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Chapter 10
The Role of Citizen Science in Environmental Education:
A Critical Exploration of the Environmental Citizen Science Experience

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ABSTRACT

Citizen Science is increasing in popularity and used by many academics, community groups and Non-Governmental Organizations in scientific data collection. Despite this, little is known about the motivations and experiences of those who contribute to citizen science projects, nor about the impacts of involvement in citizen science upon the individual. Moreover, few have considered the pedagogic process that individuals undergo as they participate in these activities. Citizen science practitioners and program developers stand to benefit from increased understanding of these experiences in terms of their capacity to enhance environmental education. Such increased understanding of the implications of citizen science may also promote the development of sustainability education. This chapter synthesizes insights from existing literature, policy documents and practical projects to explore the pedagogic potential of the convergence of citizen science and environmental education. The chapter concludes that progressive evaluation approaches are needed to complement what is an emergent field.

INTRODUCTION

This chapter will explore the role of citizen science within environmental education or education for sustainable development, as it is also know. On the one hand, it will examine the motivations of scientists for developing environmental citizen science programs. It will also address what they perceive the motivations of those who contribute to citizen science projects to be. On the other hand, it considers the motivations of individuals who become involved in environmental citizen science programs. This chapter will explore the place of citizen science initiatives within the lives of those who choose to participate

DOI: 10.4018/978-1-5225-0962-2.ch010

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within them. This is a rarely considered topic within the field of citizen science studies. However, this is perhaps unsurprising given the fact that studies of citizen science are a relatively recent research development. Within this chapter, it is argued that considering the motivations and experiences of the individuals who contribute to environmental citizen science projects is essential to understanding the role of citizen science within sustainable development, as Irwin (1995) originally set out to achieve.

THE APPEAL OF INVOLVING PUBLICS IN SCIENTIFIC RESEARCH

Citizen Science projects have grown rapidly since the mid-1990s. Involving publics in research, through citizen science, enables scientific institutions to expand their scientific endeavors. Twenty-first century technological advances are seen as tools to enable collaborative projects to be ever more ambitious. The current emphasis within science and society on 'big data', which involves collecting data across spaces and time spans previously unthinkable, means that there are ever more opportunities to contribute to global and significant research projects. Individuals can contribute, for example, to online projects like E-bird (http://ebird.org/content/ebird/) an online citizen science initiative. E-bird is an ornithology program, launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society. The project receives over five-million contributions per month (Bonney, Shirk, Phillips, Wiggins, Ballard, Miller-Rushing and Parrish, 2014). Online, citizen science projects, such as E-bird, can be engaged with regardless of geographical location. They are, therefore, able to include a limitless number of participants as contributors, due to the technological advances of the latter half of the Twentieth and Twenty-First Century. Such projects become part of the expansion of scientific endeavor, which is portrayed as a benefit to all human beings, due to the capacity to 'do' science, at ever-larger scales. Therefore, technological innovations are often considered a driver of citizen science within the present day.

Nevertheless, the appeal to scientists of involving publics in scientific research predates the emergence of the internet. Indeed, environmental citizen science has evolved within disciplines that have traditionally depended upon contributors to help facilitate research processes. These include, for example, ornithology, paleontology and atmospheric science (Bonney et al., 2014). Currently, citizen science is regarded as incredibly important to environmental conservation research (Dickinson, Zuckerberg, & Bonter, 2010; Dickinson and Bonney, 2012 and Dickinson, Shirk, Bonter, Bonney, Crain, Martin, & Purcell, 2012 and Johnson, Acton, Popovici, Karanth, & Weinthal, 2014). It contributes to the study of a diverse range of ecological fields ranging from macro-ecology to landscape ecology and forest ecology to urban ecology, while land managers and conservationists, policy makers and activists widely use the results of such studies in practical settings (Bonney, Cooper, Dickinson, Kelling, Phillips, Rosenberg and Shirk, 2009).

Furthermore, for some, citizen science goes beyond merely being a method of collecting data. For these individuals, it is a revolutionary activity, capable of affecting how the environment is managed. For example, Cooper, Dickinson, Phillips and Bonney (2007) suggest that harnessing citizen science represents a 'new frontier to advance the theory and practice of conservation in residential ecosystems' (p. 8). They suggest that this is possible because of the scale upon which citizen science makes it possible to operate. Far from being an activity once reserved for English Gentlemen who considered natural history as a hobby, twenty-first century citizen science is regarded to be open to all amateur observers, irrespective of knowledge, background or social status.

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CLASSIFYING CITIZEN SCIENCE EXPERIENCES: AN ORGANIZATIONAL APPROACH

Wide varieties of organizations are involved in the running of citizen science initiatives. Table 1 is an attempt to represent these various organizations. In doing so, it is possible to represent the nuances between various kinds of citizen science projects, including the drivers for their initial set-up. It also helps to provide a basis upon which it is possible to suggest a range of motivations and experiences of individuals who participate in different kinds of project. This typology builds upon others conceptual frameworks presented within the literature that have sort to typify citizen science. These include, that proposed by Wiggins and Crowston (2011: p. 2) whose typology describes citizen science projects 'by primary goal orientation and degree of virtuality'. More recently, Shirk, Ballard, Wilderman, Phillips, Wiggins, Jordan, and Bonney (2012) defined citizen science projects based on how involved contributors were in the entire process of research within a citizen science project. A final example is a typology proposed by Haklay (2013). Within this typology, Haklay (2013) describes four levels of participation in citizen science. These levels include:

- **Level One**: Crowd-sourcing,
- **Level Two**: Distributed intelligence,
- **Level Three**: Participatory science and
- **Level Four:** Extreme citizen science.

Table 1. Types of environmental citizen science initiatives

Types of Environmental Citizen Science Initiatives	Examples of Citizen Science Initiative
School or college -based citizen science projects	• Journey North's Tulip Test Gardens (https://www.learner.org/jnorth/tulip/index.html) • Seeds in Space (https://schoolgardening.rhs.org.uk/news/News-results/National/2015/May/rocket-science) • Microverse (http://www.nhm.ac.uk/take-part/citizen-science/microverse.html)
Citizen science projects based at eco-attractions	• Projects hosted by the Natural History Museum includes: Orchid Observers (https://www.orchidobservers.org/) • Bioblitz, run by the National Park Service in the US (https://www.nps.gov/subjects/biodiversity/national-parks-bioblitz.htm).
Citizen science projects run by conservation charities	Projects run by the Woodland Trust, UK: • Natures Calendar include: (http://www.naturescalendar.org.uk/) • and • The Big Bluebell Watch (http://www.woodlandtrust.org.uk/visiting-woods/bluebell-watch/) • Project run by the Royal Society for the Protection of Birds in the UK, for instance, The Big Garden Bird Watch (https://ww2.rspb.org.uk/discoverandenjoynature/discoverandlearn/birdwatch)
Citizen science projects organised by Non-governmental organisations	An example of such an international charity is Earthwatch (http://eu.earthwatch.org/scientific-research/our-approach-to-research-citizen-science)
Local programs organized by the community, the council or other entities	• Projecte Rius (http://www.projecterius.cat/) • Citizen Crane (http://www.cranevalley.org.uk/projects/citizen-crane.html)
University led programs citizen science programs	• YardMap (Cornell Lab of Ornithology and funded by the National Science Foundation (NSF)) (http://content.yardmap.org/) • Project Splatter, Cardiff University, UK (https://projectsplatter.co.uk/report-some-data-to-project-splatter/)

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As participants progress through the citizen science projects that they are involved in, the degree to which they progress may increase. They may, for instance, become more interested in being involved in the entire scientific process as time passes.

In contrast to these pre-existing frameworks, Table 1 presents an alternative way to categorize citizen science projects. This approach is based upon the organizational context within which such projects take place. In the section that follows, each of the categories will be described in turn. It is important to note that the categories are not mutually exclusive. There are, for instance, many instances of hybrid projects, which involve many organizations in their running. Examples include the OPAL project (http://www.opalexplorenature.org/), which involves contributors in conducting ecological surveys that include a range of species, including lichens and earthworms. The project places community scientists in museums across the UK to engage wider publics, but primarily large numbers of schoolchildren. The Opal Project is made up of a consortium of several partners, including Imperial College London, University of Birmingham, Natural History Museum and The Met Office. Another example, of such a hybrid project is Track-a-Tree (http://trackatree.bio.ed.ac.uk/). Track-a-Tree is a phenology project that looks for the first signs of spring in trees and flowering plants. It is a collaboration of the University of Edinburgh; the Woodland Trust; the British Ecological Society and is supported through funding from the Natural Environment Research Council (NERC). Individuals may also contribute to projects within more than one category, simultaneously. Alternatively, they may become involved in differing citizen science projects at different stages of their lives.

The first category presented in Table 1 is school-based citizen science projects. Students of all ages, at all levels of study, from pre-school to college level may be involved. Schoolchildren may be formally required to participate, as part of their curriculum. However, some individuals at later stages of their education, for example, at a post-compulsory level may be motivated by the desire to supplement formal education. The typical primary emphasis of such projects is science education and engagement. Thus, projects may vary in the extent to which the scientific data gathered is used within formal scientific research. An example of a school based citizen science project is *Seeds in Space* (https://schoolgardening.rhs.org.uk/news/Newsresults/National/2015/May/rocket-science). This UK-based mass observation exercise compares how seeds grow in space, as opposed to on school grounds. Astronaut Tim Peak launched this project to coincide with his recent space mission. It is a collaborative project between the Royal Horticulture Society, the UK Space agency and thousands of schools across the UK.

The second category of citizen science project detailed in Table 1 concerns projects based at eco-attractions. Eco-attractions include museum, arboretums, botanical gardens, national parks, urban parks and zoos (Dunkley, 2016). They are organizations that are involved in both engaging the public in learning experiences and encouraging appreciation of the natural world (Davis 1996). They often have large public engagement programs and host vast numbers of school, college and community groups, through specialist programs. Individuals who participate in citizen science through eco-attractions may do so to supplement their learning through informal, experiential learning (Kolb, 1984). Eco-attraction-based citizen science is inclusive of individuals of all ages, from those involved in formal education to life-long learners, who might perhaps be in their retirement. These individuals may also be motivated to interact with organizations that they respect and want to support in their conservation efforts. They may also be motivated by that fact that collecting citizen science data for these organizations enables them to enjoy the natural surrounds of these sites. An example, an eco-attraction-based citizen science initiative is the *Orchid Observers* project (https://www.orchidobservers.org/), run by the Natural History Museum, in London, UK. The project asks contributors to photograph wild orchids. It also asks contributors to help

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classify 300 years of orchid records that the museum holds. This specific project contributes to climate change research. Participants may consider the projects role in monitoring environmental change to be a worthy endeavor. They may want, therefore, to participate in a program on this basis.

A third category of organization involved in running citizen science projects are conservation charities. Organizing citizen science initiatives may enable conservation charities to reach their aims on a number of levels. For example, developing citizen science programs may help them to gather data on ecological threats to the species that they seek to protect. This will assist them in gathering wider support from both publics and policy makers. Citizen science initiatives may also be looked upon by such organizations as an effective means of engaging publics. An example of a citizen science project, run by a conservation charity in the UK, would be *Natures Calendar* (http://www.naturescalendar.org.uk/). *Natures Calendar* is a longstanding citizen science program, run by the Woodland Trust. Similarly to its sister project listed above (*Track-a-Tree*), it is a phenology project. It, therefore, looks at the effects of climate upon natural phenomena.

A fourth category of citizen science utilizing organizations includes Non-government organizations (NGOs). Such organizations may be concerned with environmental issues that have global implications. Examples might include climate change, deforestation and biodiversity loss. Setting up citizen science initiatives enables NGOs to collect data at vast scales, in a cost effective manner. Thus, this may help them to achieve their goals, in that the research insights gained through citizen science projects may help to support the claims they make in lobbying government. Individual contributors may seek to participate within such projects because they agree with the values that the particular NGO seeks to promote. An example, of such an NGO is *EarthWatch* (http://eu.earthwatch.org/scientific-research/our-approach-to-research-citizen-science), an organization that seeks to support local-level citizen science projects. They seek to effect environmental change at a global level by supporting local people all over the world to tackle local environmental issues through environmental monitoring.

A fifth category concerns programs coordinated by communities, councils, or other entities that are stakeholders within their local environment. Such projects may emerge from a concern for the local environment. For example, they may, be developed in response to a pollution breach. This was the case for the *Citizen Crane* (http://www.cranevalley.org.uk/projects/citizen-crane.html), a citizen science project run by the Crane River Partnership in London. The project monitors pollution levels in a river tributary. A further example, is *Projecte Rius* (http://www.projecterius.cat/) in Spain, a project that organizes contributors for monitoring pollution in local rivers. Individuals who choose to participate in these projects may be motivated to contribute to scientific data collection on local issues. They may be driven to do so because of their commitment to the places within which they live.

The sixth and final category presented within Table 1 is that of university-led programs. Such programs seek to answer specific research questions, developed by an academic or university-based research group. Such initiatives may be driven primarily by the needs of academics to create peer-reviewed journal publications. In addition, with the increasing focus within universities on creating societal impact, citizen science initiatives may be developed by academics who see the methodology as a means to ensure the relevance of their research. An example of such a project is *Project Splatter* (https://projectsplatter.co.uk/), at Cardiff UK University. Academics within the College of Biomedical and Life Sciences developed this citizen science project to record sightings of wildlife roadkill within the UK. The aim of the project is to explore the impact of roads upon wildlife. As well as publishing findings, researchers behind this project also hope it might be possible to influence policy maker's decisions about road construction through presenting evidence of some of the negative impacts of roads on biodiversity.

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THE MOTIVATIONS OF CITIZEN SCIENCE CONTRIBUTORS: THE SCIENTIFIC ORGANIZERS PERSPECTIVE

It is suggested within the citizen science literature that there are various reasons why vast numbers of people participate in citizen science globally. Miller-Rushing, Primack & Bonney (2012) argue that participation in citizen science enhances scientific literacy. Moreover, it was stated in a recent UK government PostNote (2014) that participating in citizen science enables contributors 'to learn new skills, often with value for future employment' (p. 3). There is also a sense that people take part in citizen science projects in order to work with scientists. Dickinson et al. (2012) state that: 'collecting data for use by professional scientists is highly motivating [and], fosters scientific knowledge' (p. 295). A related potential reason for participation in citizen science, recently recognized by scientists in the field, focuses on the social context of citizen science. Price and Lee (2013) argue that the 'social component of the project' (p.795-796) is its most important dimension. Citizen science projects often allow individuals to track their progress and compare their performance to that of other citizen science participants through, for example, contests, games and challenges. This may also be encouraged by rewarding the participants with certificates. This might also include coverage in the media, on project blogs and newsletters (Dickinson et al., 2012). All this, together with the prestige associated with being involved in scientific processes, means that citizen science may subsequently enable participants to enhance their social capital, by enabling those who take part to construct a desired personal identity.

Along with the thrill of the competition, academics suggest making friends drives contributors. Internet forums often support citizen science projects. Examples include those available via citizen science platforms, such as Zooniverse (https://www.zooniverse.org/) and iRecord (http://www.brc.ac.uk/irecord/). Bonney et al. (2009) argue that such online forums increase participant's visibility at ever-larger scales. Dickinson, Crain, Reeve & Schuldt, (2013) have discussed the benefits of online social networking. One of these benefits, they suggest is that participants can appreciate their role in the collection of large data sets. As a result, they argue that citizen science could create 'massive shifts in pro-environmental behavior and social norms' (p.1). Therefore, citizen science may nurture collective action, by appealing to pro-social sensibilities. Involvement in large-scale research projects, they argue, may lead to awareness of group efficacy. This may combat individual feelings of helplessness in confronting environmental issues (MacNaghten, 2003).

Such discourses of learning and contribution are well established in the citizen science literature. The democratization of science is thought to be a concern for organizers of citizen science (Johnson et al., 2014). This involves increasing opportunities for science learning, as well as a preoccupation with the expansion of scientific endeavor in both scale and scope. Bonney et al (2009), for example, describe citizen science as a process that 'enlightens the public' (p.977). Simultaneously, the citizen scientist emerges as a value-driven individual, willing to contribute their time, skills and efforts for the good of science. In return, it is often suggested that citizen scientists expect to learn about scientific methodologies and to benefit from interacting with scientists. In sum, the non-scientist gains the support of the scientist, while participating in vast and scientific endeavors. It is suggested that both stand to make positive contributions towards environmental citizenship. Dickinson et al. (2012), thus, argue that citizen science is a 'shareable public good' (p. 291) in both its processes and its outcomes. These authors argue that citizen science contributes to 'public participation and earth stewardship'.

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PROBLEMATISING EXISTING SUGGESTION FOR THE MOTIVATIONS OF CITIZEN SCIENCE CONTRIBUTORS

The suggested motivators discussed above are plausible reasons for individuals to choose to become involved in a wide variety of environmental data monitoring activities. Yet, existing literature on citizen science motivations may overemphasize the role of citizen science organizers. This is perhaps not surprising given that those operating citizen science programs have, to date, conducted most program evaluations for the field. Within this context, the scientist is in a position to influence participant's motivations. Moreover, as scientists guide participants in scientific processes, it is, thus, their role to enhance the participant's science literacy. It is the scientist and organizing team also who make decision on what interactive components to include within a citizen science project. For example, they decide whether to include gamification aspects and online networks as components of the projects they set-up. As a result of this, they are, therefore, able to facilitate social interactions. Existing literature, therefore, portrays citizen science organizers as facilitators of learning and social networking.

Furthermore, Cooper et al (2007) suggest that environmental citizen science offers hope, not only in terms of its ability to engage citizens with environmental issues, but also for conservation more broadly. This, they suggest, is because 'it operates over such large scales by drawing on spatially dispersed participants'. Therefore, the data generated through citizen science 'can be used to create a new frontier to advance the theory and practice of conservation in residential ecosystems' (p. 8). Thus, they see citizen science not only as a research and monitoring tool, but also as a tool for conservation. Cooper et al (2007) propose that citizen science can be used in the 'adaptive management' of residential habitat. To this end, they suggest a new approach calling it 'adaptive citizen science'. This approach, they suggest, is a 'an effective means of organizing citizens, residents and habitat management activities to achieve cumulative, positive impacts on biodiversity in research landscapes' (p.1).

It would seem then that the scientific organizers of citizen science projects have a crucial role to play in mobilizing the public in scientific data collection. On the other hand, however, contributors to citizen science projects give their time freely to be involved in what could be regarded as often quite mundane tasks. Such tasks may include measuring and counting plant and animal species or collecting water samples. These observations are often passed on to scientists who have the specialist expertize to analyze the data that emerges from them. They then use this data within research projects, the results of which the participant may never see. The likelihood of contributing participants being involved in reflections upon citizen science data is perhaps decreased, not only by the fact that these individuals are unlikely to possess the skills to interpret the data, but also by a focus on major outcomes of citizen science studies. For example, while reporting the success of citizen science projects, there is often a focus on the significant findings that emerge following participation. For example, the RSPB *Big Garden Bird Watch* (https://ww2.rspb.org.uk/discoverandenjoynature/discoverandlearn/birdwatch) reports that over half a million people counted eight and a half million birds across the UK in 2015. Under this scheme, a contributor submits her data via a smart-phone, iPad or a web-portal. Following this, all the records are collated and the results are reported online. Yet contributors rarely receive feedback within macro-level-schemes on the specific records that they have contributed. They are, thus, unable to contextualize their local results in a wider context. It is, of course, likely that some participants may keep their own records. This would enable them to compare their data to the national result. However, often there is little feedback from citizen science organizers. It could be argued, therefore, that the greatest benefits

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from citizen science go to scientists. The scientists behind citizen science make new discoveries at ever-vaster scales through these programs. They frequently acknowledge that these new discoveries are only made possible by the recording efforts of contributors. Yet, it is rare for participants to be included as co-authors on the peer-reviewed publications upon which scientific careers are built (Dickinson et al., 2012 and Venkatraman, 2010).

Further, there is also a political implication in the expansion of citizen science. The Parliamentary Office of Science and Technology (POST) in the UK, regards citizen science as key to scientific progress. For instance, they draw attention to the fact that citizen science informs the Biosecurity Action Plan and the National Pollinator strategy. In a climate of austerity, environmental citizen science is looked upon by POST (2014) as a 'cost effective' means of gathering data' (p. 3). More cynically then, public participation in scientific research could be regarded as a process that capitalizes on the labor of contributors.

Problematizing the scientific narrative concerning the value of citizen science to the public leads us towards a deeper exploration of the citizen science experience. As appealing as such scientific explanations may be, little evidence supports the assertions concerning the value of the process to participants. This places reliance upon narratives that posit the value of citizen science to those involved, posed by those who arguably stand to gain most from citizen science as a process. It is not proposed within this chapter, that scientists are over-claiming the significance of citizen science. Rather, the chapter seeks to highlight the implications of the reliance upon citizen science organizers to provide insights into the citizen science experience. It is argued here that in order to understand the role of environmental citizen science in addressing sustainability problems it is necessary to understand how such processes affect the individual person, involved in citizen science. Their role involves data collection, and less frequently, data analysis and interpretation on the ground. Gaining insights into the meanings of such experiences for participations is key to the field's development. Yet, as a relatively young field, this is yet to be explored deeply.

ENVIRONMENTAL EDUCATION PERSPECTIVES ON CITIZEN SCIENCE: A CALL FOR FURTHER EXPLORATION

When an environmental education lens is applied in order to study the citizen science experience, a different story of what motivates citizen science project contributors emerges. This perspective offers a social, political and emotional understanding rather than a scientific understanding of the role of citizen science. As citizen science has gained in popularity, its conjunction with science education and environmental education has been seen as a major opportunity by leaders within the field of Education for Sustainable Development (ESD). In a recent paper published in Science, Wals, Brody, Dillon and Stevenson (2014) stated that a convergence of efforts would be feasible for these fields. They also argue that it would be effective given that both fields seek to address sustainability challenges. These authors characterize citizen science as a process through which phenomena are classified and monitored. They portray Environmental Education as an educational field concerned with identifying causes and solutions. For Wals et al. (2014) citizen science delivers synergy between science education and environmental education. These fields, they argue have historically been regarded as 'distant, competitive, predatory and host-parasite' (p. 583). Citizen science is, thus, a particularly promising development for these environmental educationists. This is because they believe that 'citizen science enables for people to engage with science on relevant environmental issues in collaboration with scientists working in local contexts' (p. 584).

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TROUBLING THE APPLICATION OF AN ENVIRONMENTAL EDUCATION LENS TO CITIZEN SCIENCE

Nevertheless, it is also necessary to problematize the application of an environmental education lens to citizen science. Applying an environmental education lens to the analysis of the citizen science experience may be, for example, particularly problematic because of the controversies surrounding discourses of Education for Sustainable Development (ESD). There are many who have criticized the effectiveness of Education for Sustainable Development and the related United Nations Decade for Education for Sustainable Development (UNESD). For instance, Richard Kahn (2010) has suggested that Education for Sustainable Development can only serve to reinforce the status-quo because of its ideological underpinnings, which are based upon current neo-liberal values, currently held by Western Society. To this end, Kahn (2010) states:

the next decade will ultimately decide whether ESD is little more than the latest educational fad or, worse still, turns out to be a pedagogical seduction developed by and for big business-as-usual in the name of combating social and ecological catastrophes (p. 16).

Kahn (2010) and others may argue, therefore, that applying an environmental education or Education for Sustainable Development lens to any endeavor that seeks to raise ecological awareness and sensibility, may be ineffective. This is because looking at citizen science through such a lens may bring to it an anthropomorphic perspective. It may do so, by considering how humans benefit from environmental citizen science. This could happen at the expense of exploring citizen science from the angle of its significance for biodiversity, as arguably conservation biologists would. In analyzing the existing developments within the field of Education for Sustainable Development, Kahn (2010) calls for wider reform of education systems, based upon an 'eco-pedagogy'. This, he argues, would involve centralizing environmental concerns within education systems, so that humans gain a better appreciation of their place as part of such systems.

Using an environmental education lens to study of citizen science may be problematized on a second basis. Focusing on the benefits of participation may result in the ignorance of interactions with 'nature' that are perhaps lost as a result of participation. In a different context, Pergams and Zaradic (2006) have argued that a love of technology drives individuals away from experiencing the natural world. It is possible to make the case, therefore, that the use of smartphones in environmental citizen projects may distract people from directly observing and experiencing the natural world. It is also possible to envisage that participating in citizen science might mask other more significant motives. For instance, in the case of internet-based projects, the desire to participate could be a consequence of the love for technology that Pergams and Zaradic (2006) speak of. There is also yet a third basis, upon which it is possible to problematize the study of citizen science through the lens of environmental education. To date, there has been little consideration of the inequality of opportunity in terms of who gets to engage with citizen science. Some individuals, for example, may lack chances to become involved due to absence of access to technology, or project unavailability in the areas within which they live.

Nevertheless, although it is crucial to be mindful of these problematics, the involvement of environmental educators, or perhaps eco-pedagogues, in debates about citizen science is key. This will make it possible to recognize the benefits to individuals involved. It will also allow exploration of how environmental citizen science may address sustainability problems. To achieve this, it is necessary to understand what

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drives contributors to become involved in citizen science projects. To date, many studies have focused on the effectiveness of citizen science in facilitating traditional scientific processes. Yet the meaning of citizen science for the individual has been regarded as less significant. The impact of involvement upon the individual, the local school or community groups appear to have been considered as secondary.

THE NEED FOR FURTHER RESEARCH CONCERNING EXPERIENCES OF CITIZEN SCIENCE

As noted in the preceding section, it is necessary to seek the perspectives of wider disciplines, beyond those who are responsible for the design of citizen science programs. There are interesting stories about the contexts in which participation takes place and about the making of citizen science data that currently go unreported. Understanding who collects the data and why they do so is crucial to understanding the value of citizen science. From an environmental education perspective, such insights are as important as understanding scientific outcomes.

Aside from a few notable recent studies (Jones, Riddell, Morrow, 2013; Johnson, Hannah, Acton, Popovici, Karanth, & Weinthal, 2014 and Rotman, Preece, Hammock, Procita, Hansen, Parr, & Jacobs, 2012), there has been a lack of focus on the motivations of those who participate in citizen science and on the citizen science experience itself. This means that little is known about who might and might not participate and for what reasons. Furthermore, while the ancient roots of citizen science are known, there has been no consideration of what appeared to motivate those early contributors. The short number of motivations that emerge from the scientific literature may also be the result of the fact that there has been a tendency to focus upon current citizen science programs for understanding. There are many historical examples of individuals engaging with citizen science. Lighthouse keepers, for instance, began collecting data concerning bird strikes as long ago as 1880 (Bonney et al., 2009), while there has been no shortage of past citizen science projects. For example, the National Weather Service Cooperative Observer Program (http://www.nws.noaa.gov/om/coop/) began in 1890, while the National Audubon Society Christmas Bird Count (http://www.audubon.org/conservation/science/christmas-bird-count) began in the 1900's and the Breeding Birds Survey of the British Trust for Ornithology (BT0) (https://www.bto.org/volunteer-surveys/bbs) was established in the 1930's. It would be possible to conduct a study of the motivations of the early participants in citizen science programs. If such a study was conducted, a different picture might emerge of some of the central drivers for the individuals who choose to participate in citizen science.

Moreover, it would also be interesting to conduct studies of how the motivations and experiences of contributors to citizen science projects vary in accordance to the types of citizen science program, within which they participate. Using Table 1 as a starting point it might be interesting, for instance, to explore the experiences of those who participate in citizen science programs run by NGO's as opposed to those run by schools, or those run by eco-attractions. A particularly interesting and underexplored instance of citizen science experiences includes projects that are considered community-led, perhaps even more activist projects. Such projects are often considered to be less connected to the endeavors of 'grand science' (McQuillan, 2014). Thus, conducting studies that involve an exploration of the experiences of individuals involved within them may provide different comprehensions of the motivators that drive those who contribute to citizen science projects.

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The few existing studies that analyze the practices of those individuals who contribute their time to become involved in citizen science provide insights into the variety of reasons that influence individual decisions to become involved and the impacts of their experiences. Both areas, motivations and experiences, will be socially and culturally constructed. Yet, the social and cultural factors that drive individuals to contribute to citizen science are often not clearly visible. It is necessary, therefore, to explore such drivers in depth, drawing upon a range of disciplines, including history, geography and sociology. Doing so, may reveal the underlying factors that influence individuals to contribute to citizen science. It may also uncover the important effects of participation upon individuals.

The ability of citizen science to expand the scale and scope of data collection appears to be what makes it appealing to scientists, as well as to the popular imagination. Yet it is clear from the preceding discussion that it is possible to consider the benefits of citizen science from an alternative perspective. This involves beginning at the scale of the individual participant, considering what motivates them to become involved and how participants experience the process. The outcomes of involvement for the individual are also important to understanding the significance of citizen science within contemporary society. Therefore, as well as considering citizen science at a scale that is relevant to scientific progress, it is also worthy of consideration at the scale of personal progress for the individual. Such individuals may learn about and see and sense novel surroundings through their participation, which could have key implications for their everyday lives.

It may be desirable, therefore, to consider the nature of the connections that individual contributors have to citizen science. This may include, for instance, thinking about how long they participate in projects for and whether they are involved in multiple projects. It may also be valuable to consider the backgrounds of individual contributors. It would then be possible to explore how such personal histories, together with present circumstances, influence decisions to contribute to citizen science projects. Doing so, may provide an appreciation of citizen science and its role within increasing environmental literacy. An appreciation of how such initiatives expand individuals' sense of care for the environment, as well as, their willingness to act in pro-environmental ways may also be gained. This would go some way in providing understanding of how environmental citizen science initiatives might contribute to solving 'sustainability problems' through social responses at a personal and collective community level. Such studies would therefore be useful to those working within the field of sustainability science. Providing understandings of what makes individuals get involved and stay involved in citizen science programs would also be useful to those conservation biologists looking to harness citizen science as a research method.

BROADER INTERPRETATIONS OF THE MOTIVATIONS OF CITIZEN SCIENCE CONTRIBUTORS: EXPLORING THE TOPOPHILIA HYPOTHESIS

It may be the case then that the language of education, social cooperation and technological innovation may be inadequate for understanding the motives of individuals who contribute to environmental citizen science. Indeed, it is possible to argue that environmental citizen science differs from other citizen science programs, such as those focused upon human health, from this point of view. In addition to those motivations suggested by previous authors, it might be beneficial to adopt a language of 'philos' – that is a language of love and affection to understand what might also inspire individuals to contribute to environmental citizen science projects. In 'A Sand Country Almanac', Leopold (2001) suggested that the development of an ecological consciousness is very much dependent upon an 'individual's internal

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emphasis, loyalties, affections and convictions' (p. 174). Leopold (2001) argued that 'we can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in' (p.179). It has been argued in the preceding section that by considering the deeper, affective drivers that may be present within citizen science, it is possible to gain a greater appreciation of the values, perceptions and emotions that bring individuals to participate in citizen science activity. The remainder of this chapter, therefore, seeks to explore a hypothesis concerning how a particular phenomenon, 'topophilia' (Tuan, 1974) may influence citizen science experiences. In doing so, this chapter demonstrates how underlying ways of seeing (Berger, 1972) might affect people's desires to become involved and continue to participate in citizen science.

Topophilia describes the phenomenon of having a deep knowledge of a place and love of such a place (Tuan, 1974). It is comparable to the notion of biophilia, which indicates a love of life. It is proposed here that topophilia might drive individuals to become involved in environmental citizen science. Furthermore, topophilia may be a desirable outcome of participating in citizen science, for individuals. These individuals may become connected to their locale through participating in local environmental monitoring initiatives. For instance, *Citizen Crane* is a citizen science project that asks local contributors to monitor a stretch of river near to their homes. The contributors of Citizen Crane have worked in groups of two or three to conduct the river monitoring surveys once a month for the past three-years. They may be motivated to do so because of a love of the place within which they live. Topophilia is not necessarily, however, a phenomenon that connects participants to their home environments. Participants may be, for example, encouraged to develop affective bonds with places that they consider special through their participation in a citizen science projectwhich may be considerable distance from their homes.

Sampson (2012) argues that individuals form such bonds with place through 'both an attraction to place and sense of place-based history' (p. 41). Building upon these early theorizations of topophilia, he proposes the 'topophilia hypothesis', suggesting that the ability to bond with local place is an evolutionary adaptation, which enabled human beings to learn specific place-based skills required to adapt to and thrive within the particular places to which they found themselves bound. For Sampson (2012), 'topophilia' is something that is innate to human beings, but has been lost within modern societies. He argues that 'the proposed affective connection with place that characterized humans during the bulk of their history has been largely severed today in industrialized societies' (p. 35). Within the present day, therefore, human beings are failing to recognize their dependencies upon local places, which results in a 'dysfunctional human-nature relationship at the heart of the ecocrisis' (Sampson 2012: p.42). Yet, he suggests there is cause for hope in that 'the human brain is genetically wired to incorporate knowledge through local place' (Sampson 2012: p.38). Sampson (2012), therefore, calls for efforts to reinstate the bonds between people and places. He suggests that place-based education, beginning at the earliest possible stage would be one way to approach this.

Nevertheless, it is also possible to contest the idea that such topophilic bonds to local places are not experienced by individuals within the present day. Both Welsh and German cultures have expressions with no direct translations that describe the bond and attachments that an individual can have to their local place. The Welsh word 'hireath' is used to describe the bond that one feels to the land to which they were born and their connection to their culture. It is often thought to be felt as homesickness by those who are displaced. This term is still pervasive within Welsh language and culture. Indeed, it has been adopted within popular culture and has even been used in tourist campaigns to market to the Welsh diaspora (Morgan, Prichard and Pride, 2003). Similarly, the German concept of heimat is used to refer to a communion with place. Thus, a healthy skepticism might be maintained regarding the nostalgic

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overtones of such concepts. Yet, the concept of affective bonds to place does seem to persist within cultures of the present day. It is also possible to argue that within a modern industrialized world, towns and cities have adapted so that gardens, parks and nature reserves offer intrinsically valuable opportunities to reconnect with the natural world within urban settings. Over the last half a century, the importance of natural spaces within urban contexts has been increasingly acknowledged (Goode, 2011), while urban initiatives, including community-based science programs and nature festivals that address disconnections between the human and natural world have been established (Goode, 2014), including many citizen science programs.

Regardless of whether we feel topophilia is present in contemporary society or in the need of reawakening, it is clear that the presence of affective bonds to place, at a local or indeed global scale, may act as a motivator for those who choose to contribute to citizen science projects. Understanding what drives individuals to engage with place-based environmental citizen science is, therefore, fundamental to our appreciation of participation. If we follow the topophilia hypothesis, as Sampson (2012) proposes, it could be posed that individuals may be attracted to participate in citizen science initiatives because of an innate desire to preserve, protect or restore places that they value. Such initiatives often occur within urban spaces. Environmental citizen science initiatives provide a means through which individuals can become attentive to urban nature. Furthermore, while many environmental citizen science projects rely upon web content, email and postal means to report data, they are still place-based in their collection of records. There are also environmental science initiatives that are being organized through partnerships with local museums, science centers and local organizations. The Open Air Laboratories (OPAL) Network (http://www.opalexplorenature.org/), for example, is a citizen science project that is operated by a team of community scientists, based regionally within museums across the UK. These community scientists then work with local schools, community and social groups to involve young people and communities in citizen science. Environmental citizen science in such contexts may well, therefore, offer the opportunity to bond with nature within urban settings, as Sampson (2012) puts it, 'as our foraging forbearers bonded with savannahs, rainforests, tundra and deserts' (p.39). This may well be part of the appeal of environmental citizen science for those who contribute. Therefore, a consideration of 'topophilia' as playing a role in citizen science motivation and experiences warrants further exploration.

An awareness of the fact that participating within local citizen science initiatives might have a positive effect on an area that an individual cares about could well be a motivation for that individual. For example, Cooper et al. (2007) highlight the capacity of citizen science projects to have a positive effect on residential areas that are regarded as important in terms of ecosystem services and biodiversity support. They argue that an 'adaptive citizen science model' could be an effective 'means of organizing citizens, residents and habitat management activities to achieve cumulative, positive impacts on biodiversity in research landscapes' (Cooper et al., 2007: p.1). The ability to contribute to the restoration of local areas would undoubtedly be seen as rewarding by many who choose to contribute to environmental citizen science, who may arguably increase their 'environmental stewardship' through 'active participation in research and subsequent informal (i.e. not classroom based) science education' (Cooper al, 2007: p.7). Thus, the experience is assumed meaningful within the everyday lives of individual participants, as well as beneficial for scientists.

In many cases, those who contribute to citizen science are choosing to pursue their own projects with their own research questions enabling them to produce evidence to protect local areas and influence local decision making as collectives, often working with scientists in this process. Dickinson et al. (2012) suggests that learning outcomes are 'more robust among volunteers who explore their own questions'

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(p. 295), while such groups benefit from increasing their social networks and their opportunities for social learning. In this context, there is perhaps also an activist motivation for citizen science contributors. McQuillan (2014) has recently noted the activist potential of citizen science projects that arise out of disorder rather than order as a scientific endeavor. He argues that though those who participate in citizen science 'rarely characterize themselves as countercultural' (p. 1), usually aiming instead to create 'orthodox scientific knowledge', citizen science shares counter-cultural resonance. It possesses such resonance, he argues, because of its focus on 'participatory experimentation and the principles of environmental sustainability and social justice'. For some, citizen science is, therefore, seen as a means of democratizing science, involving people in caring for and making decisions about local landscapes, and in cases where citizen science projects are 'grassroots' challenging received wisdom about the state of the environment (McQuillan, 2014). Citizen science offers opportunities to challenge through mass data collection. Through collecting large amounts of data on current issues, it is possible to support counter-cultural movements (McQuillan, 2014). In responding to the destruction of places and life forms that they see to be at risk, citizen science contributors may become involved in projects that seek to halt environmental damage or change. Examples of such community-led citizen science initiatives include *Grupo Tortuguero* (https://www.oceanfdn.org/projects/international-partner-project/grupo-tortuguero), which has through research, helped to establish marine projected areas and sustainable fisheries. Furthermore, the *West Oakland Environmental Indicators Project* (http://www.woeip.org/) in California has helped empower individuals in disadvantaged communities to gather evidence of air quality and health data, while Bonney et al. (2014) discuss a project, based at University College London, which documents poaching and illegal logging in the Democratic Republic of the Congo. Such projects: 'use science to address community-driven questions [which involves] attentiveness to diverse interests including why and how members of the public would even want to be involved (p. 1437).

The implications of affective bonding to place are also further reaching than they first appear. Indeed, within a global context, it may be possible that citizen science helps individuals to make connections between the global and the local. For example, they could make such connections by considering how the data they collect on a local scale links to data that is collated at an international level. Sampson (2012) argues that 'achieving sustainability at higher levels (state, nation, biosphere) will be realized only through iterative accumulation of sustainable societies in local places' (p. 45). In this sense, it is not only the outcomes of specific citizen science projects that will help to address environmental change, but crucially the effect of participation on the individual participant in terms of being generative of a sense of care for place through establishing affective bonds to place. If topophilia is an outcome of citizen science participants, it may emerge that such experiences have even wider implications for enabling societies to tackle both local and global environmental crises.

CONCLUDING THOUGHTS

It is clear that citizen science is a field capable of capturing the imaginations of a large number of people, while also having vast media appeal. There is great potential within the phenomenon to advance sustainable development through links with Environmental Education. Yet, this chapter has sought to highlight that the motivations and experiences of those who choose to contribute to citizen science projects need to be explored in greater depth than occurs at present. This chapter is likely to be valuable to citizen science providers given its emphasis on finding novels ways of enabling understanding of the individuals

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with whom they engage. Crucially, expanding knowledge concerning the effects of citizen science will be achieved through harnessing progressive methods of exploring the meanings and impacts of individual citizen science experiences. As Bonney et al. (2009) states, 'the full potential of citizen science is just beginning to be understood' (p. 983). This applies perhaps as much to its potential as a form of environmental learning and public engagement, as it does to the exploration of its ability to contribute to rigorous, peer-reviewed science.

In-depth qualitative study would lend themselves to such analysis through their ability to elicit meaningful insights into experience. Narrative is central to our way of making sense of our lived experiences. Therefore, a possible way of gaining such insights would be through narrative inquiry (Riessman, 1993). This approach involves listening to the stories that participants tell about why they became involved, why they stay involved or leave projects and why they choose to spend their time on environmental citizen science, as opposed to other means of interacting with the environment. Through employing narrative techniques, we may gain insight into emotional, social and cognitive experiences. Such studies would provide insights into how participants feel their involvement in citizen science shapes their identity. This future research would enable us to gain an in-depth understanding of the citizen science experience for contributors within the context of their histories, political leanings, communities and their views on environmental change. Furthermore, through understanding the nuanced stories of involvement, we gain insight into the multiple meanings of citizen science within the lives of different individuals, while taking into account their diverse backgrounds and circumstances. In going through this process, we are likely to encounter conflicts and contradictions in how individuals who choose to contribute to citizen science projects come to understand their involvement in scientific endeavor. Yet, doing so would enable us to move away from the grand narratives provided by science, concerning the effectiveness of citizen science. In providing opportunities for such insights into the educative and cooperative process, we stand to gain a richer understanding that acknowledges that citizen science is part of a longer history, as an activity that can play a prominent role within the everyday lives of participants. This may help conservation biologists to appreciate, in turn, how the stories they tell motivate individuals to become part of their scientific endeavors.

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