Undergraduate Students and Environmental Research

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Abstract: Research integrated into higher education curricula has been shown by numerous studies to be beneficial to undergraduate students. Citizen science provides an alternative to research performed in a lab and is gaining traction as a good choice for integration into classes. The Undergraduate Student Experiences in Citizen Science (USE Cit Sci) research collaboration network is working to help more instructors in higher education adopt citizen science as part of their curriculum by providing training and educational materials. To date, the Network has identified areas of critical need for citizen science to be more readily used in higher education courses and created a clear- inghouse of lessons for faculty to use freely. Forthcoming products of the USE Cit Sci network include direct partnerships between educators and citizen science projects in addition to a peer mentoring program. Given the preponderance of ecology citizen science projects available, bringing this educational opportunity to students opens new avenues of pedagogical experiences.

Key words: Environmental science; participatory science; pedagogy; undergraduate education.

INTRODUCTION

The 21st century saw the confluence of three important events that have come to shape education: (1) the rapid development of mobile technology and computing power, (2) the internet becoming our global hub of information, and (3) the rise of citizen science as a mainstream system for research. Citizen science is a form of participatory science in which the public can collect or analyze data for a scientific project. Citizen science projects are generally designed by scientists or academics and rely on volunteers to participate. This approach has made it possible for scientists to gain access to data from broad geographical areas while expanding the idea of who can participate in the scientific process. Although citizen science has been described as a way to "democratize science," studies examining who participates in citizen science have shown that considerable work remains before the diversity of participants matches that of society (Strasser et al. 2019, Blake et al. 2020, Pateman et al. 2021). The inclusion of the term "citizen" in the name has generated some controversy in the United States, and the term "participatory science" is being increasingly used as a larger umbrella term (Cooper et al. 2021). The increased acceptance of citizen science as a valid form of inquiry was partially dependent on the development of mobile technology and the Internet. It did not take long for projects such as Galaxy Zoo [2007] to utilize the internet to get the public's help in defining the shape of galaxies across the universe. This single citizen science project was the foundation for what was to become Zooniverse [2009]; zooni verse.org; (Simpson et al. 2014; Huffling et al. 2021), an organization whose mission is to help researchers create citizen science projects and host them on an online platform. Just 2years later, SciStarter [2011]; scistarter.org; Hoffman et al. (2017) launched with a similar goal; now together, these organizations provide the public with copious opportunities for doing scientific research anywhere in the world.

Not long after the launch of the citizen science web platforms, researchers and educators began a more concerted effort to bring citizen science into K-12 classrooms (Dunn et al. 2016, Dunn and Menninger 2016, McKenney et al. 2016, Schuttler et al. 2019). A grassroots effort involving numerous institutions of higher education in North Carolina (Vance-Chalcraft et al. 2021) quickly revealed that higher education faculty were also interested in adding citizen science to their curriculum as a means to bring real science into their classrooms, as they do with Course-based Undergraduate Research Experiences (CUREs). Early efforts to bring citizen science to undergraduate courses were seen as having great potential to improve student engagement and learning (Voss and Cooper 2010, Oberhauser and LeBuhn 2012, Surasinghe and Courter 2012, Guertin 2014), but little assessment data existed to determine evidence-based approaches to implementation. In 2018, the U.S. National

Academies issued a report discussing the potential for learning through citizen science and encouraged further research in this area (National Academies of Sciences, Engineering, and Medicine 2018).

To better understand how citizen science was used in undergraduate classes and the evidence supporting its use for learning, the Undergraduate Student Experiences with Citizen Science (USE Cit Sci) network was created with funding from the National Science Foundation.

Three goals form the mission of the network:

1. Facilitate the adoption of citizen science by higher education instructors.
2. Develop and test recommended practices for implementing and assessing of citizen science with students.
3. Assist citizen science project staff in attracting instructors to use their project.

One of the first products of the USE Cit Sci network was a "state of the field" survey describing published accounts of citizen science in higher education (Vance-Chalcraft et al. 2022). Vance-Chalcraft et al. (2022) uncovered only 15 published accounts of citizen science being used in higher education that met the study inclusion criteria. To capture information from instructors who were using citizen science but not publishing on its use, we distributed a survey through multiple listservs. The results showed that although citizen science was being used in diverse institution types, primarily in ecology- related courses, the availability of instructional and assessment resources to facilitate this approach were lacking. In addition, many research gaps remained in our understanding of the benefits of including undergraduate classes in citizen science.

To help fill this research gap, members of the Network are participating in four working groups that are each investigating a different aspect of citizen science in higher education: (1) citizen science and social justice in the classroom, (2) online citizen science, (3) theoretical frameworks of citizen science in the classroom, and (4) review of assessment tools for citizen science in the classroom. The citizen science and social justice in the classroom working group produced an article (Vance-Chalcraft et al. 2024) and a webinar describing how participatory science approaches can be used to teach about social justice and enhance collaborations to work toward enacting social change. The second working group reviewed 25 recent studies using citizen science in online undergraduate courses, producing a manuscript (Cotey et al. unpublished manuscript) and another webinar. The theoretical frameworks of citizen science in the classroom working group highlight relevant theories that inform potential impacts of participatory sciences when used in classes with students. Finally, the review of assessment tools for citizen science in the classroom is just beginning. However, it aims to develop a collection and classification of assessment tools that will be made publicly available in the next year.

Resources for instructors wanting to use citizen science in classes:

A number of recent resources have become available to help instructors who wish to use citizen science in a class. To get started, faculty or students can complete online training, such as the "Teaching in Higher Education with Citizen Science" module (https://scistarter.org/training). SciStarter and Zooniverse both have easily searchable databases of citizen science projects one can choose as well as a variety of educator resources (https://scistarter.org/educators, https://www.zooniverse.org/get-involved/education).

In addition, the USE Cit Sci network has a growing collection of ready-made lesson plans. Members of the Network are able to download lessons or to upload their own creations for other faculty on the Network website (use-cit-sci-network.org), hosted by the QUBESHub Platform. More lesson plans will be added soon because we are facilitating collaboration between seven citizen science projects and higher education instructors. These pairings will create at least one lesson plan per project, which will be available for download on the Network website. We also expect that the collaborations will offer the greater higher education community more citizen science projects that are amenable to and accessible to higher education instructors for use in their courses. The latter benefit is important because, at the moment, most citizen science projects are set up to accomplish research goals and be user-friendly to the participants. Using these projects in education often requires additional components to reach course learning outcomes, such as the availability of raw data or the online visualization of data. To facilitate the implementation of existing lesson plans or the

development of new ones, the USE Cit Sci Network hosts webinars and monthly online office hours. These webinars are produced in cooperation with the Association for Advancing Participatory Science. The monthly office hours are open to anyone wishing Undergraduate Education to talk about their successes, get advice for implementing citizen science in their classroom, discuss other topics such as collaboration and ways to get more involved or introduce themselves to others in the community. Links to recordings of the webinars and the calendar of office hours can be found on the Network website.

Our Network also is striving to build the capacity of faculty members by initiating a peer mentoring program in spring 2025. Higher education instructors who want to get more guidance in using citizen science in their classrooms will be paired with experienced faculty members to act as logistical and collegial support, collaborators, sounding boards, and more. Ultimately, this program may be a positive feedback loop for faculty adopting citizen science in the classrooms by having mentored faculty provide the same experience to others, in addition to propagating the direct benefits that peer mentoring has on the self-efficacy of mentors and mentees (e.g., Kalpazidou Schmidt and Faber 2016, Simmonds and Dicks 2018).

CONCLUSION

Providing students the opportunity to perform real research in the classroom is not a new concept (e.g., Buchanan and Fisher 2022), but citizen science-based research experiences share data with audiences outside the classroom, often contributing to projects with dozens or thousands of other people. Indeed, the reach of citizen science data can be staggering, providing students with a chance to contribute to, and analyze data from, a much wider geographical range than in a CURE. Another advantage of using citizen science projects in higher education is that the project is run by another research team, making the logistics of student data collection easier to manage. The variability in data access after students go through the process of data collection can be a downside to citizen science projects, but that is why the USE Cit Sci network is actively working to make integration with education much more interoperable (e.g., Bowser et al. 2020, de Sherbinin et al. 2021).

Preparing higher education students for STEM careers in the 21st century requires that they understand the process of science from data collection through analysis and interpretation. The USE Cit Sci Network is committed to opening citizen science as an option for higher education instructors to consider when designing curriculum. Ecology and environmental science are well represented in the citizen science arena, so we welcome you to explore this approach to bring more opportunities to students.

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