ARTICLE

Laboratory-Based Undergraduate Research Experiences (LUREs): Evidence of Effectiveness from the Social Sciences

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Abstract

The impact of undergraduate research experiences (UREs) is supported by evidence from physical and life science fields, especially when student-apprentices work in traditional laboratories. Within social sciences specifically, some excellent student outcomes associated with UREs adhere to non–lab-based modalities like course-based research experiences (CUREs). Here, the authors evaluate the laboratory-based undergraduate research experiences (LUREs) as a potentially valuable approach for incorporating social science undergraduates in research. Using comparative analysis of survey data from students completing three types of social science-based UREs (n = 235), individual research experiences (IREs), CUREs, or LUREs, students perceived gains overall regardless of the type of experience, with some indication that LUREs are the most effective.

Keywords: *course-based undergraduate research experience (CURE), experiential learning, laboratories, social science*

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Undergraduate research experiences (UREs) are well-proven as high-impact teaching practices with excellent student outcomes (Kuh 2008). Following the recommendation of the 1999 Bower Commission to increase access to UREs (Healey and Jenkins 2018; Katkin 2003), investments in providing UREs have significantly increased in the science, technology, engineering, and mathematics (STEM) disciplines (Crowe and Brakke 2019; Linn et al. 2015). Specifically, research shows that STEM students participating in UREs are able to critically think and practice as researchers in their discipline (McCune and Hounsell 2005) and are more prone to pursue science-related careers (Kuh 2008; Russell, Hancock, and McCullough 2007).

There are many types of URE experiences, including student-led, community-focused, individual research apprenticeship/internship models, course-based experiences, summer intensive programs, and lab experiences (Gentile, Brenner, and Stephens 2017). But, although UREs in physical and life science fields can be heterogenous, they often default to standard laboratory settings (Gentile et al. 2017, 33–42). Research labs are so engrained in the bench sciences that it is often not thought of as a place for research activities in other disciplines. For instance, there are numerous publications on how to set up and manage a STEM lab to suit undergraduate training (Barker 2010; Cohen and Cohen 2005; EMBO Solutions 2020; Goldstein and Avasthi 2021; NIGMS 2021; Petry 2017; Somerville et al. 2019) as well as how to mentor undergraduates in laboratory settings (Benson 2002; Gray 2000; Lukeman 2013; Packard et al. 2014; Prunuske et al. 2013; Whiteside et al. 2007).

Efforts to provide and expand social science faculty-led UREs have been, by contrast, far fewer and slower to develop. There are, relatedly, but a handful of published research articles that assess their impacts on students (Crowe and Boe 2019; Cuthbert, Arunachalam, and Licina 2012; Ishiyama 2002; Ruth, Brewis, and SturtzSreetharan 2021; Ruth et al. 2022; Wessels et al. 2020). Further, there is almost no information on the impacts of social science lab-based UREs (LUREs) on student outcomes, perhaps stemming from the perception that these opportunities are rare. This is despite social science labs being recently promoted as centers of undergraduate training (Becker 2020; Dengah et al. 2016; Ruth, Wutich, and Brewis 2019; Weinschenk 2020).

In this article, the authors identify social science LUREs as one potentially impactful model for providing UREs. Then, a comparative study design is used to quantitatively measure the perceived student outcomes for participation in three types of social science UREs: individual research experiences (IREs), course-based research experiences (CUREs), and LUREs. Lab-based formats are perceived as the most effective for student outcomes.

URE Types

Individual Research Experiences

The traditional model of undergraduate research is the one-on-one mentor-to-student apprenticeship model (Gentile et al. 2017; Sadler et al. 2010). Students engage in a real-world project over a length of time under the guidance of a research mentor (Gentile et al. 2017). In general, undergraduate students who participate in research better understand the research process and increase their ability to work independently, surmount obstacles, and think logically and analytically (Ishiyama 2002; Lopatto 2004). These students also have better retention rates, increased self-confidence, and honed career goals (Russell et al. 2007). The downside is that IREs are usually competitive, reserved for advanced students, and limited by the number of students that researchers can mentor (Katkin 2003; Linn et al. 2015; Seymour et al. 2004).

Course-Based Undergraduate Research Experiences

More recently, course-based undergraduate research experiences have become an increasingly popular way to provide access to research. Students conducting research studies (such as replication projects as part of a psychology major's capstone or methods courses) are one example of projects incorporated into classes (Cucculo et al. 2021; Grahe et al. 2018; Wagge et al. 2019). CUREs, however, focus on a team-based research project that take the entire semester to complete and are different from preformulated lab-based classes in which students learn step-by-step procedures and have anticipated outcomes (Brownell et al. 2012). In CUREs, students enroll in a credit-bearing class, participate in a novel research project for which the answer is unknown, and have a chance for discovery in real time (Corwin Auchincloss et al. 2014). CUREs are defined by five characteristics: (1) they use scientific processes; (2) students help create knowledge through research discovery and analysis; (3) learners can present their findings and potentially coauthor manuscripts; (4) students collaborate by working as teams; and (5) students can build on the research in the future or propose future studies (Corwin Auchincloss et al. 2014). Because they are open-enrollment classes, CUREs can serve a larger and more diverse student body, including those who may have responsibilities that preclude them from extracurricular UREs (Bangera and Brownell 2014).

CUREs, like traditional IREs, have been mostly offered in the physical and life sciences and present similar student outcomes (Brownell et al. 2015; Corwin Auchincloss et al. 2014; Linn et al. 2015). Students gain the ability to think scientifically and improve their confidence in scientific reasoning and capabilities; their ability to collaborate; their technical, analytical and interpretive skills; and their intention to pursue postbaccalaureate studies (Corwin Auchincloss et al. 2014; Brownell et al. 2015; Linn et al. 2015). In one study of social science CUREs, students improved similarly in the understanding of the research process, research ethics, collaborative skills, overall self-confidence, perseverance, and increased intentions of pursuing graduate education (Ruth et al. 2021). In physical and life science–focused CUREs, the laboratory is central to the class setting (Bangera and Brownell 2014; Ballen et al. 2017), whereas in social sciences CUREs research training happens in the classroom, the data collection occurs in the real world, and the data management and analysis return to the classroom.

Laboratory-Based Undergraduate Research Experiences

In the physical and life science fields, the traditional lab-apprenticeship model has been the norm but rarely distinguishes the lab as a variable for studying undergraduate research experiences (Crowe and Brakke 2019; Gentile et al. 2017; Katkin 2003; Lopatto 2010; Shellito et al. 2001; Thiry and Laursen 2011). In the social sciences, researchers have recently promoted the use of laboratories for undergraduate research training (Becker 2020; Dengah et al. 2016; Ruth, Wutich, and Brewis 2019; Stein et al. 2016; Weinschenk 2020), but have provided little evidence to support student learning outcomes. Some social science data collection occurs in laboratory settings (e.g., Doubleday and Viseu 2019; Webster and Sell 2014), but often social scientists collect data in field settings and then process the data in their offices or labs. Many social scientists have been trained as solo researchers (Stein et al. 2016), but laboratories are designed to be collaborative enterprises where training occurs through hands-on research with real-world data (e.g., see Barker 2010).

The authors have combined decades of student-lab training and here define what makes LUREs different than an IRE or a CURE. LUREs should: (1) have dedicated space, equipment, and software needed to support ongoing research projects; (2) include multiple members of the lab with varying experience, from novice to expert, who collaboratively work together, learn from each other, and provide mentorship; (3) use real-world research projects to provide training and foster increasing skill development, so that members can take on more responsibilities and challenging work; (4) have policies and procedures to collect, manage, analyze, publish, and archive data; and (5) include opportunities for professional development of members through presenting, publishing, and/or leading their own collaborative projects. These five characteristics of LUREs foster a community of practice through which lab members can gain a sense of identity as researchers (Rand 2016). Last, LUREs are more accessible than IREs due to more available positions, but not as accessible as CUREs because students must go through a screening process to join the lab.

Given that IREs, CUREs, and LUREs are distinct research experiences, what follows is a comparison of students' perceived outcomes from their participation in one of the three types of UREs. The aim was to determine which modality provided higher perceived outcomes.

Study Setting

The large interdisciplinary School of Human Evolution and Social Change at Arizona State University has 61 faculty, 53 of whom are tenured or tenure eligible and teach courses for five undergraduate degree programs, with over 900 undergraduate majors. The school created the Undergraduate Research Apprenticeship Program (URAP) in 2011 to help faculty easily identify students interested in engaging in faculty-led research. Through this program, research mentors centrally post either IRE or LURE positions; students apply to the positions with a common application. Since its inception, over 1,100 students have participated. About half of the students participated in IREs, and the other half participated in LUREs. Additionally, the school offers CUREs each semester. These offerings provide an ideal setting to compare students' perceived benefits from participation in IREs, CUREs, and LUREs.

Undergraduate Research Experiences

Since 2011, the school has offered 203 IRE opportunities with 60 different faculty mentors as part of the URAP. Research mentors advertise a specific position and select one to three students to work with a supervisor one-on-one and fulfill specific tasks, much like a job application. Although the research experience varies based on the individual project and mentor, students usually receive training on the project as a whole, complete research tasks, meet with the mentor regularly, and receive individual feedback on their completed tasks.

Since 2009, 293 students have participated in one of 11 social science CUREs. On average, 26 students participate in a course, and each course focuses on a distinct research question led by a faculty principal investigator. These courses are designed to introduce students to research ethics, development of research questions (through reviews of the literature), data collection, data input and management, and preliminary analyses.

The school has 17 laboratories; some are larger, with more than 20 undergraduate and graduate student members, and some smaller with three to five total faculty and student members. Since 2011, 127 LURE opportunities have been offered as part of URAP (LURE opportunities select multiple undergraduate students). Labs sometimes include postdoctoral scholars and grant-funded research assistants. Three different social science labs of varying sizes at the school are described here to help provide context to their functioning and projects.

Research Labs

The Culture, Health, and Environment Lab (established 2006) is a collaborative research group for faculty, postdoctoral students, graduate students, and undergraduates. Research is led by four faculty members specializing in ethnographic, biocultural, linguistic, and educational methods and includes an average of 20 to 25 members each semester. Faculty, postdoctoral scholars, and PhD students provide cross-training on projects, in which lab interns gain skills in qualitative and quantitative data collection, management, and analysis. A hierarchical management structure ensures that students learn by teaching and supervising peers as they gain proficiency in increasingly advanced research skills.

The Mesoamerican Archaeology Lab (established 2006) includes faculty, postdoctoral scholars, and graduate and undergraduate students, with an average of 15 members each semester. The lab houses two kinds of projects. It is the local base for archaeological fieldwork projects in Mexico. Students work on data entry and analysis, scanning and data archiving, and creation of graphics for reports. This lab also is the setting for projects on comparative urbanism. Students gather data from publications and online sources, generate data files and reports, and work on data analysis tasks. In addition to the research activity, lab personnel host informal professionalization sessions.

The Osteology Laboratory (established 2007) includes faculty, postdoctoral scholars, and graduate and undergraduate students working collaboratively on projects focusing on archaeological skeletal remains and human dentition. The lab serves an average of four to five students per semester; they learn osteological data recording techniques, conservation methods, and methods related to 2D and 3D data capture. Many students conduct a semester-long joint project aligned with their career goals that is presented at the school's annual undergraduate research symposium. This experience provides them with training in research design and implementation.

TABLE 1. Survey Sample

Sample population	Responses (*n*)	Response rate to email elicitations (%)	Time frame captured (years since participation)
Individual research experiences (IREs)	71	13.8	Median = 1.5, range = 9
Course-based UREs	88	28.4	Median = 4, range = 10
Lab-based UREs	76	12.9	Median = 2, range = 8

Methods

The survey consisted of 20 items regarding perceived gains stemming from undergraduate student participation in an IRE, LURE, or CURE. Questions from the Survey of Undergraduate Research Experiences (SURE) from Lopatto (2004; 2007) were utilized, following the guidance of Shortlidge and Brownell (2016) about how to assess undergraduate research experiences. "Understanding science" was revised to "understanding social science," "learning laboratory techniques" was not used (as specific to wet labs), and one statement relevant to the school's undergraduate research experiences was added, "learning to work collaboratively." Responses utilized a scale of 1 to 5, with 1 being no or very small gain, 2 being a small gain, 3 being moderate gain, 4 being large gain, and 5 being a very large gain. Of the 20 "perceived improvement" items, 19 overlapped with the original SURE study ("potential to be a teacher of science" was replaced with "learning to work collaboratively"). Analysis of differences in mean reported scores was performed using one-way ANOVA with a Tukey post hoc test (to interpret any significance among the three test groups). All analysis was done in SPSS, version 26, with alpha set at .05.

The survey was deployed in two different waves during the spring of 2020. The first wave was specifically for students who participated in CUREs, and the second wave was for students who participated in an IRE and/or LURE via the undergraduate research apprenticeship program between 2009 and 2020. The CURE survey request was sent by email to 292 students who had participated in one of 11 courses. Students were emailed three times to improve response rates. There were 88 students who filled out the survey. In the second wave of data collection, a survey request was emailed to all 1,100 students who participated in the research apprenticeship program. It was confirmed that 550 of those students received and opened the survey request; it was assumed that the other 550 did not receive it or chose not to open the email. Again, students were contacted three times to encourage participation. Of those 550 students who viewed the invite, 147 filled out the survey. As part of the survey, respondents were asked if their research experience included participating in a lab. Of the 147 respondents, 71 participated in LUREs. The other 76 students participated in IREs. Each of the three groups represented approximately one-third of the 235 total respondents in the analytical sample (Table 1). Response rates for this study aligned with expectations for web surveys with email samples (Daikeler, Bošnjak, and Manfreda 2020; Nayak and Narayan 2019). It could not be confirmed whether students participated in both a CURE and a LURE or IRE, but each survey introduction explained clearly that students should answer based on their experience in one specific type of URE.

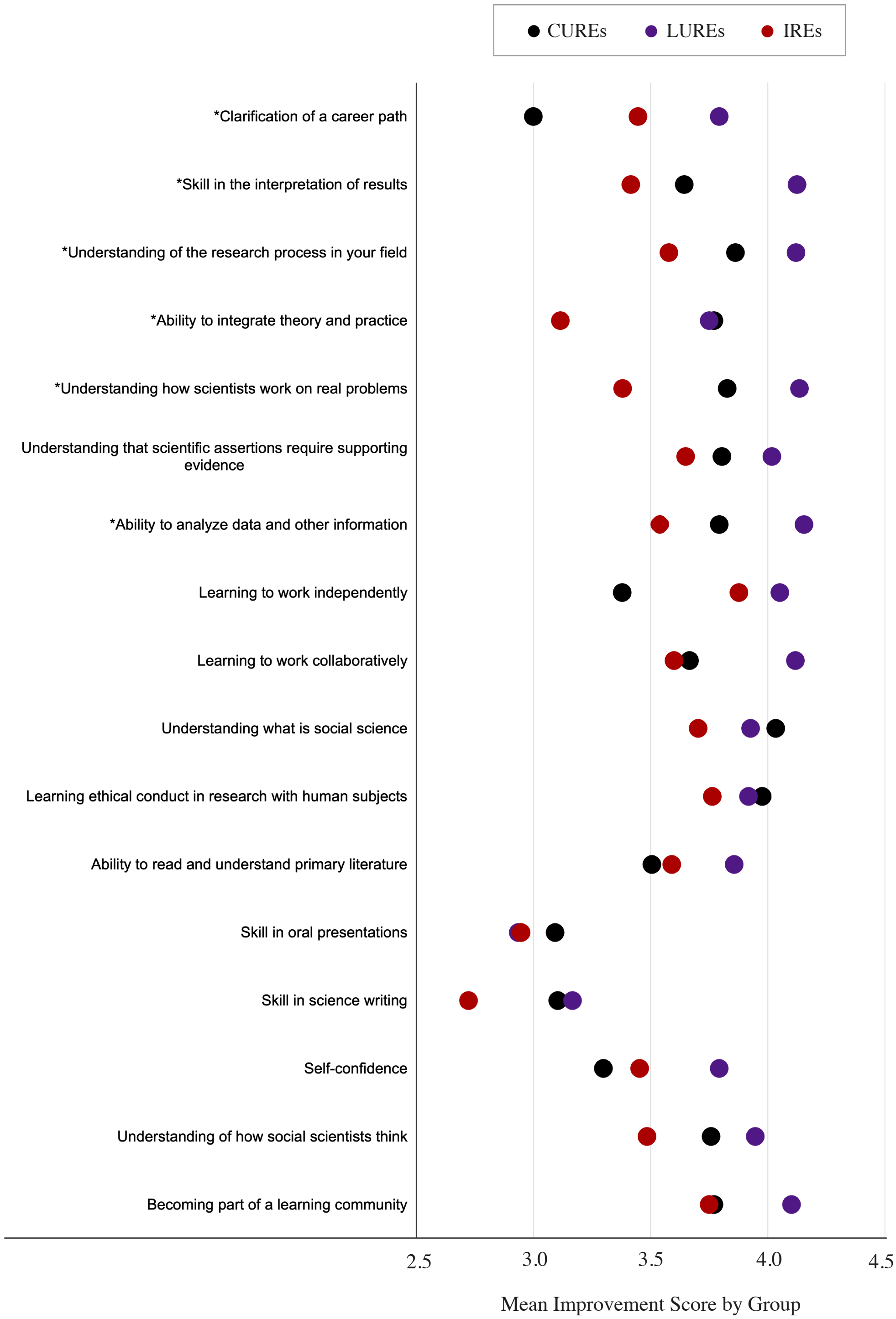
Analysis and Results

Overall, on average students reported gains in all items and for all modalities. That is, all mean scores were 2.9 or above; 2 represented "small gain," 3 represented "moderate gain," and 4 represented "large gain" (Figure 1).

For the 20 questions asked, LUREs returned the highest mean improvement for 15 questions, CUREs returned the highest mean improvement for 5 questions, and IREs had no items for which the perceived improvement was highest (Table 2). One-way ANOVA was used to assess whether these differences were significant (Table 2; indicated by an asterisk in Figure 1). ANOVA results indicated that there was a statistically significant difference in mean perceived improvement between at least two groups for eight of the items: clarification of a career path; skill in the interpretation of results; understanding of the research process; ability to integrate theory and practice; understanding of how scientists work on real problems; ability to analyze data and other information; learning to work independently; and learning to work collaboratively. The number of significant differences ($n = 8$) exceeded that expected by chance alone (for 20 tests, 1 is expected to be significant by chance at the .05 level). The other items all showed average perceived improvements, but there was no significant difference among the research course modalities ($p < .05$).

Tukey post hoc tests (with Kramer modification to adjust for unequal sample sizes) identified eight items in which the pairwise differences in reported mean improvement scores were significant (Table 3). Here is a summary:

FIGURE 1. Mean Scores for Research Experiences



Note: Items marked with an asterisk have significant differences in reported scores between groups.

- Clarification of a career path: LURE and IRE outperformed CURE
- Skill in the interpretation of results: LURE outperformed CURE, which outperformed IRE
- Understanding the research process: LURE outperformed IRE, but neither was significantly different from CURE
- Ability to integrate theory and practice: LURE and CURE outperformed IRE
- Understanding how scientists work on real-world

TABLE 2. Improvement Scores for Tested Items by Study Group

	Survey Item	CURE mean (±SD)	LURE mean (±SD)	IRE mean (±SD)	F	Significance (*p*)	Total standard error
1	Clarification of a career path	3.00 (1.1)	3.79 (1.2)	3.45 (1.1)	8.501	.000	0.082
2	Skill in the interpretation of results	3.64 (1.1)	4.13 (1.1)	3.42 (1.3)	5.734	.004	0.082
3	Tolerance for obstacles faced in the research process	3.79 (1.0)	3.74 (1.1)	3.56 (1.1)	0.911	NS	0.075
4	Readiness for more demanding research	3.70 (1.1)	3.86(1.2)	3.59 (1.1)	0.888	NS	0.077
5	Understanding how knowledge is constructed	3.99 (1.0)	4.02(.97)	3.63(1.0)	2.841	NS	0.073
6	Understanding of the research process in your field	3.86 (1.1)	4.12 (.95)	3.58 (1.3)	3.429	.034	0.080
7	Ability to integrate theory and practice	3.77 (1.09)	3.75 (1.08)	3.11(1.29)	6.725	.001	0.083
8	Understanding of how scientists work on real problems	3.83 (1.1)	4.14 (0.95)	3.38 (1.2)	7.462	.001	0.077
9	Understanding that scientific assertions require supporting evidence	3.80 (1.1)	4.02 (1.1)	3.65 (1.3)	1.388	NS	0.083
10	Ability to analyze data and other information	3.79 (1.1)	4.16 (1.1)	3.54 (1.3)	4.272	.015	0.082
11	Understanding what is social science	4.03 (1.0)	3.93 (1.1)	3.70 (1.1)	1.703	NS	0.076
12	Learning ethical conduct in research with human subjects	3.98 (2.0)	3.92 (1.4)	3.76 (1.4)	0.501	NS	0.089
13	Ability to read and understand primary literature	3.51(1.1)	3.86 (1.2)	3.59 (1.2)	1.535	NS	0.083
14	Skill in oral presentations	3.09 (1.3)	2.93 (1.5)	2.95 (1.5)	0.261	NS	0.103
15	Skill in science writing	3.10 (1.2)	3.17 (1.5)	2.72 (1.4)	1.705	NS	0.100
16	Self-confidence	3.30 (1.1)	3.79 (1.2)	3.45 (1.3)	3.012	NS	0.083
17	Understanding of how social scientists think	3.76 (1.2)	3.95 (1.1)	3.48 (1.2)	2.507	NS	0.080
18	Learning to work independently	3.38 (1.2)	4.05 (1.0)	3.88 (1.3)	6.532	.002	0.083
19	Learning to work collaboratively	3.67 (1.2)	4.12 (0.98)	3.60 (1.3)	3.800	.024	0.079
20	Becoming part of a learning community	3.77 (1.1)	4.10 (1.1)	3.75 (1.3)	2.167	NS	0.079

Note: Table shows one-way ANOVA results showing mean perceived improvement score for all tested items by study group, where 1 = little or no gain and 5 = very large gain, with F statistics and *p* values to establish a significant difference between at least two of the group. NS = not significant, with alpha set at .05.

problems: CURE and LURE outperformed IRE

- Ability to analyze data: LURE outperformed IRE, but neither was significantly different from CURE
- Learning to work independently: LURE and IRE outperformed CURE
- Learning to work collaboratively: LURE outperformed IRE, but neither was significantly different from CURE

Taken together, these results show that different research modalities have different perceived benefits relative to each other. And, in particular, LUREs offer clear advantages over both CUREs and IREs when measured in terms of the raw number of higher mean scores as well as the statistically significant mean differences. For the most part, CUREs were the second-best-performing modality and IREs were the least-well-performing modality.

Discussion

The data in Table 3 on all three types of UREs—CUREs, LUREs, IREs—support that students perceive receiving valuable outcomes, yet, for the eight significant multiple comparisons, LUREs showed significant improvement over at least one, and in many cases both CUREs and IREs.

The greater gains in clarification of career paths in LURE students may be due to the mentorship and sustained

TABLE 3. Significant Differences between Test Groups

			Mean difference	Standard error of the mean	Significance (*p*)
Clarification of a career path	CURE CURE LURE	LURE IRE IRE	– 0.79 – 0.446 0.346	0.196 0.189 0.208	.000 .050 NS
Skill in the interpretation of results	CURE CURE LURE	LURE IRE IRE	– 0.481 0.228 0.709	0.200 0.191 0.213	.045 NS .003
Understanding of the research process in your field	CURE CURE LURE	LURE IRE IRE	– 0.259 0.283 – 0.542	0.194 0.188 0.207	NS NS .026
Ability to integrate theory and practice	CURE CURE LURE	LURE IRE IRE	0.020 0.655 0.635	0.198 0.192 0.213	NS .002 .009
Understanding of how scientists work on real problems	CURE CURE LURE	LURE IRE IRE	– 0.308 0.447 0.755	0.183 0.180 0.197	NS .037 .001
Ability to analyze data and other information	CURE CURE LURE	LURE IRE IRE	– 0.362 0.254 0.616	0.198 0.192 0.211	NS NS .011
Learning to work independently	CURE CURE LURE	LURE IRE IRE	– 0.674 – 0.497 0.174	0.199 0.193 0.212	.003 .028 NS
Learning to work collaboratively	CURE CURE LURE	LURE IRE IRE	– 0.452 0.067 0.519	0.193 0.187 0.206	NS NS .034

Note: Clarification of significant differences between test group means (Table 2), using Tukey's test with Kramer modification to make pairwise comparisons. NS = Not significant, with alpha set at .05.

interactions with graduate students, postdoctoral students, and faculty. Moreover, lab environments as communities of practice can provide a sense of belonging (Ruth et al. 2022) that contributes to persistence in science-related fields, especially for underrepresented groups (Fisher et al. 2019; Walton and Cohen 2007). Many factors may explain LURE students' higher scores on the five research task improvement items: skill in the interpretation of results, understanding the research process, ability to integrate theory and practice, understanding how scientists work on real problems, and ability to analyze data. LURE students were exposed to a wider range of research processes because they often continued in a lab for more than one semester and had exposure to multiple projects and tasks. For instance, students who continued on in labs also had opportunities to be coauthors (see for example, DeMyers, Warpinski, and Wutich 2017; Palta et al. 2016; Ruth, Brewis, Blasco, and Wutich 2019; Ruth and Landers 2021; Smith et al. 2014, 2015, 2019; Trainer et al. 2016; Vins et al. 2014; Wutich, Beresford, and Carvajal 2016). As experiential practices, LUREs provide hands-on, real-world exposure to research that can make abstract processes more understandable (Kolb and Kolb 2009). The last improvement item, learning to work collaboratively, highlights the team-focused nature of the lab environment. This finding bodes well for social scientists training students to continue on in collaborative teams, something that is important in current research funding and needed to solve complicated research problems (Bozeman and Youtie 2017; Lassiter 2008; Stein et al. 2016).

In Table 3, CUREs show more improvement over IREs in three items: skill in the interpretation of results, ability to integrate theory and practice, and understanding how scientists work on real problems. IREs show more improvement over CUREs in two items: clarification of career path and learning to work independently. For IRE students, this is not surprising, given these were usually one-on-one experiences in which students received directed mentorship and worked independently on data already collected. For the CUREs, however, students worked as a research team to learn about the entire research process from the research design, including situating the research question in the literature and collecting and analyzing data.

Study Limitations

Study limitations derived from the sampling strategy, in which overall only 27.9 percent of potential participants provided responses (see Table 1). This may be reflected in the results if, for example, students who had more positive experiences were more likely to respond. The response rates, however, were relatively consistent across the different data sets, meaning the comparison itself may be less affected by this. The relatively small sample size also indicates a need to interpret results with adequate caution. To capture a relevant sample, given the nature of the activity being studied, students had to be recruited from different time periods (time since participation). This may bias results, as it may be that perceptions of particular values change with time since graduation. Also, each student's experience may differ greatly regardless of the type of URE, given that research projects and tasks vary from semester to semester and research mentor to research mentor. It is important to note that this study measured students' perceived learning and not actual learning. Nevertheless, social science UREs promise to be impactful student experiences (Kuh 2008) that mirror similar outcomes in physical and life science UREs (Ishiyama 2002; Lopatto 2004; Russell et al. 2007).

Future Directions

These findings are promising for social science researchers who wish to integrate undergraduates into their research training programs. IREs, CUREs, and LUREs all provide valuable outcomes for students. But social science LUREs surpass the other types of UREs, foster improvements in research skills, and can better prepare students to pursue graduate studies. This is especially important for underrepresented students and students outside of the physical and life science fields where a majority of research experiences reside (Katkin 2003). Further research is needed to study the actual learning outcomes with pretests and posttests for all types of social science UREs. For LUREs specifically, research is needed to gain an understanding of the best structures for learning and meeting research goals, the best practices for social science mentorship, and how to create spaces of belonging for all students. Identifying ways to scale LUREs within the social sciences, such as creating online opportunities, will also be beneficial (Ruth et al. 2022). Last, longitudinal studies assessing actual enrollment in social science graduate degrees would be valuable.

Data Availability Statement

Deidentified data supporting the conclusions of this article can be made available by request to the first author.

IRB Statement

This research was approved under Arizona State University IRB STUDY00012034 and STUDY00003652.

Conflict of Interest Statement

No conflict of interests to declare.

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