Mini-Course-Based Undergraduate Research Experience: Impact on Student Understanding of STEM Research and Interest in STEM Programs

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Undergraduate research experiences (UREs) increase interest in STEM (science, technology, engineering, and mathematics) research and careers. UREs are utilized as recruitment tools for advanced degree programs and often target underrepresented minorities (URMs). However, UREs accommodate a limited number of students. Course-based UREs (CUREs) have the same benefits as UREs and reach more students, but traditionally cannot be used for recruitment. Here we describe and assess a 1-week "mini-CURE" for the perceived value of its components and ability to meet course learning objectives, provide similar research benefits, and serve as a URM recruitment tool. The mini-CURE was incorporated into an undergraduate genetics course at a minority-serving institution and was taught by a professor and graduate student from a distant research-intensive university. Through a course evaluation and pre/post surveys, we find the mini-CURE provides increased student perceived understanding of course learning objectives and biomedical research/careers. Additionally, students reported an increase in interest in applying to programs at the distant university. Thus, the mini-CURE is a low-cost mechanism of introducing students to an authentic research experience, while serving as a URM recruitment tool.

The scientific research community and people pursuing STEM (science, technology, engineering, and mathematics) education and careers do not reflect American diversity (National Science Foundation, 2017). One barrier is a lack of understanding about what scientific research, and careers in it, entail (Grandy, 1998; Kinkead, 2003; Thiry & Laursen, 2009; Tsui, 2007; Ward et al., 2003). One method for overcoming this is research experiences for undergraduates (Lopatto, 2004, 2007; Russell, Hancock, & McCullough, 2007). Research experiences can occur as an individual student performing research in a faculty member's laboratory, termed *undergraduate research experience* (*URE*), or in the context of a course, termed *course-based undergraduate research experience* (*CURE*). Such experiences are particularly beneficial for students from underrepresented backgrounds, increasing retention in STEM courses and majors, positive graduation outcomes, and likelihood of pursuing graduate studies (Barlow & Villarejo, 2004; Jones et al., 2010; Palmer et al., 2011). These findings, along with the desire of universities to increase the diversity of students pursuing advanced STEM degrees, have resulted in UREs being utilized as a recruitment tool for underrepresented minorities (URMs; Dahlberg, Barnes, Rorrer, Powell, & Cairco, 2008; Narayanan, 1999; Poock, 2007; Shadding et al., 2016).

Summer UREs are widely used as a graduate school recruitment tool (Beck, Buckner, & Nikolova, 2007; Conrad, May, & Auerbach, 2013; Dahlberg et al., 2008; Morley, Havick, & May, 2013; Narayanan, 1999; Poock, 2007; Rathore and Pariyothorn, 2015; Shadding et al., 2016). These experiences not only increase student understanding of research, but also provide insight into the institution and its programs (Hurtado et al., 2009; Thiry & Laursen, 2009; McDevitt et al., 2016; Shadding et al., 2016). Studies show that participants in summer UREs are likely to apply to programs at that institution (Beck et al., 2007; Conrad et al., 2013; Dahlberg et al., 2008; Morley et al., 2013; Rathore & Pariyothorn, 2015).

Although UREs are effective at increasing interest in STEM

education and careers and serve as a recruitment tool, UREs reach a small number of students (Eagan et al., 2013; Linn, Palmer, Baranger, Gerard, & Stone, 2015). Spots are limited by the number of research faculty and funding (Eagan, Sharkness, Hurtado, Mosqueda, & Chang, 2011). Additionally, the success of UREs is often measured by publications and student outcomes (Brown, Lewis, & Bevan, 2016; Desai et al., 2008; Wood, 2003). Thus, URE placement is competitive, and high-achieving senior students are more likely to obtain a position (Russell et al., 2007). Finally, students need to know they are interested in research to apply for a URE. Many individuals, including URMs, do not have a background that fosters interest in science or the knowledge that UREs are available (Bangera & Brownell, 2014). The cost, limited availability, and self-identifying nature of UREs make it clear that alternative methods of providing research experiences are needed, both in general and for recruitment programs (Corwin, Graham, & Dolan, 2015; Harrison et al., 2011).

One alternative to UREs is the semester-long CURE (Brown et al., 2016; Brownell et al., 2015; Corwin et al., 2015; Harrison et al., 2011; Wood, 2003). A CURE can reach more diverse students, including those early in their undergraduate career, and with different academic performance and professed levels of science interest, because students simply have to enroll in the class (Bangera & Brownell, 2014; Linn et al., 2015). Additionally, CUREs increase student understanding of STEM concepts (Brown et al., 2016; Brownell et al., 2015). However, traditional CUREs cannot be utilized as a recruitment tool.

Here we describe and assess a weeklong CURE—termed *mini-CURE*—for the perceived value of its components and ability to meet course learning objectives (CLOs), provide similar research benefits as UREs and longer CUREs, and serve as a URM recruitment tool. The mini-CURE was incorporated into an existing undergraduate introductory Genetics course with a required laboratory component at a historically black college or university (HBCU), whose undergraduate population is ~85% African American; it was taught by a professor and graduate student from a distant research-intensive university (subsequently referred to as *visiting*) that has a student population of ~10% URM and wants to increase its diversity. The objectives were to determine if (a) the mini-CURE was perceived as an effective means of meeting CLOs; (b) the mini-CURE can increase students' perception of their understanding of biomedical research and careers (mini-CURE objective, MCO); and (c) having a visiting professor and graduate student leading a mini-CURE can increase reported student interest in programs at the distant institution (MCO). The mini-CURE was assessed by pre- and postsurveys and an evaluation of the curriculum components to determine their perceived value for meeting the objectives. We find the mini-CURE provides students with an increased perceived understanding of CLOs and biomedical research/careers (MCO). The curriculum component perceived as most effective for achieving these objectives was the laboratory experience. Additionally, students reported an increase in interest in applying to programs at the distant university (MCO).

Methods

Design constraints

One week of a semester-long course was allotted for the mini-CURE, including two 80-minute lecture periods and one 3-hour laboratory session (2–4 separate laboratory sections). The time frame was chosen to limit the travel time of the visiting professor and graduate student, and to easily fit into the course curriculum. The visiting university covered the majority of the costs, as it was being utilized as a URM recruitment tool.

Curriculum description

The mini-CURE curriculum included lecture, authentic research experience, small-group session, and optional visiting graduate student seminar directly related to the research area (Figure 1). It was led by a visiting professor and graduate student from a research-intensive university and was embedded into an undergraduate introductory genetics course with a required laboratory component at an HBCU. The course prerequisites are two semesters of general biology. The class consists of ~40–80 students, mostly sophomores, and is taken by both biology (~70%–80%) and nonbiology majors (~20%–30%). The course consists of 33 hours of lecture, 42 hours of laboratory (≤ 25 students per lab section), and 4 hours of small-group/active learning sessions. The mini-CURE was conducted once in each of three consecutive years (2014–2016; with 39 (2014), 76 (2015), and 69 (2016) students enrolled), but Years 2 and 3 were structured slightly differently from Year 1 to accommodate expanded class sizes (Figure 1). The specific objectives, both CLOs and

MCOs, and the points of assessment are provided in Supplemental Table 1 (available at available at https://www.nsta.org/college/connections.aspx).

Day 1 was a lecture period (Figure 1). The mini-CURE project was described, consent forms provided/collected, and the presurvey taken. The lecture covered how cancer is a genetic disease and what pharmacogenetics is (CLOs), then extended into how biomedical research generally studies cancer (MCO). It ended with a specific example of how the professor's research using *Drosophila* follicle, or egg chamber, development and pharmaco-genetic studies provide insight into the mechanisms driving cancer. The related research question and experimental approach used in the laboratory session were also discussed.

FIGURE 1

Outline of mini-CURE experience. Table outlining the mini-CURE curriculum by day, and the differences in Year 1 compared with Years 2 and 3. Grad = Graduate.

	Year 1	Years 2 and 3	Time
Day 1	**LECTURE** • Informed consent • Pre-course knowledge survey • Pharmacogenetics lecture • Info on university programs	**LECTURE** • Informed consent • Pre-course knowledge survey • Pharmacogenetics lecture	80 min.
Day 2	**Lab Group A** <25 Students Instructor: Faculty **Lab Group B** <25 Students Instructor: Grad student	**Lab Group A** <25 Students Instructors: Faculty and Grad student **Lab Group B** <25 Students Instructors: Faculty and Grad student	3 hours each lab
Day 3	**SMALL GROUP SESSION** • Data collection and analysis in lab • Written assignment • Post-course knowledge survey	**SMALL GROUP SESSION** • Interactive lecture • Data analysis • Written assignment • Info on university Programs • Post-course knowledge survey and mini-CURE Evaluation (Lab Groups A and B) **GRAD STUDENT SEMINAR** • Optional attendance	80 min. 60 min.
Day 4	**N/A**	**Lab Group C** <25 Students Instructors: Faculty and Grad student **Lab Group D** <25 Students Instructors: Faculty and Grad student Post-course knowledge survey and mini-CURE evaluation (Lab Groups C and D)	3 hours each lab

The curriculum, laboratory experience, and instructors were essentially the same in all 3 years; however, minor changes occurred in Years 2 and 3 to accommodate expanded class sizes (Figure 1). In Year 1, the two laboratory sessions

occurred simultaneously on Day 2; one session was led by the visiting graduate student and the other by the visiting professor. In Years 2 and 3, there were four nonoverlapping laboratory sessions on Day 2 and Day 4. Thus, both the visiting professor and graduate student were available to guide the students with their experiment.

Day 3 was used slightly differently in Year 1 versus Years 2–3 (Figure 1). In Year 1, the students went to lab and collected and analyzed their experimental results. They had time to work on the written assignment and ask questions. Based on the difficulty students had with data analysis in Year 1 and due to the altered laboratory schedule, we introduced active learning activities during the Day 3 lecture in Years 2 and 3. These interactive activities were designed to assist students in understanding how to interpret pharmaco-genetic interaction studies and analyze example data. The students also had time to work in small groups on the written assignment and get assistance from the visiting graduate student and professor. Also, on Day 3, the visiting graduate student presented a research seminar that was open to the whole university community. Students enrolled in the class were not required to attend but could earn extra credit by writing a one-page summary of the seminar.

The postsurvey and evaluation of components occurred either at the end of Day 3 (all students in Year 1, and Day 3 lab sections in Years 2–3) or Day 4 (Day 4 lab sections in Years 2–3); the evaluation of components only occurred in Years 2–3 (Figure 1). Student survey and evaluation data were handled according to the University of Iowa IRB# 201503794 and Howard University IRB-15-CAS-26; both institutions ruled the project exempt.

Finally, approximately 5 minutes were used to promote the distant university and the programs available for summer research and graduate/professional degrees (Figure 1). In Year 1, this occurred at the end of Day 1's lecture. In Years 2 and 3, it was presented at the end of Day 3's small-group session; however, in Year 3, unforeseen circumstances led to this presentation being cut

TABLE 1

Evaluation of curriculum components.

_____was effective as a means of teaching pharmaco-genetics.		
Curriculum component	**Mean ± *SD*; *p* values**	**% Agreement**
Lecture	3.89 ± 0.84	68.1%
Online materials	3.67 ± 1.06	59.3%
Laboratory	4.22 ± 0.94* † ‡	81.4%
Small-group session/Writing assignment	3.84 ± 1.07	67.3%
_____provided useful information regarding a career in biological research.		
Curriculum component	**Mean ± *SD*, *p* values**	**% Agreement**
Lecture	3.71 ± 0.90	55.8%
Laboratory	4.07 ± 0.9* ‡ §	73.5%
Small-group session/Writing assignment	3.61 ± 0.97	59.3%
Research seminar by visiting graduate student	3.80 ± 0.98	60.2%
Interactions with visiting faculty/grad student	3.90 ± 0.96‡	67.6%

Note: Students evaluated the above statements for each curriculum component on a Likert agreement scale (1 = *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*). Mean ± standard deviation (*SD*) are reported along with % agreement (selected *agree* or *strongly agree*). Adjusted *p* value was determined by one-way analysis of variance with Tukey's multiple comparison's test. *$p < .005$ vs. lecture, †$p < .005$ vs. online materials, ‡$p < .005$ vs. small-group session/writing assignment, §$p < .05$ vs. research seminar by visiting graduate student. CLO (course learning objective) indicated by yellow background and MCO (mini-CURE objective) indicated by blue background. $n = 108–113$.

short, and many students did not have the opportunity to hear about these programs.

Survey and evaluation development

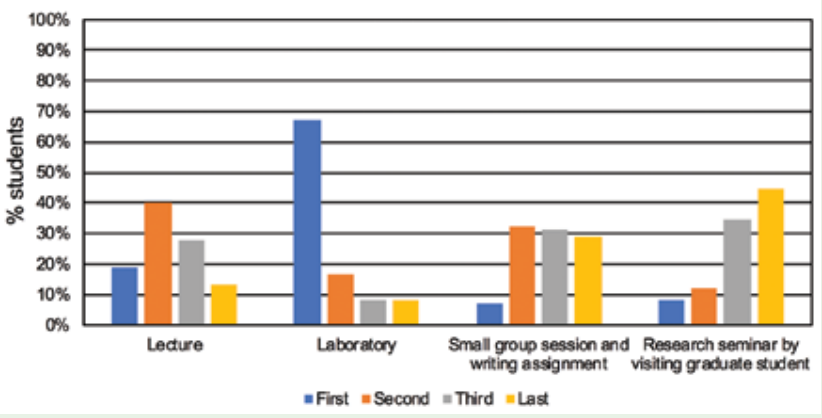
Surveys and evaluations were developed and used to assess two main aspects: (a) value of the individual curriculum components as perceived by students and (b) impact of the program on CLOs, perceptions about biomedical research careers (MCO), and programs at the distant university (MCO). To assess the perceived value of the curriculum components (lecture, online material, laboratory, small-group session/written assignment, research seminar by graduate student, informal interactions with the visiting faculty member and graduate student), the instructional team developed a short evaluation. The evaluation was developed collaboratively by two of the team members and reviewed by a noninstructional team member for content validity. The evaluation asked students to rank the usefulness of each component of the curriculum for obtaining one CLO and providing career insight (MCO). The same development process was used to construct the precourse and postcourse survey, which utilized a Likert agreement scale, to assess perceived understanding of CLOs and MCOs and interest in the distant university (MCO). Although it was not yet possible to evaluate long-term impact of this program, pre/post survey comparisons did provide a mechanism to assess immediate impact (the full pre/post survey and course evaluation are available at https://www.nsta.org/college/connections.aspx).

Analysis parameters

Survey and evaluation data were compiled in Microsoft Excel and analyzed in either Excel or GraphPad Prism. Comparisons between evaluations of curriculum components and pre/post surveys were carried out using one-way analysis of variances (ANOVAs). To control for multiple comparisons, Tukey's multiple comparisons test was utilized for comparing curriculum components, and Sidak's multiple comparisons test was utilized to compare pre- and postsurveys. Statistical significance was set at adjusted $p < .05$. Data from Likert agreement scales were also clustered into a % agreement calculation (*agree* or *strongly agree*) to indicate actual level of perception change because ANOVA of ordinal scales may yield statistically significant results with little educational significance.

FIGURE 2

Overall ranking of curriculum components. Students were asked to rank four curriculum elements in order of their usefulness (First = *most useful,* Last = *least useful*). The percentage of students reporting each rank for each curriculum component is reported (*n* = 89–97).



Results

Evaluation of components

An important first step toward assessing impact of the mini-CURE was to evaluate the learners' perceived effectiveness of the program components for teaching pharmaco-genetics (CLO) and understanding research careers (MCO); the evaluation used a Likert agreement scale (1 = *strongly disagree*, 5 = *strongly agree*; Table 1). The concept of pharmaco-genetics is an advanced principle that is normally taught in upper level genetics courses. The students indicated that the laboratory experience "was effective as a means of teaching pharmaco-genetics" (81.4% agreement; $n = 113$) and "provided useful information regarding a career in biological research" (73.5% agreement; $n = 113$). Notably, these levels of perceived effectiveness are higher than that for the other components (Table 1). The lecture and the small-group session/written assignment were also useful to the students for teaching pharmaco-genetics (lecture: 68.1% agreement; small group: 67.3% agreement; $n = 113$) and providing research career information (lecture: 55.8% agreement; small

group: 59.3% agreement; n = 113). Additionally, students indicated that interactions with the visiting professor and graduate student (67.6% agreement; n = 111) and the graduate student research seminar (60.2% agreement; n = 108) were useful for providing career insight (Table 1). These trends were confirmed when students ranked four curriculum elements—lecture, laboratory experience, small-group session/written assignment, and research seminar by the visiting graduate student—in the order of their overall usefulness (first = *most useful*, fourth or last = *least useful*; Figure 2). Similar to the findings above, the majority of students (~67%, n = 97) indicated the laboratory experience was the most useful (Figure 2).

Learning outcomes

The pre/post survey was designed to assess whether the CLOs and MCOs were met (Supplemental Table 1; available at https://www.nsta.org/college/connections.aspx). Students evaluated the following statement for each topic on a Likert agreement scale: "I have a good understanding of . . . " (Table 2). In relation to the CLOs, student perception of their understanding of cancer significantly increased postcourse (Table 2). It is important to note that students' perception of their understanding of "what pharmaco-genetics means" increased from 2.73 ± 0.96 precourse (n = 142) to 4.24 ± 0.85 postcourse (p < .0001, n = 153), with a substantial shift in agreement from 18% to 82%. Relevant to the MCOs, student perception of their understanding of "how biomedical research is performed" strikingly increased from 2.87 ± 0.95 precourse (n = 143) to 4.03 ± 0.84 postcourse (p < .0001, n = 151), representing a shift in agreement from 24.48% to 76.16%. Additionally, student perception of understanding of "how genetic screens can provide insight into how cancer develops and progresses" significantly increased postcourse (Table 2).

Impacts

In the pre- and postsurveys, students were asked about their interest in applying to the distant university for summer undergraduate

TABLE 2

Assessing student understanding of the topics.

I have a good understanding of _____.				
Topic	**Precourse (n = 142–145)**	**Postcourse (n = 151–153)**	**Precourse % agreement**	**Postcourse % agreement**
How cancer is a genetic disease	3.66 ± 0.94	4.26 ± 0.74*	60.42%	86.93%
How cancer develops	3.64 ± 0.88	4.26 ± 0.72*	59.31%	90.20%
What regulates cancer progression	3.24 ± 0.89	4.16 ± 0.78*	35.17%	83.01%
What pharmaco-genetics means	2.73 ± 0.96	4.24 ± 0.85*	18.18%	82.35%
How biomedical research is performed	2.87 ± 0.95	4.03 ± 0.84*	24.48%	76.16%
How genetic screens can provide insight how cancer develops and progresses	3.23 ± 1.03	4.26 ± 0.81*	40.14%	86.27%

Note: Students evaluated the above statement for each topic on a Likert agreement scale (1= *strongly disagree*, 5= *strongly agree*). Mean ± *SD* are reported. Adjusted p value was determined by one-way analysis of variance with Sidak's multiple comparisons test. *p < .0001 vs. precourse. % Agreement indicates percentage of students who responded *agree* or *strongly agree*. CLOs (course learning objectives) indicated by yellow background and MCOs (mini-CURE objectives) indicated by blue background.

research, medical school, other professional schools, graduate programs in biomedical sciences, and other graduate programs using the Likert scale (MCO). Initial interest, as seen in the presurvey, was low, ranging from 2.38 to 2.94 with percent agreement for various programs ranging from 18% to 32%. However, after the mini-CURE, students indicated a significant increase in their interest in each of the distant university programs, ranging from 2.98 to 3.47 (Table 3, $p < .005$, $n = 138–150$), which represented a nearly 2-fold increase in the number of students who agreed that they were considering applying to distant university programs (% agreement ranged from 36% to 57%).

When each year was analyzed individually, we noticed something interesting (Figure 3). In Year 1, the postcourse increase in interest in the distant university was small; this is likely due to it being the first iteration of the mini-CURE and offering less interaction with the professor and graduate student because of the simultaneous lab sections (Figure 1). In Year 2, after the course design was improved with more opportunities for interaction (see Figure 1), the increase in student interest was striking. In Year 3, when course design was similar to Year 2 but the opportunity to inform the students about programs at the distant university was cut short (see details in Curriculum description section), the increase in interest in the university was less than in Year 2, but still greater than Year 1.

Discussion

One objective of the mini-CURE was to fulfill CLOs for the section, which focused on cancer (Supplemental Table 1, available at https://www.nsta.org/college/connections.aspx). Students reported a perceived increase in their understanding of cancer—as a genetic disease, its development, and how it progresses (Table 2). This finding suggests the mini-CURE curriculum is suitable for meeting CLOs and could be adapted to many different CLOs.

Additionally, the mini-CURE curriculum covered an advanced genetics topic—pharmaco-genetics—that is normally taught in upper level genetics courses. Thus, we assessed if the curriculum increases students' perceived understanding of pharmaco-genetics (CLO). Although students initially reported little understanding of "what pharmaco-genetics means," the postsurvey revealed a striking increase in perceived understanding (Table 2). In the evaluation, students reported the

TABLE 3

Assessing student interest in distant university programs.

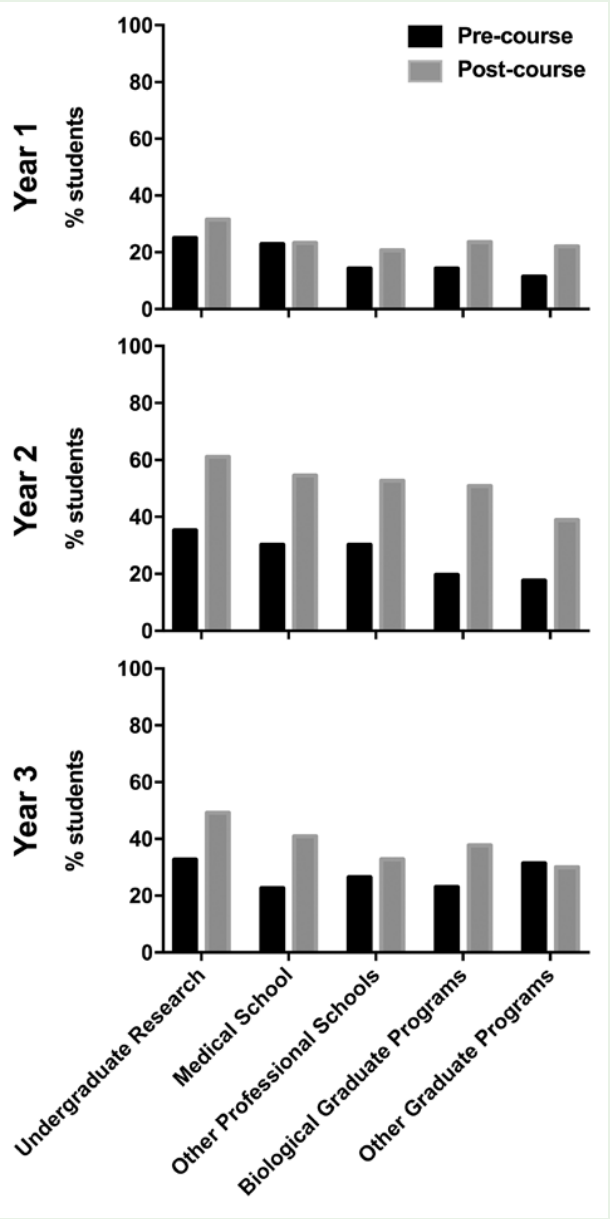
I am/will consider applying to the distant university for _____				
Program	**Precourse (*n* = 138–141)**	**Postcourse (*n* = 148–150)**	**Precourse % Agreement**	**Postcourse % Agreement**
Summer Undergraduate Research	2.94 ± 1.29	3.47 ± 1.33*	32.14%	56.67%
Medical School	2.81 ± 1.27	3.26 ± 1.42*	29.29%	47.33%
Other Professional Schools	2.53 ± 1.33	3.13 ± 1.37*	23.40%	42.00%
Graduate Programs in Biomedical Sciences	2.50 ± 1.24	3.15 ± 1.30*	20.86%	44.67%
Other Graduate Programs	2.38 ± 1.24	2.98 ± 1.35*	18.12%	36.49%

Note: Students evaluated the above statement for each program type on a Likert agreement scale (1 = *strongly disagree*, 5 = *strongly agree*). Mean ± *SD* are reported, adjusted *p* value was determined by one-way analysis of variance with Sidak's multiple comparisons test. *$p < .005$ vs. precourse. % Agreement indicates percentage of students who responded *agree* or *strongly agree*. MCO (mini-CURE objective) indicated by blue background.

laboratory was the most effective curriculum component for teaching pharmaco-genetics (Table 1). This finding is significant as studies on semester-length CUREs report increased student understanding of the scientific subject (Brown et al., 2016; Brownell et al., 2015). Our findings suggest that incorporating an authentic research experiment to illustrate a difficult course concept may assist with student learning.

As both UREs and CUREs increase student perception of their understanding of biomedical research and careers (Lopatto, 2004, 2007; Russell et al., 2007), we assessed whether the mini-CURE can have a similar impact (MCO). Given that prior research on UREs indicates that longer experiences have more of an effect (Linn et al., 2015), it was unclear how effective a short experience would be. Two assessments in the pre- and postsurvey addressed this question (Table 2; Supplemental Table 1, available at https://www.nsta.org/college/connections.aspx). The first asked the students to report the level of their perceived understanding of "how biomedical research is performed." The pre-survey revealed that this topic had one of the lowest reported levels of understanding; only 24% indicated a good understanding. Conversely, the postsurvey revealed a striking increase in perceived understanding, as 76% reported agreement. The second assessment was directed at the experimental approach and asked the students to report their perceived understanding of "how genetic screens can provide insight into how cancer develops and progresses." In the presurvey, 40% agreed that they had a good understanding, and this increased to 86% in the postsurvey. The evaluation also addressed this topic and asked students to rate the perceived usefulness of the different curriculum components for providing "useful information regarding a career in biological research" (Table 1). As with meeting the CLOs, the laboratory component was perceived as the most useful, with 73.5% reporting agreement. These findings suggest the mini-CURE approach

FIGURE 3



Assessing student interest in applying to distant university programs by year. Graphs show the percentage of students with reported interest in applying to specific programs precourse (black bars) and postcourse (gray bars) broken down by year.

can alter student perception of biomedical research and careers similar to what has been shown for UREs and CUREs. However, long-term changes in perception and student outcomes were not assessed.

The final objective was to assess if the mini-CURE might be a cost-effective URM recruitment strategy (MCO). The annual cost of the mini-CURE is less than that for one summer URE spot but reaches 40–80 students. The length of the mini-CURE (1 week) was also determined to be very reasonable in cost and time for the faculty and graduate student traveling from the distant university. The survey data reveal a significant increase in reported student interest in considering applying to programs at the distant university (Table 3 and Figure 3). It is unclear whether this is a general increase in interest in research experiences and professional/graduate school or specific interest in the distant university. Supporting that it is specific to the distant university is our unintentional finding that in Year 3, when we spent less time describing the university programs, there was less of a reported increase in interest. This finding also indicates that spending 5 minutes talking about one's university and programs can have a big impact. Additionally, a comparison of the lower Year 1 change in interest in the distant university programs with that in Years 2 and 3 suggests that curriculum changes, including the addition of the active learning small-group session, and having both the visiting professor and graduate student in each laboratory section, helps improve student interest in applying to programs. The potential impact of increased interactions is particularly intriguing as studies indicate that the relationship between research mentors and mentees is important for both increasing STEM persistence, education, and careers (Carlone & Johnson, 2007; Eagan et al., 2013; Lopatto, 2007), and recruiting students (Narayanan, 1999; Poock, 2007). Further research is necessary to determine how and why the mini-CURE was effective in changing attitudes about the distant university. For example, this program may have impacted students' perceptions by providing information that they had not previously been exposed to, but it may also have increased self-efficacy for biological research or reduced perceived barriers to the field. Another important area for future study is the duration of impact on students' interests in the distant university.

In summary, this study describes the development and assessment of a mini-CURE. According to reported student perceptions, the weeklong research experience is effective at meeting CLOs, increasing understanding of biological research and careers (MCO), and increasing interest in programs at a distant university (MCO). This collaborative approach between two institutions represents a way for research institutions to invest in their student diversity by leveraging strengths in providing relevant research experiences and supporting connections with more diverse undergraduate programs.

It is our hope that the mini-CURE influences students to pursue other research experiences and STEM degrees and careers. Additionally, given the low-cost and relative ease of implementing a mini-CURE, we encourage others to develop similar programs as a mechanism to introduce a more diverse population of students to authentic research experiences and potentially help increase the diversity within STEM fields. To assist with this, the following section provides insight into designing and implementing a mini-CURE.

Implementing a mini-CURE

A mini-CURE can be implemented as either a collaboration between two institutions or by the instructing institution alone. The most difficult part of designing a mini-CURE is aligning the experimental question and approach with the CLOs and the level/ability of the students. Key points to consider include: (a) availability of reagents and equipment, (b) reasonable expectations for inexperienced undergraduates in the given lab time, and (c) the number of facilitators needed to successfully implement the experiment. If the mini-CURE is being led by a visiting professor, the curriculum needs to be developed with significant input from the host professor.

When implementing a mini-CURE, there are a number of issues to consider. First, it is important to have key reagents in excess. For example, undergraduates need ~5 times the number of flies compared with an experienced dissector. Another potential issue to consider is how to teach a difficult experimental step, that is, tissue dissection. We found that having prereading and a video, along with going over the steps and video in the lab, demonstrating the dissection for the entire lab, and then providing individual group demonstrations worked best. Additionally, flexibility is needed. We found that adjusting from one lab section to the next (i.e., to better describe the dissection) helped optimize the curriculum. Finally, it is important to have alternative data (i.e., a data set gener-

ated by the visiting graduate student) to interpret in case the students fail in the hands-on lab, as data analysis is an important part of the experience.

The mini-CURE could be expanded to a multiweek experience to provide students more time to learn the technique, thereby increasing the likelihood of experimental success and allowing for the addition of a scientific writing exercise and/or presentation, which are beneficial for developing a science identity (Carlone & Johnson, 2007; Eagan et al., 2013). However, with such an expansion it is unlikely that the visiting faculty and graduate student would be there for the whole experience.

In conclusion, we encourage others to design and incorporate mini-CUREs into their curriculum, as this type of program provides authentic scientific experiences that could inspire students to pursue a lifetime of scientific study. ■

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