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SPECIALTY SECTION

This article was submitted to
Higher Education,
a section of the journal
Frontiers in Education

RECEIVED 06 January 2022

ACCEPTED 06 July 2022

PUBLISHED 22 July 2022

CITATION

Ruth A, Brewis A, SturtzSreetharan C,
Wutich A and Stojanowski CM (2022)
Effectiveness of online social science
undergraduate research experiences:
Exploratory evidence.
Front. Educ. 7:849908.
doi: 10.3389/educ.2022.849908

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Effectiveness of online social science undergraduate research experiences: Exploratory evidence

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Undergraduate research experience (UREs) benefit students, but are typically conducted in person. In 2020–2021, many research and teaching activities unexpectedly moved into virtual spaces. We identify key benefits and challenges experienced by virtual URE participants in the social sciences, based on systematic coding of aligned surveys with both faculty and students. Perceived benefits included access and flexibility. Both mentors and students who had switched from in-person modalities, however, expressed a perceived loss of community, undermining the perceived effectiveness and value of the URE. They also perceived the lack of “hands-on work” as a negative. In contrast, existing online students identified UREs as creating a much needed and valued connection, enhancing their experiences. We suggest the experience of all participants in virtual UREs can benefit from centralizing community-building strategies, and give some possible examples.

KEYWORDS

undergraduate research, online, virtual, remote (distant) education, experiential learning

Introduction

Undergraduate research experiences (UREs) have consistently been identified as an especially effective pedagogical tool, with demonstrated success in accelerating student skills development, confidence in research, and enhancing the likelihood of postgraduate study (Russell et al., 2007). Accordingly, there are many calls to expand opportunities to participate in UREs to more students – and, importantly, more diverse students (Healey and Jenkins, 2018). Virtual UREs provide one potential means to meet the calls for scaling opportunities for undergraduate research, and especially provide greater opportunities for more diverse students. Here, we analyze qualitative data from research mentors and students to assess the benefits and challenges of delivering and participating in fully online UREs.

Benefits and challenges of undergraduate research experiences

Extensive evidence demonstrates the benefits of UREs for undergraduate students. UREs are one of ten high impact practices (Kuh, 2008) proven to have positive outcomes for students such as building skills (Ishiyama, 2002; Landrum and Nelsen, 2002; Lopatto, 2004; Kilgo et al., 2015) and shaping career paths (Nnadozie et al., 2000; Russell et al., 2007; Crowe and Brakke, 2008). URE students hone their ability to work collaboratively and independently, collect and analyze data, and tolerate obstacles (Lopatto, 2004). They also address new challenges, surmount obstacles, develop communication techniques, learn to work independently, and improve their critical thinking and analytical abilities (Ishiyama, 2002; Landrum and Nelsen, 2002; Lopatto, 2004; Kuh, 2008; Kilgo et al., 2015). While UREs are powerful tools to help students develop skills they also guide students into career paths.

Undergraduate research experience students are retained at a higher rate and they have more refined career goals (Russell et al., 2007). They develop an understanding of what it is to think and practice in their academic discipline (McCune and Hounsell, 2005) and are more likely to pursue science-related careers (Russell et al., 2007; Kuh, 2008). Their undergraduate experiences with research can improve their rates of acceptance to graduate programs (Nnadozie et al., 2000) and URE students enroll in graduate programs at increased rates (Crowe and Brakke, 2008). However, non-traditional students (e.g., first-generation, older students) often have competing responsibilities and have difficulties finding and committing to such extracurricular activities (Pascarella et al., 2004).

Identified student challenges to accessing UREs include their focus in traditional lab-based disciplines using an apprenticeship model of training (Healey and Jenkins, 2018). As such, UREs are offered inequitably to relatively few students: more often science, technology, engineering and mathematics (STEM) continuing generation, and male students (Steele et al., 2002; Katkin, 2003; Rand, 2016). UREs are also a resource intensive way to train undergraduates in research (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017). Taken together, these challenges may explain why UREs might be difficult to offer to a wider range of students. One way faculty have been trying to increase access is through course-based undergraduate research experiences (CUREs). In CUREs, students enroll in for-credit courses and the instructor leads them through a real-world research project (Corwin et al., 2014; Brownell et al., 2015). Not only can CUREs serve a larger number of students, but they have shown similar student gains as traditional UREs (Corwin et al., 2014; Brownell et al., 2015; Linn et al., 2015; Ruth et al., 2021). CUREs are therefore one way to increase access.

Moving toward virtual undergraduate research experiences

Moving UREs into virtual spaces are another way to provide valuable opportunities to a more diverse student body. Online programs historically have offered non-traditional students access to higher education, but increasingly include younger and more traditional college students (Sánchez-Gelabert et al., 2020). Before the pandemic in 2019, U.S. enrollment in online degrees was steadily increasing with 36.3% of students taking online courses in 2019. This jumped to 72.8% in 2020 (National Center for Education Statistics [NCES], 2020a) but with the return to in-person courses this is expected to return to a pre-pandemic level and trajectory. With over a third of higher education students now participating regularly in online courses, there is a pressing need to develop and test effective means to deliver virtual undergraduate research opportunities.

The COVID-19 pandemic exacerbated the need to translate in-person research opportunities into a virtual environment across disciplines including STEM, history, health, business, humanities, and social science courses (Coleman et al., 2022). Moving UREs online requires more face-to-face interaction than most typical online classes, active and continual mentorship and feedback from instructors, and opportunities to actively practice research skills (Lincoln, 2022). A recent study of transfer students participating in a 2-week virtual bootcamp research experience, before the semester started, showed an increase in confidence to undertake science-related activities as well as created a sense of belonging (Majka et al., 2021). Other research points to similar student learning outcomes of virtual and in-person CUREs (Doctor et al., 2021). Yet, research on virtual UREs is still nascent and here we present exploratory evidence to help elucidate the benefits and challenges for offering these opportunities.

Materials and methods

Study setting

We work in a school with a large social science faculty ($n = 61$) that include anthropologists, epidemiologists, political scientists, and sociologists. Arizona State University (ASU) is located in the Southwest United States and is a public, state-funded institution with ~77,000 immersion (in-person) students across four physical campuses and ~57,000 online students. For the last several years, we have been developing and testing new URE models beyond STEM such as scalable lab-based social science programming (e.g., Ruth et al., 2019) and course-based research experiences (CUREs) (Ruth et al., 2021) to a more diverse student body. Our

school has sponsored an undergraduate research experience since 2011, serving over 1,100 students to date. Within our social science school, faculty and graduate student research mentors offer an average of 20 UREs to an average of 90 student research apprentices per semester. Students who participate in UREs are supervised by a mentor (faculty or advanced graduate student) and assist with their mentor's real-world research project for one or more semesters. We also have an increasing number of undergraduate online students (as of fall 2021 $n = 584$ students declared as one of our online majors) and have been slowly offering virtual URE programming.

When COVID-19 arrived in March 2020, our in-person faculty (like many others) switched to fully online provision of UREs for our on-campus majors; we continued this through the pandemic in two subsequent semesters. And, for the first time, we opened the same synchronous URE experiences to students enrolled in our parallel online degree programs, creating an opportunity to identify and compare how virtual UREs might serve students enrolled in online and in-person programs. This also allowed us to explore the perceptions and experiences of online UREs, such as whether this varied between mentors and students. Here, we describe the findings of a preliminary study (via open-ended survey questions) to assess their experiences. We used qualitative analysis (theme analysis and systematic coding) of the responses to understand the relative benefits/advantages and costs/disadvantages identified by students and mentors for virtual UREs in social science.

Data collection and analysis

In May 2021, survey invitations were sent via email to all URE mentors (faculty and graduate students) and URE undergraduate students who had participated in a URE. Respondents were asked a variety of structured and semi-structured questions about UREs. The data for this research brief come from a subset of open-ended text responses about respondents' experiences with virtual UREs. Of 550 URE students who opened our invitation, 122 completed the survey (22% response rate); 50 students (31 female, 8 male, 11 no response) completed the section on virtual UREs. Of 127 URE mentors, 58 responded (45% response rate); 32 completed the online question sets. All responses were collected anonymously with age, gender, ethnicity collected for students while only collecting mentor status (e.g., faculty or graduate student) from our colleagues. These decisions were made to help assure as honest and open responses as possible and to protect identities. The team collecting and analyzing the data are mid-career and senior female and male scholars, who each have long records of working closely with students and colleagues to develop UREs that are accessible to historically excluded students; however,

the lack of early-career and minoritized scholars on the team may have shaped the analytic perspective of the researchers in unknown ways.

The open-answer questions about the benefits and challenges of virtual UREs were first subjected to theme analysis (Bernard et al., 2016). We used both deductive categories (access and connectivity) (Ragusa and Crampton, 2018; Ruth et al., 2021) and inductive theme identification, following Ryan and Bernard (2003). Our deductive categories of access and connectivity grew to include flexibility. Inductive categories that emerged included lack of community and lack of hands-on experiences. Once we identified our themes, we created a codebook with definitions (under the guidance of MacQueen et al., 1998) and then systematically coded the data. We report here on theme meanings, typical exemplars (i.e., common quotes that typify the theme), and context in which the theme emerged or can be understood (Ryan, 1999). Additionally, we coded the texts for the presence or absence of each theme, which enables us to calculate the percentage of respondents reporting each theme. Mentor and student responses were compared for differences in thematic meanings and frequencies.

Results

This analysis yielded two key themes about benefits (access and flexibility) and two key themes about challenges (communication/connectivity and lacking hands-on experience). In the sections that follow, we provide brief summaries of our findings that include typical exemplars, contexts, and frequencies (i.e., the percentage of respondents reporting this theme) for the four key themes. This enables us to answer our key questions about the extent to which online UREs produce good outcomes, and for whom.

Benefits of virtual undergraduate research experiences

Theme 1. Access

Students and mentors reported numerous benefits. One key benefit mentioned by both mentors (65%) and students (14%) was access. URE mentors appreciated that the online option afforded an increase in students from different backgrounds participating in the research experiences. Online students, particularly, reported similar appreciation for access to the UREs.

The biggest pro for me was that I would have never been able to be a part of such an amazing opportunity if I could not do it remotely. I live in another state, so these kinds of options to participate remotely make me feel more a part of ASU. – Online Student.

A virtual research apprenticeship is an incredible opportunity for people like myself who had to do school fully online, as I had to work full-time in order to support myself in college. – Online Student.

Virtual research apprenticeships (VRA) allow for students who wouldn't otherwise have an "in-person" opportunity to understand research processes and work with other students [...] Many students that I came in contact with said that having the opportunity to be a part of a VRA was the highlight of their ASU experiences and gave them a positive sense of belonging or a means to connect with students, professors, and graduate students. – Mentor.

As these responses indicate, being able to participate in a research apprenticeship virtually increased the sense of access to research projects in general and thus greater access to other students, mentors, and faculty. These respondent answers demonstrate how access led to the added benefit of feeling connected to the university community for online students. The quotes from fully online students highlights how virtual UREs can be unlike their traditional online classes and offers a way for non-typical URE students to connect to other students and faculty and ultimately feel part of the university. This is most likely a result directly tied to the fact that they physically could not come to campus. Given that the profile of an average online student is non-traditional (Sánchez-Gelabert et al., 2020), providing opportunities for research experience is highly appreciated. However, access to virtual UREs need not be confined to online students as the quote from the research mentor states. Students who had not been able to participate in-person expressed having a sense of belonging and connection with others.

Theme 2. Flexibility

Students (68%) and mentors (44%) valued the flexibility in completing tasks that the online modality offers. Moreover, removing the requirement to be in a classroom meant decreased stress in general and better task/time management. For online degree students, virtual apprenticeships allowed participation regardless of their locations in the world and their time zones. Echoing students, URE mentors mentioned that virtual UREs eliminated the premium on physical space that is endemic to many institutions. Scheduling virtual meetings was also reported to be easier.

Even if I were an on-campus student, I would prefer a virtual research apprenticeship for the freedom of work environment and access to meeting hours. The moment that I would log out of our Zoom Conference, I would be fresh on the tasks just discussed and could immediately get to work. – Online Student.

As someone who commutes to ASU, the virtual apprenticeships were extremely beneficial to having less stress in attending meetings on time and saving gas money. While

enabling me to have more free time away from my commute to finish research and conduct interviews. – In-person Student.

A positive is that it allows more students to participate in research projects. Some of the students couldn't participate if they were not on campus during certain hours or lived out of state [...] The flexibility of virtual research apprenticeships provides a more equitable entrance to research than in-person assistantships alone. – Mentor.

These quotes illustrate how crucial it is for students to be able to use their time effectively which means greater flexibility is needed in order to accommodate other mundane aspects of life (commute times, residence, etc.). The virtual UREs allow a wider range of students to participate as they can work on their tasks according to their availability. This was echoed by both online and in-person students, especially those that have to commute to campus. It also was noted that experiences saved time that was redirected toward the assigned tasks. While the flexibility of virtual UREs as well as access was widely mentioned as a benefit, it was also noted that they are not the same as face-to-face experiences. Despite noting the flexibility, students lamented not getting the same experience, as shown by this in-person student's comment: "I don't think virtual anything could compare to in-person training and experience." Nonetheless, students appreciated the ability to complete work on their own schedules, pointing to the fact that current students tend to have more responsibilities that are inflexible (e.g., work and family) (Gayle and Lowe, 2007) and value flexible opportunities to participate in similar activities that traditional students do.

Challenges of virtual undergraduate research experiences

Theme 3. Lack of community and connection

Both mentors (44%) and students (50%) mentioned the lack of connection to a larger community. Research mentors identified challenges including: decreased rapport, limited informal conversations, anxiety of Zoom participation, and inability to troubleshoot problems quickly. Students expressed concern with not getting to know their mentor well and not feeling connected with other students.

The con was feeling disconnected from other students and staff within the lab. The virtual meetings were a nice way to connect but I realize I missed out on a different experience if the lab was in person. – In-person Student.

The con of the virtual format was that it was hard to feel connected to the team while never meeting them face to face. – In-Person Student.

The biggest challenge was being unable to get to know students in person and have informal, casual interactions before/after lab

meetings. It was difficult to really develop a community of practice and help apprentices feel integrated and part of a lab group without being able to work in one location. – Mentor.

While online students thought UREs allowed for connection (highlighted above in benefits), in-person students felt that connection and community were missing, noting the following challenges: lack of in-person communication, inability to have quick chats with mentors, less collaboration, difficulty getting help if struggling, and lack of general conversations like they would have if they were in person. The responses from in-person students highlight a “feeling of disconnection” from not seeing others face-to-face. The mentor response echoes this feeling while underscoring the difficulty in getting to know students in casual, non-computer-mediated settings. Developing a feeling of community in a virtual space are currently underdeveloped skills by students and mentors. These findings are echoed in recent research done in the exercise sciences with online UREs (Hall et al., 2021). Interestingly, similar to access, we see that online students positively associate virtual UREs with connection that can be lacking in their regular online classes and that can lead to academic success (Ragusa and Crampton, 2018).

Theme 4. Lack of hands-on experience

Undergraduate research experience mentors (69%) noted the difficulty of training students remotely whereas a few students (8%) lamented that they did not receive the full experience of “hands-on” data collection. Although increased access to technologies such as screen sharing was recognized, the inability to engage in hands-on training was understood as a limiting factor.

[A negative] would be the lack of the physical environment which gives more of “real world experience.” – In-person Student.

I missed out on a lot of hands on experience that the in person students got. I would have loved to have been able to be in the collections and being able to help collect data. Seeing the collections and working with it hands on would have been an amazing experience. – Online Student.

Greatly limits the types of tasks that can be learned, the ability to communicate those tasks, and places an extra burden on students to reach out when they have questions or concerns during their tasks. – Mentor.

These quotes show that not every in-person research experience can easily translate to a virtual environment, widely noted by mentors but seldomly mentioned by both in-person and online students. As these responses suggest, simply the idea of “hands on” and the value placed on that experience is not considered the same when the instruction is mediated through computer screens. Mentors who work with physical materials found online modalities limiting, resorting to literature reviews. Mentors also mentioned the difficulties of creating materials that had to be succinct and clear, which took valuable time. It also was difficult to monitor progress and help students when

questions arose. Furthermore, there was the issue of data storage and security and having access to specific programs needed to complete certain tasks. Thus, a majority of mentors and a few students recognized that not working with materials directly as a downside to virtual UREs.

Discussion

This study provides a novel contribution to the literature by sampling research mentors, online students, and in-person students about benefits and challenges to conducting UREs in virtual environments. The reported benefits of online UREs include improved access and flexibility. Given that UREs have historically been offered to a small portion of more privileged students in STEM fields (Steele et al., 2002; Katkin, 2003; Rand, 2016), these results are encouraging. The fact that 43% of full-time students and 81% of part-time students work while taking classes (National Center for Education Statistics [NCES], 2020b) means that increased access to remote UREs and the added flexibility of completing hours on their own time is essential to increase the number of students’ exposure to research.

One of the major challenges, noted by both mentors and students, was the difficulties with feeling connected and having a sense of community while working online. Without a dedicated physical place to work, research meetings took place online and it was difficult to connect with each other. This sense of loss of in-person students and faculty was in the context of a pandemic; this may have potentially contributed. This is important to note because a sense of belonging is crucial for students’ academic achievement and – specifically for women and students of color – their persistence to continue into science-related careers (Walton and Cohen, 2007; Fisher et al., 2019). Feelings of belonging to a community are also important for students’ overall wellbeing as well as for developing and maintaining aspirations and retaining students (Strayhorn, 2018). However, online-only students perceived virtual UREs as valued and highly effective with special note of the community-building connections they provided. This may be because our surveyed mentors had devised many means to do this: drop-in hours, work-beside group sessions on Zoom where students could log on at specific times to work with each other, and virtual social events. Similar to another recent study (Samad et al., 2021), our study suggests that regular points of contact are essential to ensuring students feel connected when completing tasks fully virtually. Mentorship that can help build students’ sense of community virtually can include: planning, setting clear expectations, teaching the necessary methods (via video recording or synchronous meetings), having a balance of expectations along with emotional support, having group and one-on-one meetings, providing leadership and mentoring opportunities, and providing professional development and opportunities to present research (Hall et al., 2021; 2).

One of the biggest challenges identified by mentors was finding appropriate tasks for undergraduates that did not require the handling of physical materials. This challenge is difficult, but not insurmountable, to overcome when designing virtual UREs (Coleman et al., 2022). Some faculty relied upon digitizing research materials, had students focus on computer-based work, and focused on other aspects of the research process (literature reviews and writing up analyses). Others have suggested filming lab-based processes live to show students the analytical process (Samad et al., 2021), while others have focused on professional development of researchers, or used digital mapping tools and publicly available data (Sloan et al., 2020).

Our research provides useful observations with regard to scaling virtual UREs, especially considering the goal of extending URE benefits to a more diverse set of students (such as reflected in non-traditional and/or online degree-seeking students) with effective outcomes. Scaling UREs to virtual modalities should be especially valuable for supporting the educational experiences of online degree-seeking students. Online enrollment in degree programs continues to expand nationally, and these capture more student diversity (age, employment status, ethnicity, etc.) than traditional in-person programs. Developing and testing new ways to engage more of these students in collaborative research should reap substantial educational benefits.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Arizona State University's Institutional

Review Board. The participants provided their written informed consent to participate in this study.

Author contributions

AR and AB contributed to the conception and design of the study, and wrote the first draft of the manuscript. AR collected and coded the data. CSS, AW, and CMS wrote portions of the manuscript and contributed to the analysis and discussion. All authors contributed to manuscript revision, read, and have approved it for publication.

Acknowledgments

We would like to thank the faculty and graduate students who mentor research apprenticeships as well as the students who participate and help make these great experiences.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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