The Center for Innovative Research in CyberLearning

CIRCL Primer: Citizen Science

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Overview

Citizen science is the practice of public participation and collaboration in scientific research or scientific exploration to increase scientific knowledge. Citizen science differs from traditional science because data is collected by volunteer researchers — citizen scientists — with varying backgrounds as opposed to professional scientists with high levels of training. All variants of citizen science include members of the scientific research community working with members of the public to answer a research question.

Citizen science originated as a way for the general public to assist scientists in collecting data for their research, as well as a vehicle to communicate aspects of science to the general public (Bonney, Ballard, Jordan, & McCallie, 2009). As the field of citizen science has evolved, the methodologies for conducting citizen science have evolved as well.

Citizen science has been explored in different ways in the public domain for over a century (Bonney, Ballard, Jordan, & McCallie, 2009) but has garnered heightened interest due to the proliferation of mobile technologies that allow for rapid contribution of data points of interest by scientists and citizens alike (e.g. crowdsourcing). Bird surveys, which have occurred in Europe and America for over 100 years, provide an example of typical citizen science projects. These types of projects have created some of the longest continuous ecological data sets we have that help us understand global environmental change (Shirk, Ballard, Wilderman, Phillips, Wiggins, Jordan, Bonney, 2012).

In their seminal 2009 report, the Center for Advancement in Informal Science Education (CAISE) brought together the leading researchers and practitioners in citizen science and tasked them with describing the different forms of public participation in scientific research (PPSR), or citizen science. Out of this report, three commonly accepted types of citizen science emerged, which vary according to the level of citizen engagement (see Figure 1):

1. **Contributory** citizen science projects are designed by research scientists alone; the scientists then ask members of the public to contribute (only) data to the research projects. These types of projects have the lowest level of engagement with the public, and follow a top down approach. This form of citizen science is best employed when a research project needs a very large amount of data from a wider geographic range. “Crowdsourcing” is a contributory technique that utilizes the Internet and social media to collect responses from individuals across a wide geographic area within a typically short timeframe. The quintessential contributory citizen science project is the Audobon Christmas Bird Count, a century-old, annual bird survey in which amateur bird watchers can provide information on the number and species of birds seen at a specified geographic area determined by conservationists. This data contributes to the monitoring of the environment and informs

conservation efforts. Other examples of contributory projects include an online protein folding game (fold.it) and various astronomy-focused projects (for example, citizensky.org). In addition, the Zooniverse platform curates a collection of contributory citizen science projects from which interested citizens can choose based on their interests.

2. **Collaborative** projects aim to engage the public in ways that go beyond data collection to include other components of the scientific process, such as analysis of data, assistance in disseminating findings, or other methods for the public to use the data collected for their own purposes. Like contributory projects, the research questions, design, and data collection protocols originate solely with the scientific community, but collaborative projects also reach out to achieve different modes of engagement that the public would like to have with the overall research. Since 1995, the Global Learning and Observations to Benefit the Environment (GLOBE) Program has provided students, teachers, and citizens with age-appropriate atmospheric and earth science activities developed by scientists and validated by teachers. By participating in hands-on data collection about their local environment and putting their local information into a global perspective, students and the public can learn about the scientific process, and contribute to our understanding of changes in the Earth system and global environment. Likewise, the Billion Oyster Project is a type of collaborative citizen science project focused on the restoration of New York Harbor using partnerships across many local organizations.

3. **Co-created** projects originate and grow, from start to finish, as partnerships between scientists and members of the public. Sometimes referred to as “community science”, co-created projects are often very small in nature due to the focused intent to investigate a very specific concern or occurrence. Co-created projects usually begin with a question that the public has rather than originating within the scientific community and often leverage existing partnerships between researchers and community-led organizations and NGOs. WeatherBlur and Public Lab are examples of online, co-created citizen science projects in which citizens, teachers, and students, can propose to study a question or problem in their local community related to the weather or environment. Specifically, WeatherBlur allows citizens to connect with different communities to conduct investigations and share data across sites.

Level of Engagement

CONTRIBUTORY	COLLABORATIVE	CO-CREATED
“Crowdsourcing” Audobon Christmas Bird Count Fold.it CoCoRaHS (Community Collaborative Rain, Hail and Snow Network)	“Collaborations” GLOBE Billion Oyster Project EyeWire Stardust@home	“Community Science” WeatherBlur Public Lab WOEIP (West Oakland Environmental Indicators Project)

Figure 1. Types of Citizen Science Projects by level of citizen engagement.

Within the past decade, citizen science initiatives have become adept at leveraging the ubiquitous nature of Internet access and associated technologies to empower citizens with tools they can use to understand their environments better, share those understandings with a broad audience, and exponentially amplify connections across the globe (Dickinson, Bonney, Fitzpatrick, & Louv, 2012). These technological affordances — such as mobile technologies, aerial and satellite imagery, mapping technologies, deep space imaging, digital archiving, the many facets of the Internet, and many others — are quickly and steadily changing the landscape of citizen science. For example, due to the rapid development of smartphones, volunteers can readily provide geolocation information about counts of animal species or occurrences of other natural phenomenon in real time, facilitating communication with scientists and other citizens.

Today, citizen scientists are exploring/studying deep space images from telescopes to locate new galaxies, tracking changes in climate as they catalogue when and where leaves emerge each spring, and connecting with each other online to design and use new low cost technologies to monitor the environment to answer local community questions. These are just a few examples of the wide array of citizen science projects currently underway. The possibilities of what citizen science projects can do using the benefits of technology are opening up new doors for public engagement in science.

Citizen scientists originally participated in informal and lifelong learning settings, but citizen science projects now build bridges between formal and informal education settings. Such projects are beginning to shed light on how out-of-school learning strategies and methods could be adapted to achieve classroom-based learning outcomes.

By engaging people with local and distant environments, and giving them tools to visualize and make meaning from data they collect, citizen science participants are better able to understand and potentially act upon phenomena related to a whole host of subject areas. Volunteer researchers have the opportunity to direct their own learning of science, geography, genetics, and many more subjects by asking and answering their own questions, through projects that are scaffolded by collaborating scientists and scientific methods.

Issues

Sharing of Data Across Projects. There is a pressing need for continued technical support of existing citizen science projects' online collaboration and data collection tools when technology platforms change. As one reviews the lists of citizen science projects looking for volunteers online, it very quickly becomes clear that many citizen science projects have re-invented the wheel, replicating similar projects in different parts of the country and world, rather than sharing findings to advance the field as a whole. Likewise, due to the autonomous development of many citizen science projects, various online data collection platforms have been independently designed and customized such that sharing of data across similar projects has proven cumbersome. Thus, oftentimes, investigators must spend time and funding to re-develop their projects on newer online platforms when old platforms get outdated. Perhaps the creation of technology content standards for the citizen science community may facilitate sharing of findings across locations and projects, however, no such standards currently exist

Evaluating Community-Level Impacts. The citizen science field has developed a significant understanding of how to achieve and measure individual learning outcomes, such as knowledge, attitudes, motivation, science identity, and behaviors (for example, see Cornell's User's Guide for Evaluating Learning Outcomes from Citizen Science), however, the field continues to wrestle with how best to understand and measure both programmatic and community-level outcomes. For example, developing programmatic models that identify the most effective use of technology in citizen science — such as mobile phones, online communities, and social networks — is a high priority for the field. Additional research on how to define and achieve community-level outcomes of citizen science, such as increased social capital or environmental conservation outcomes, also has huge potential support to broader impacts. The Frontiers publication by Jordan, Ballard, and Phillips (2012) provides further clarification on understanding and evaluating theses important outcomes..

Scientific versus Community Understanding. A point of debate in the field relates to the differing audiences that use findings from citizen science. Scientists need high quality data to generate reliable research findings that will be accepted in the scientific community. If the data is to be used for scientific research, there are many barriers and obstacles to overcome in order for scientists to work with volunteer researchers, such as fidelity to data collection protocols and quality and precision of data. By their nature, contributory citizen science projects can help maintain these more stringent data collection procedures.

On the other hand, citizen scientists, volunteers and members of the public participating in these research projects, want to use citizen science as a tool to get more community members involved in scientific inquiry without placing an absolute premium on data quality and instead placing it on participation in the scientific process. To alleviate this tension, co-created versions of citizen science have arisen that bring together the virtual and physical worlds in new ways that are egalitarian, collaborative, applied, localized and globalized to solve real world issues that matter to local citizens. In these instances, the data collected may not meet the standards of rigorous scientific research, but they provide critical community-based information to local decision-makers across the globe. Both WeatherBlur and Public Lab offer examples of this type of citizen science project. In addition, this approach to citizen science engages the public in authentic science inquiry and interpretation. The involvement of local people in all aspects of scientific inquiry through citizen science can also lead to faster and more reliable data collection (Newman, Crall, Laituri, Graham, Stohlgren, Moore, Kodrich, & Holfelder, 2010). This, in turn, can inform environmental decision-making at a much faster rate than more traditional scientific approaches (Mueller & Tippins, 2012).

Big Data & Data Privacy Concerns. Many citizen science projects collect geolocation data from individuals that might unintentionally reveal other personally identifiable information (PII) of the contributor. Likewise, significant privacy issues may arise if volunteers download an app that does not alert them to the fact that data about them will be collected when they use the app. To maintain privacy, best practice dictates that individuals are informed ahead of time, typically by providing agreements to be reviewed and accepted before downloading. Additionally, pop-up screens on smartphones can now can prompt the user to permit the collection of current location information. Other practices to protect citizens from inadvertently sharing their personal information without their knowledge have been discussed (see Bowser et al, 2014), however, implementation of such privacy practices in citizen science projects remains varied.

Particularly when citizen science projects aim to collect data about people, it becomes of paramount importance for investigators (scientists and citizens alike) to maintain compliance with federal regulations to ensure an individual's privacy. For instance, if medical information is collected from citizens, the project would need to comply with the Health Insurance Portability and Accountability Act (HIPAA), which requires prior consent from the individual whose health data is being requested. Likewise, if data is collected from children under 13 years of age, the project would need to comply with the Children's Online Privacy Protection Act (COPPA). Additionally, for any organization conducting research that involves human subjects, obtaining prior approval from an institutional or independent ethics review board (e.g. IRB) is as necessary as ever to ensure the project adheres to ethical guidelines and obtains permission from individuals to collect and share information for the project's purposes. For specific guidelines, the Ethics of Mobile Data Collection discusses issues and practices to protect the privacy and integrity of projects when using mobile devices in research. Adhering to regulations helps ensure not only scientific rigor, but also helps maintain public trust in the scientific process.

Access. Technology access and equity issues that pervade society in general are also apparent when discussing citizen science initiatives. Wireless communication and associated technologies are expanding quickly, especially in developing nations, but they are still not everywhere. If an individual does not have access to the Internet via a computer or smartphone, they cannot contribute to citizen science projects. Poor communities exist all over the world where individuals lack access to hardware that has become ubiquitous in developed nations, such as smartphones, laptops, and desktop computers. However, local community centers or libraries have also begun to provide access to computers and other technology in situations where access may be an issue.

Projects

Examples of NSF Cyberlearning projects that overlap with topics discussed in this primer.

- DIP: Next Generation WeatherBlur: Expanding Non-Hierarchical Online Learning Community Models for Citizen Science
- DIP: Collaborative Research: STEM Literacy through Infographics
- DIP: ScienceKit for ScienceEverywhere - A Seamless Scientizing Ecosystem for Raising Scientifically-Minded Children
- DIP: Potential for everyday learning in a virtual community: A design-based investigation
- CAP: Towards Inclusive Design of Serious Games for Learning

Other relevant cyberlearning-themed projects:

Initially developed with funding from NSF, CitSci.org provides tools and resources to those implementing citizen science projects.

Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) is a volunteer network of backyard weather observers of all ages and backgrounds to measure and map precipitation (rain, hail and snow) in their local communities.

The Crowd & the Cloud: Citizen Science, Big Data, & the Democratization of Research is an NSF funded project that will showcase citizen science projects on public television starting in Spring 2017.

Curriculum + Community Enterprise for Restoration Science (a CIRCL Spotlight) is an example of an NSF Smart and Connected Community for Learning project that builds on the Billion Oyster Project, a citizen science project focused on the restoration of New York Harbor.

Eyewire is a citizen science game in which volunteers can help map the circuitry of the brain from the Seung computational neuroscience lab in Princeton.

Scistarter is an NSF-funded project that allows citizens and scientists to connect.

Stardust@home allows volunteers to help search images for interstellar dust particles from the NASA Stardust spacecraft.

West Oakland Environmental Indicators Project (WOEIP) is a resident-led, community-based organization that conducts projects related to air quality and other issues of interest to the community.

Resources

Related CIRCL Primer: Smart and Connected Community for Learning

Citizen Science Central

Clay Shirky: How cognitive surplus will change the world

The Crowd & The Cloud (video)

National Geographic Citizen Science

National Geographic Fieldscope

User's Guide for Evaluating Learning Outcomes from Citizen Science

Readings

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