% (11/25) identified their race as White, 25% (5/25) as Black or African American, 8% (2/25) East Asian or Asian American, 8% Latino/a/x/e, 8% Middle Eastern or Arab American, 4% (1/25) South Asian or Indian American, and 8% declining to respond.

Data collection and analyses

A CURE survey (26) and the Draw a Researcher Task (DART) and narrative reflections (27) were collected as pre- and post-assessments. The CURE survey contains 25 questions assessing students' experience with the research process and 22 questions assessing attitudes toward and perceptions of science; the DART and narrative reflections assessed students' concepts of a scientific researcher (see Appendix 1 for full instruments).

To address Research Questions 1 and 2, quantitative data from the CURE survey were analyzed using paired *t*-tests in IBM SPSS Statistics 26. Analyses were conducted using data from all participants (n = 25) and then split into subgroups (undergraduate and graduate students; men and women; White and non-White students) to determine if any results were unique to specific subgroups. To ensure that statistical analyses provided meaningful results, students' races were collapsed into White (44%, 11/25) and non-White (48%, 12/25), with participants who declined to identify their race excluded from analyses by racial group.

To address Research Question 3, qualitative data from the DART and narrative reflections were analyzed by two coders using thematic analysis and open coding (28). The coders compiled a list of codes from prior literature (29–31). Both coders used these to independently code the DART and narrative reflections, with one coder (first author) also noting emergent themes during this coding process. The coders met to discuss their codes and reach consensus. At this time, the first author shared the emergent themes they identified, and the coders separately recoded the data set for these themes. Interrater reliability for all 25 final codes was calculated using an adjusted Cohen's kappa (κ) suitable for binary presence/absence nature of these codes (32–34). Nineteen codes demonstrated substantial agreement of $\kappa > 0.60$, four codes demonstrated moderate agreement with κ between 0.41 and 0.60, and two demonstrated fair agreement with κ between 0.21 and 0.40 (32, 35). All disagreements were discussed with consensus reached on all codes.

To characterize changes in students' perceptions of scientific researchers, we analyzed the frequency of each code between the pre- and post-assessments. Since the DART and narrative reflections were coded for the presence or absence of each code, it was necessary to use a statistical method that accounted for the binary nature of these data. Thus, we used the Related-Samples McNemar Change Test with a binomial distribution, which has been used for qualitative presence/absence data in prior work [e.g., reference (34)]. This analysis was conducted in IBM SPSS Statistics 26. We then selected four participants to highlight as examples of how students' perceptions of a scientific researcher changed, which are presented in the Discussion.

RESULTS

Research question 1: students' perceptions of research skills

The first section of the CURE survey asked students to rate their experience with specific course elements on a Likert scale, ranging from no experience at all (1) to extensive experience (5). On the post-survey, these same questions asked students to rate how much experience they gained with the same course elements using the same scale. A summary of statistically significant pre-post changes is shown in Table 2; results including descriptive statistics and test statistics are shown in Appendix 2.

As shown in the table above, statistically significant pre-post gains were present in 16 of the 25 course elements listed in the CURE survey in at least one group of students. Of these 16 statements, 5 showed pre-post changes in the analysis of all student responses and at least three subgroups; the pre-post changes in these 5 statements are represented visually in Fig. 1.

Research question 2: students' perceptions of science and themselves

The second section of the CURE survey asked students to evaluate statements regarding their opinions about themselves and about science on a Likert scale, ranging from strongly disagree (1) to strongly agree (5). None of these statements showed statistically significant pre-post change among all students; when broken out into subgroups, only three statements showed any type of pre-post change, each in a different subgroup (Table 3).

Research question 3: students' perceptions of a scientific researcher

Analysis of the DART and narrative reflections showed no statistically significant changes between the pre- and post-assessment except for one code; the code "lab coat" was present in 12 of the pre-assessments, but only in 4 of the post-assessments ($P = 0.008$). None of the subgroups showed any statistically significant pre-post change. Frequencies of each code are shown in Table 4.

DISCUSSION

While there are many potential interpretations of the data presented above, below, we highlight three findings that we find particularly relevant to this specific CRE context.

Students gained experience in independent research skills without lecture-based instruction

As shown in Table 2 and Fig. 1, students across four or more groups reported substantial gains in several course elements related to research skills. Students also reported that the course did not increase their experience in listening to lectures. Although the benefits of active learning compared with lecture-based instruction are well documented, we argue that it is noteworthy that students reported these experiential gains in the course-based context while acknowledging the lack of lectures; prior to being revised as a CRE, this course included lectures about each technique, which were eliminated during the revision to a CRE. This further confirms many of the positive outcomes of CREs (6, 7, 11, 12) and reinforces that such outcomes are possible in a CRE and not limited to

TABLE 2 Summary of results from the "course elements" section of the CURE survey across all groups analyzed[a]

Statement	All	Graduate	Under-graduate	White	Non-White	Men	Women
A lab or project where no one knows the outcome.	*			*			
At least one project that is assigned and structured by the instructor.						*	
A project in which students have some input into the research process and/or what is being studied.	**	*		*	*	*	
A project entirely of student design.	***	***	*	*		**	
Working as a whole class.						*	
Working individually.		*					
Being responsible for a part of the project.	**	**			*	**	
Writing a research proposal.	***	***		**		*	*
Analyzing data.				*			
Presenting results orally.		*					
Presenting results in written papers or reports.	*					*	
Listening to lectures.^	*		**	*		*	
Reading a textbook.^		*	**	*			
Working on problem sets.^				*			
Taking tests in class.^	**		*		*		
Discussing reading materials in class.^			**				

[a]*$P \le 0.05$, **$P \le 0.01$, and *$P \le 0.001$. All pre-post changes were increases in mean scores except for statements denoted with the ^ symbol, which showed pre-post decreases.

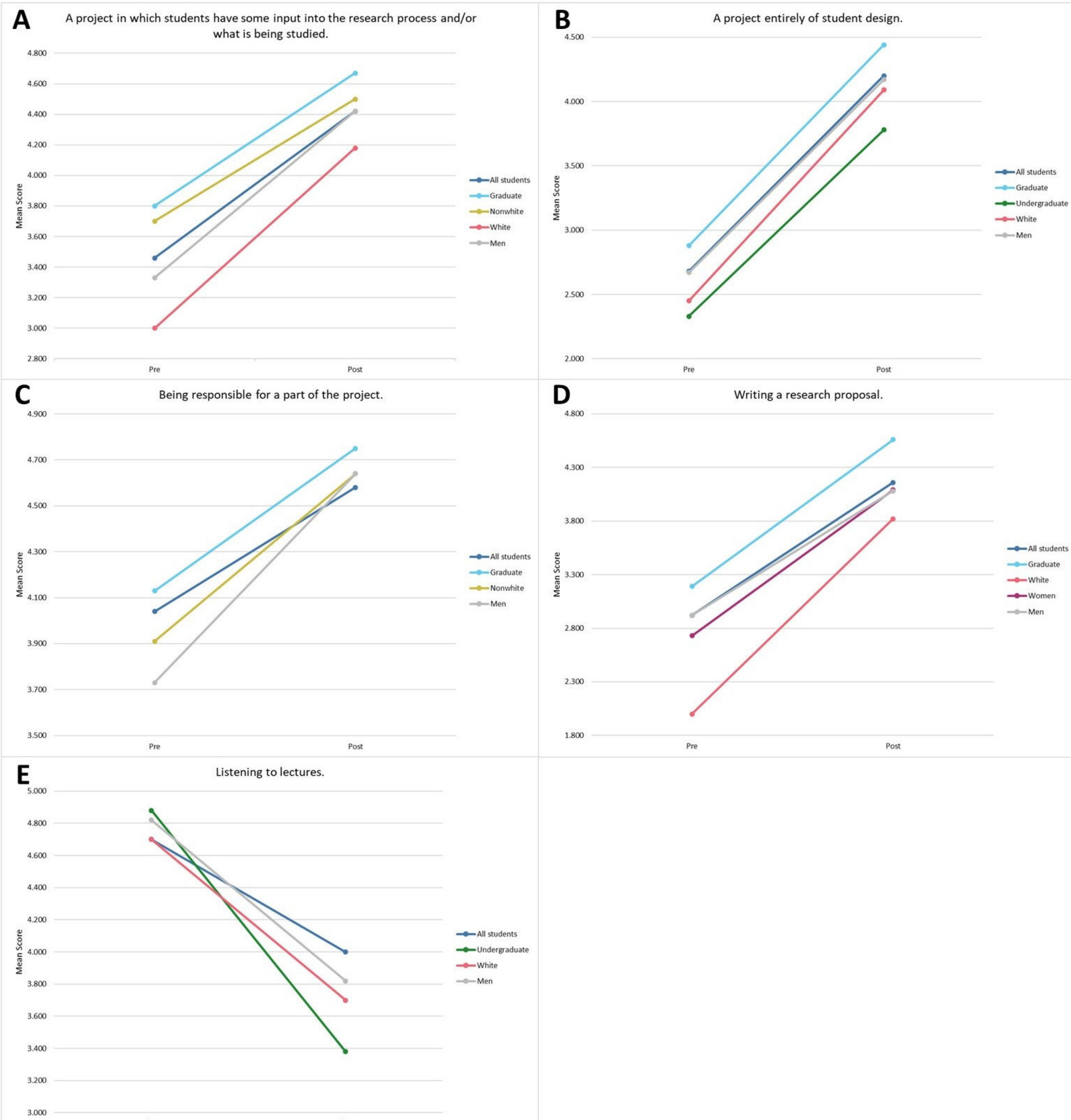

FIG 1 Statements assessing students' self-reported level of experience in various course elements. The five statements represented here showed statistically significant pre-post change at α = 0.05 in the full group of all student responses and at least three subgroups, as shown on the graphs.

extra-/co-curricular research experiences. Observations of students' research experiences by the co-instructors also support these self-reported gains; during the Spring 2022 semester, students endeavored to use the TnT T7 Insect Cell Extract Protein Expression System as a novel approach to purifying proteins from venom. However, the initial use of this system was unsuccessful in extracting neprilysin. Rather than pivoting to a different project that would still teach the lab skills, students persisted in troubleshooting various aspects of the protocol with the goal of effectively adapting this protocol for use in the

TABLE 3 Results from the "science opinions" section of the CURE survey across all groups analyzed

Group	Statement	Pre (mean ± SEM)	Post (mean ± SEM)	Test statistic
White students	When experts disagree on a science question, it's because they don't know all the facts yet.	2.64 ± 0.203	3.45 ± 0.312	$t(10) = -2.764$, $P = 0.020$
Undergraduates	Real scientists don't follow the scientific method in a straight line.	2.78 ± 0.434	3.67 ± 0.408	$t(8) = -3.411$, $P = 0.009$
Men	Lab experiments are used to confirm information studied in science class.	3.58 ± 0.260	4.17 ± 0.297	$t(11) = -2.244$, $P = 0.046$

parasitoid wasp system. An example of one group's proposal to troubleshoot this procedure is shown in Appendix 3. Prior to redesigning this course, students would not have gained experience in testing protocols in novel systems and proposing strategies to troubleshoot the protocol for use in a novel system.

Students reported very little change in their opinions about themselves and science

Results from the "science opinions" section of the CURE survey demonstrated that, with a few exceptions listed in Table 3, students' opinions about science and themselves in science did not change. While this result did not support our hypothesis, we suggest that this may be because the participants, all of whom were undergraduate biology majors and graduate students pursuing a specialization in biotechnology, already had positive opinions of themselves and science. On the pre-assessment, students' mean score on statements representing a positive attitude toward science (26) was 4.61 on a five-point Likert scale, while the mean score was 2.03 on statements representing

TABLE 4 Final coding scheme for DART and narrative reflections with frequencies of each code in pre- and post-assessments

Category	Code	Pre	Post
Standard stereotype (29)	Lab coat	12	4
	Eyeglasses	10	8
	Facial hair	2	1
	Symbols of research (e.g., beakers)	16	17
	Symbols of knowledge (e.g., books and laptop)	8	8
	Products of science (e.g., rockets and protein analysis image)	2	4
	Captions ("Eureka!")	5	7
Additional stereotypes [DAST-C (30)]	Only men	8	7
	Indoors	9	9
	At least middle aged	5	4
Alternative stereotypes [(31) and emergent]	Team/individuals working together	2	6
	Women included	5	7
	Outside/in the field	1	1
	Non-White	1	2
	Variety of tools	12	7
	Personally known people	1	2
	Self	3	4
	Expressions of joy/positivity/happiness	8	10
	Indications of safety	2	1
	Mentored	2	0
Other (emergent)	Indication of COVID-19	4	1
	Accomplished/famous	4	3
	Feelings (tired, etc.)	2	3
	Showing relationship between science and society	4	4
	Scientists wear many hats	1	2

a negative attitude toward science, showing students entered this course in high agreement with positive statements about science (e.g., “I get personal satisfaction when I solve a scientific problem by figuring it out myself”) and low agreement with negative statements about science (e.g., “If an experiment shows that something doesn’t work, the experiment was a failure”). Thus, while participation in a CRE can increase students’ opinions of science and their abilities as science students, we suggest that these gains may be less pronounced or absent in high-level undergraduate or graduate students, potentially because they already have positive impressions about science.

Students’ perceptions of a researcher represent individual journeys

Contrary to our predictions, there were not many trends, let alone significant changes, in codes on students’ DART assignments. However, upon examining each student’s pre-post journey independently of one another, we recognized individual growth that was unique to each student. Below, we present four students’ drawings and summarize their narrative reflections; the full narrative reflections are presented in Appendix 4. Note that the names below are pseudonyms.

Abigail

During data collection, Abigail, an East Asian woman, was pursuing her MS in biotechnology. In Abigail’s pre-assessment, she drew herself observing organisms under a microscope, explicitly describing herself as “happy […] because I was always having a fun time doing research in the lab.” Both her pre- and post-assessment (Fig. 2A and B, respectively) included symbols of research, indoors, women included, self, and expressions of joy/positivity/happiness, demonstrating substantial consistency in her perception of a researcher. Abigail’s development is highlighted in two key areas: mentorship and collaboration. In her pre-assessment, she mentioned being mentored by her graduate advisor, but this was absent in the post-assessment, indicating a growing sense of independence as a researcher. Additionally, the shift from working alone at the microscope to collaborating with labmates on a protein analysis showcases her growing

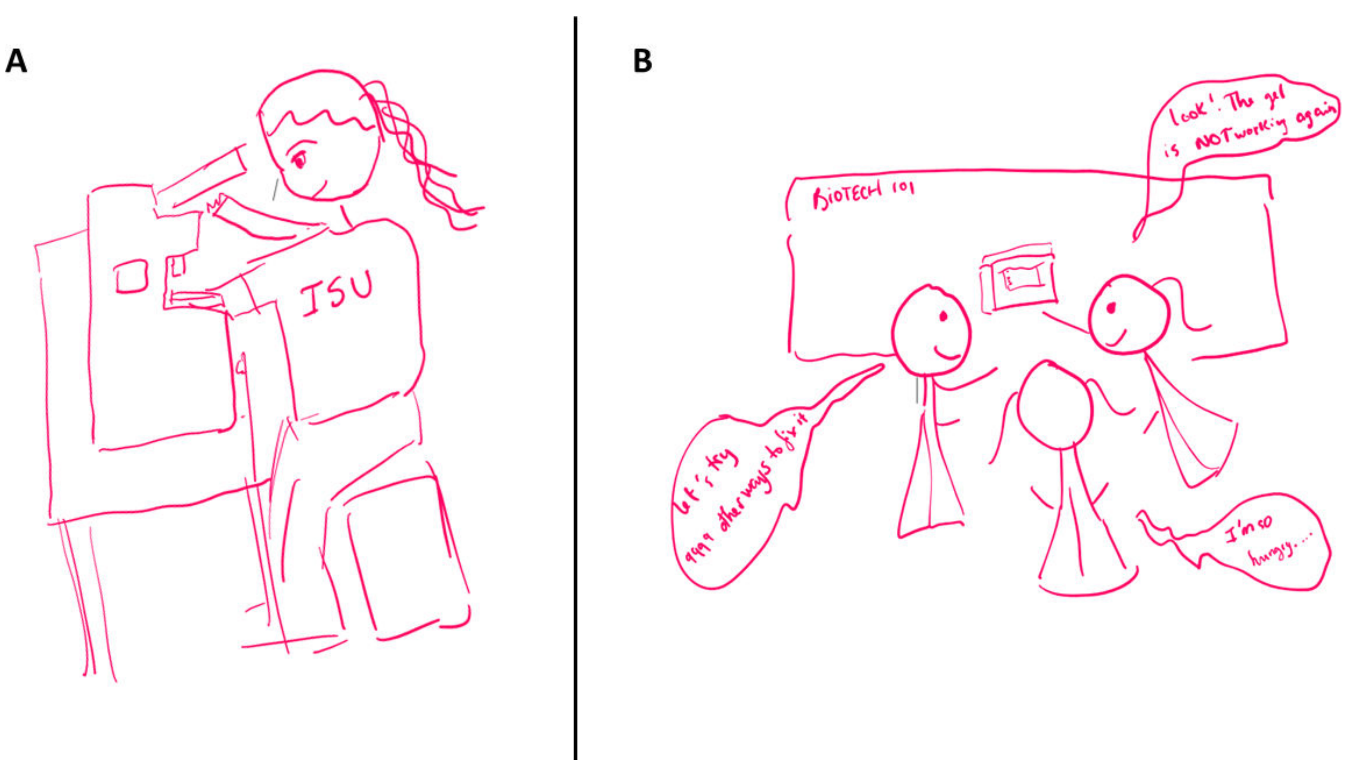

FIG 2 Abigail’s Draw-A-Researcher-Task sketches for the pre-assessment (A) and post-assessment (B).

understanding of collaboration and the iterative nature of scientific research, aligning with several dimensions of CREs (3).

Stephen

Stephen is a White man who was pursuing his undergraduate degree in general biology. In Stephen's pre-assessment, he drew a stereotypical representation of a male researcher at a lab bench surrounded by science equipment taking detailed notes on his protocols (Fig. 3A). However, his post-assessment drawing (Fig. 3B) showed a non-White woman interpreting the results of a western blot with a thought bubble stating "Wow that's incredible! This did not give me the results I was expecting at all! […] At least I now know what does not work!" Stephen's pre- and post-assessment drawings shared common elements like lab coats and tools but diverged in specific details. The pre-assessment depicted symbols of knowledge and only men, while the post-assessment included a western blot, a non-White woman, and expressions of joy and tiredness, emphasizing the unpredictability and emotional aspects of scientific research. In his narrative reflection, Stephen highlighted the iterative nature of research, emphasizing the value of learning from unexpected outcomes in experiments.

Taylor

At the time of data collection, Taylor, a Black woman, was pursuing her MS in biotechnology. In Taylor's pre-assessment (Fig. 4A), she drew Anthony Fauci, who was the NIAID Director at the time and a high-profile figure in the US government's response to the COVID-19 pandemic. Taylor's pre- and post-assessment drawings shared only the elements of a lab coat and eyeglasses, with the pre-assessment also including the codes of only men, middle-aged, and accomplished/famous. However, her post-assessment (Fig. 4B) reflected a significant shift, illustrating a gender-neutral researcher and expressing a belief that anyone contributing to knowledge in a specific field can be

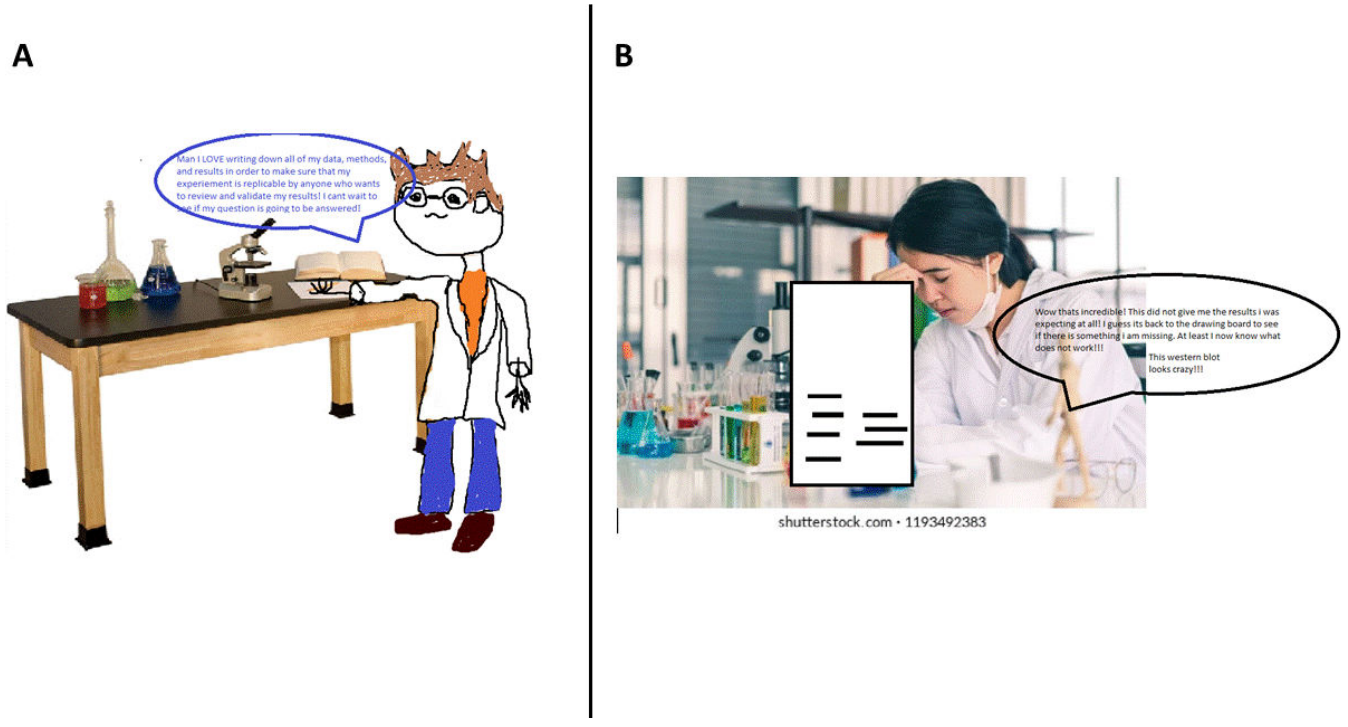

FIG 3 Stephen's Draw-A-Researcher-Task sketches for the pre-assessment (A) and post-assessment (B). Photo in panel B used under license from Shutterstock.com (contributor Namoyim, image 1193492383).

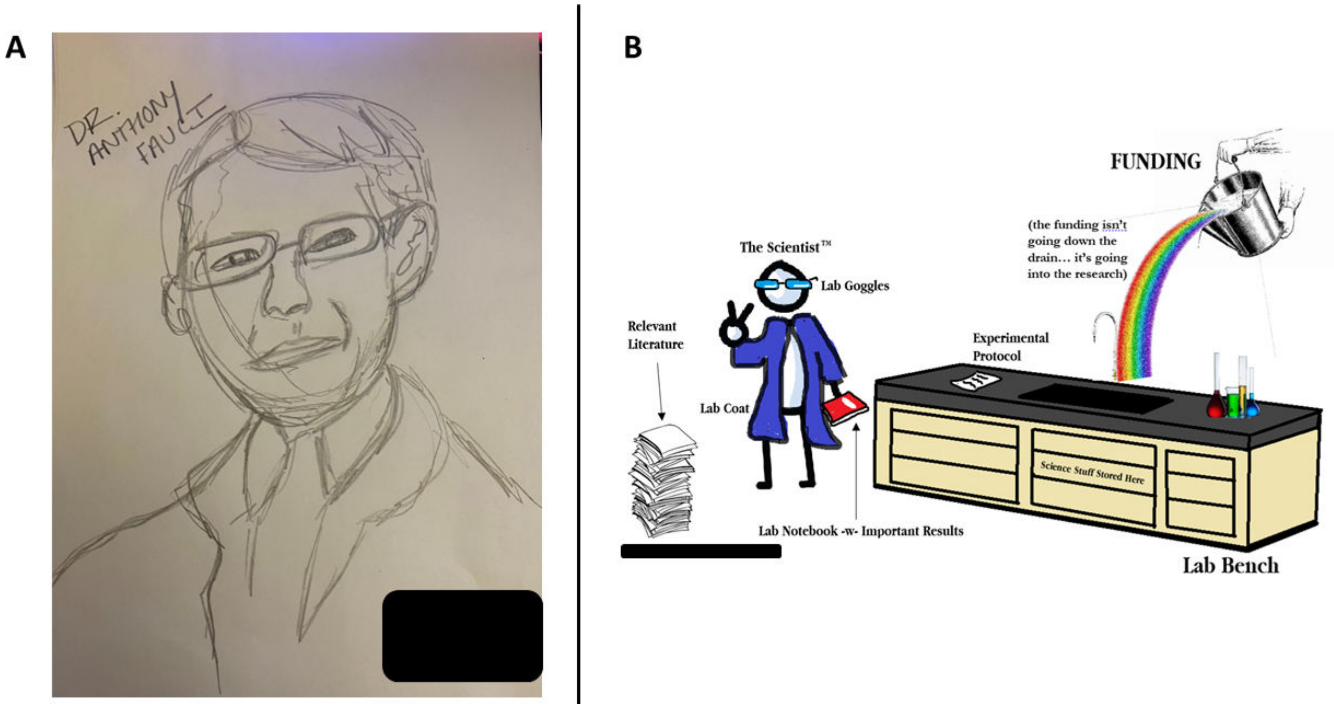

FIG 4 Taylor's Draw-A-Researcher-Task sketches for the pre-assessment (A) and post-assessment (B).

considered a scientist, highlighting a broader and more inclusive perception of the scientific community and collaboration.

Travis

At the time of data collection, Travis, a Black man, was pursuing his MS in biotechnology. Notably, Travis is the only participant who explicitly depicted non-White individuals in both the pre- and post-assessment. Like Taylor, he chose a specific famous scientist for his pre-assessment, drawing Dr. William A. Hinton (Fig. 5A). In his narrative reflection, Travis described the obstacles that Dr. Hinton faced as a Black man and his relevant discoveries, concluding with "Dr. Hinton embodies the quintessential traits of a researcher: tenacity, curiosity, and a willingness to exceed expectations." In his post-assessment, Travis chose to draw another individual: himself. We believe that his full narrative description speaks for itself:

> "My submission is a cartoon sketch of myself. Prior to this course, I had a deep-seated belief that research, as a pursuit, was only reserved for a select few who displayed extraordinary brilliance. After designing and successfully executing our projects, my opinion has drastically changed. Watching our ideas evolve into testable experiments that translated into reasonable results taught me that science is not reserved for a select few, in fact, not for anyone. If you are passionate about the problem of interest and are excited about spending hours to solve it, you are a scientist. So, I drew myself because though I may not possess the intellect of a genius, I deeply enjoy science, and for me, that is enough to be a researcher."

Conclusion

The results of this study illustrate that participating in the CRE yielded gains in students' independent research skills, with near-universal gains in input into the research process, designing their own research project, being responsible for at least part of a project, and writing a research proposal. However, these gains in research skills did not translate into increases in students' opinions of science or themselves as science students/researchers.

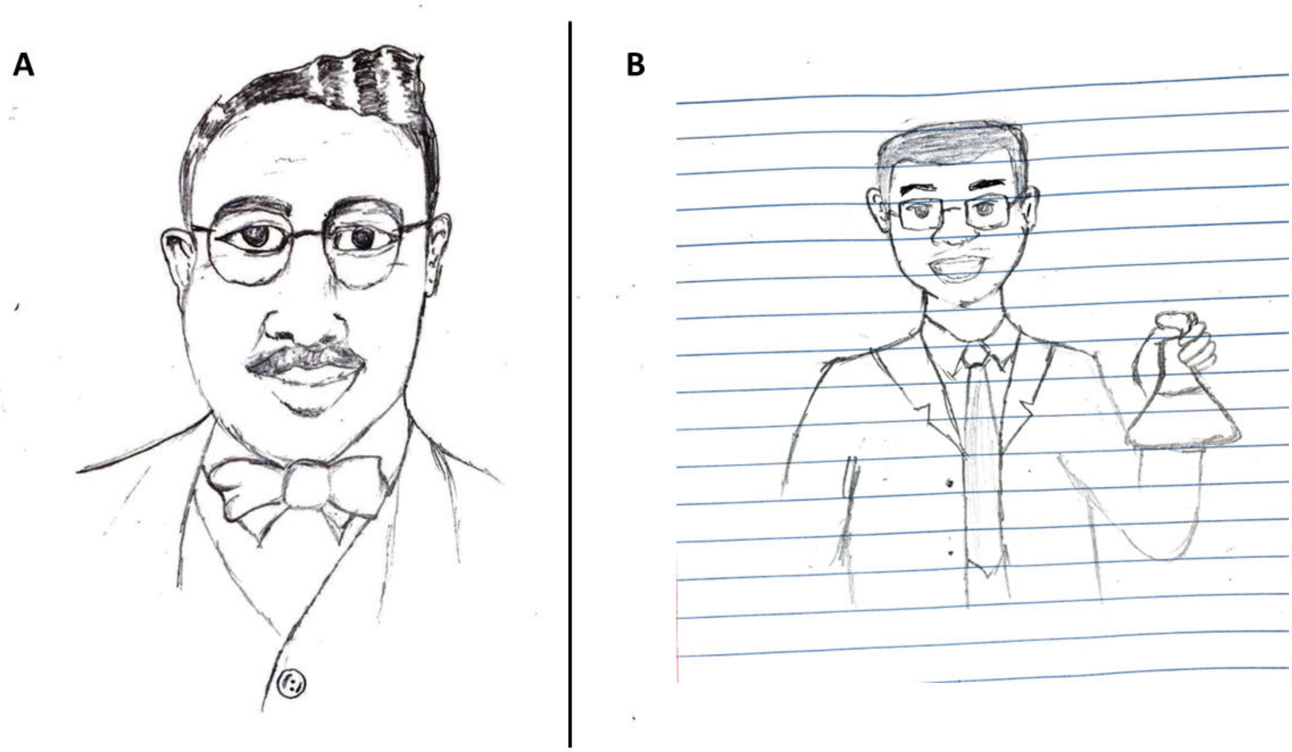

FIG 5 Travis's Draw-A-Researcher-Task sketches for the pre-assessment (A) and post-assessment (B).

We suggest that this is because students, who were all graduate students or high-level undergraduate biology majors, entered the course with positive opinions; this suggestion is supported by students strongly agreeing with positive statements about science on the pre-assessment. Finally, we have shown that students' perceptions of scientific researchers, as measured by the DART, did not change on a whole-class level but showed meaningful growth on the individual level.

While these results support the efficacy of CREs in developing students' research skills and perceptions of a researcher, this study is not without limitations. This work took place in small sections of an upper-level biotechnology course with graduate and advanced undergraduate students, which, along with the small sample size, eliminates the potential for generalizability to all CRE courses. Two of the authors were the co-instructors of the course, which may have impacted student responses. Nonetheless, students' growth in this biomedically relevant CRE is important as the science education community continues to develop best practices in undergraduate research and determining strategies to foster students' research skills and perceptions of researchers. Furthermore, we have identified that even upper-level biology students and graduate students may not initially think of themselves as researchers; thus, as science educators and mentors, it is imperative that we continue to provide innovative experiences that build students' conceptions of what it means to be a researcher and develop their self-efficacy as scientists.

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ETHICS APPROVAL

This study was conducted in accordance with Illinois State University IRB #2021-11. All participants consented for their data to be included in this study. While these data are not publicly available, deidentified data are available from the authors upon request.

ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplemental Appendices (jmbe00183-23-s0001.pdf). Appendices 1 (pre- and post-assessments), 2 (CURE survey results), 3 (troubleshooting proposal example), and 4 (narratives).

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