Citizen Science and Democracy: Participation with a Purpose

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Abstract: In this paper we discuss the changing role of citizen science in research, teaching, and learning. This change is being brought about by the development of a wider perspective on the potential purposes of participation in citizen science both for scientists and for members of the public. In this paper we review frameworks for participation, discuss benefits of participation and consider whether we can use new models of citizen science to democratise research. Citizen science is best understood as a democratic endeavour. The more opportunities for learning, the more people benefit, the more challenging the task for educators, the more varied the media and tools developed to support this purpose. Educators have extended the range of opportunities for learning to include not just formal settings, but informal ones. This position paper discusses the development of tools to support the connections between formal and informal learning settings and in particular the potential of tools to support citizen science, as a vehicle for learning both about science and about the conduct of research.

1 INTRODUCTION

Citizen science is a relatively new activity which is becoming more and more popular. Its growth has been accelerating due to the relative ease with which the participation of citizens in scientific studies has been greatly increased by the possibility of taking part in online studies e.g. Curtis (2018), in varied capacities and beyond merely sharing their data (e.g. collecting data, analysing data, co-defining research focus). However, there are a number of issues that are emerging as a consequence of this growth in participation. These include considerations of equity, which in turn is altering the nature of participation, and the benefits of participation to be reconsidered.

2 CONTEXT

2.1 Learning

So often we engage in trying to understand what people have learned when they engage in an activity as part of a formal learning opportunity. However, it is obvious that these opportunities have changed. No longer do learners need to be physically co-located with instructors, or even with other learners. No longer do we see learners as being required to be part of a formal accredited program of study.

In the past, these opportunities for learning were often examined as discrete lessons taking place in classrooms. However, the opportunities for learning have become more widespread and often exist in many different forms. In recent years, new learning opportunities in relation to collaboration, inquiry and location-based learning have emerged as practical possibilities. The concept of learning journey supported by technology, in the sense that learners may be engaged in moving between different settings, is a powerful one.

While we might wish to ensure that learners engage enthusiastically with science and that they are satisfied with their participation in science activities and see learning as fun and enjoyable, this is not automatically a benefit of informal settings. It is also difficult to track learning in these settings.

Going forward, we need to address the challenges of evidencing learning in informal settings, or connecting learning across settings, and ensuring that this learning is enjoyable and engaging. The concept of learning journey supported by technology, in the sense that learners may be engaged in moving between different settings is appropriate, and in the

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sense that multiple learning experiences, rather than learning from isolated incidents, are important.

We are particularly interested in the ways in which technology tools can support these new learning journeys, and particularly the prospects for citizen science. Citizen science is an interesting approach which serves multiple purposes and can play an important part in learning journeys. One purpose is that, by becoming involved in citizen science projects, members of the public can become volunteers to a wide range of activities which contribute to the development of science. As such they are a valuable resource. We are interested in the other potential benefits from this activity, of using the participation in such activities to help participants learn science and learn about science.

Aristeidou et al. (2017) provides a review of platforms produced for online citizen science. Masters et al. (2016) reviewing on-line citizen science activities notes that because new technologies allow for much higher levels of participation, collaboration, and interaction in citizen science, the form that these take can be important.

In their paper Masters et al. conduct a discussion which:

> *"explores what online citizen science projects reveal about the 'democratisation' of science and distributed engagement with authentic research. Analysing the wider appeal of these projects as well as their potential for informal science learning and creating communities of practice, […] asks whether 'citizen' and 'researcher' will ever be on equal footing*." [p. 1]

So, in our exploration we have developed tools to support this activity of participation in science, and we consider that the tools involved need to be considered also from the perspective of technology enhanced learning.

> *".... Technology-enhanced learning consists of much more than a set of research-informed products. It is a complex system, which includes communities, technologies and practices that are informed by pedagogy (the theory and practice of* teaching*, learning and assessment)"* (Scanlon et al. 2013).

The potential learning environments to be studied are complex, and as described in the reference quoted above, we appreciate that the uptake of technology-enhanced learning tools is influenced by 'persistent intent' evident in the description of the development of the tool provided in the next section.

3 THE TOOL nQuire

The tool we developed has been through a 15-year development cycle. In its first iteration, we produced a support for inquiry learning in formal school settings. Over the years, we have deployed it in citizen science settings and in a sequence of design-based research experiments improved its usability and functionality. See e.g. Aristeidou, Scanlon & Sharples (2021), Herodotou et al., (2018).

We designed a tool to help people to engage in citizen science activities and in doing so learn about how research is done. They can do that by taking part in studies set by others, receive feedback, data visualisations, peer learning, as well as set up their own studies through an authoring functionality. It is free to use and provides support from scientists. See Scanlon & Herodotou (2024) for more details. nQuire can be accessed via www.nquire.org.uk.

We want to help people to start thinking critically and scientifically, to understand and assess information around them, change their attitudes to science, and develop scientific literacy. We designed the tool to help people to learn. Within this overall ambition we can see potential for learning science, but also learning about how research is done. In the next sections, we present example citizen science projects hosted on nQuire.

3.1 Case Study: Forest 404

The Forest 404 study (or as we called an exploration using nQuire a 'mission') was a collaboration between the BBC Radio 4, the University of Bristol, the University of Exeter, and the Open University. The aim of the investigation was to understand how people feel when listening to various sounds. These included the sounds of nature such as wind in the trees, birds singing, or waves washing on to the beach, in addition to poems or stories about nature.

The nQuire mission was structured around several sections each one asking participants to reflect on a listening experience. The listening experience was enabled by audio files uploaded to the mission. Follow-up questions such as *How pleasant do you find the experience of listening to this sound*? *Do you find this sound boring or exciting*? were as

Questions were answered by using sliders and multiple-choice items. People who participated could slide left or right to indicate their agreement with statements. Participants were asked about personal information such as age and gender.

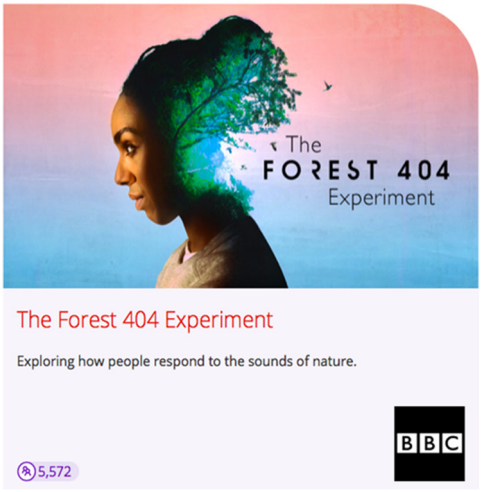

Figure 1: The Forest 404 Experiment.

The motivation behind the mission was to enable scientific understanding of the therapeutic potential of nature on wellbeing. 7,596 people took part in the study, mainly from the South-East, South -West of the UK and London. The mission brief included the following.

> "*.... A large body of evidence shows that spending time in natural environments can have positive effects on people's wellbeing. But we know very little about the importance of sound in this relationship. How might listening to birdsong or waves lapping on the beach help people who are stressed or tired? The effects won't be the same for everyone, so we want as many people as possible to take part and help us uncover what works and why."* Lead researcher from Exeter University

Findings from the study showed that people's responses to the mission were overwhelmingly positive, and in some cases, they reported on behaviour changes after taking part in the Forest 404 experience. One participant explained "*My ears seem more attuned to nature now. On my morning dog walk I could hear nothing but birdsong, I don't think this is any different than before I think I've just noticed it now.*"

Findings from the study were published by Smalley et al. so participants had the incentive of contributing to the development of scientist's understanding of an important topic.

What seemed to be important with engagement with the mission was the involvement of the media in this case the British Broadcasting Company (BBC) for the associated radio broadcasts. The connection between the development of the nQuire tool and its redesign to cope with participation at scale was due to a partnership between the OU and the broadcaster and this has had significance in determining public engagement with some of the larger scale missions or investigations.

3.2 OU Pollinator Watch

OU staff launched a mission to explore the topic of pollinators with a view also to help people learn. It was titled Pollinator watch and it was promoted in the popular BBC2 TV series Springwatch. It is an example of the many citizen science projects related to the theme of sustainability. The potential for citizen science projects to make a contribution in this area has been recognised. (See e.g. Austen et al., 2024)

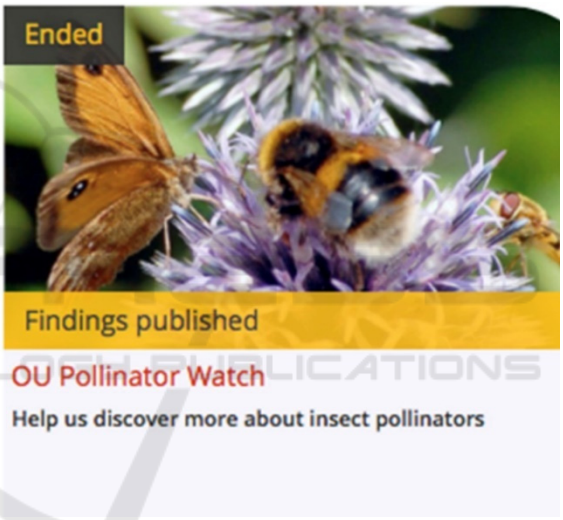

Figure 2: OU Pollinator Watch.

The interest of OU scientists in biodiversity focussed on insect pollinators which are essential, and under threat and a team was brought together to design a mission. The aim of the mission was to help people to learn about different types of pollinators. By people sharing observations and uploading photographs, data were collected on where pollinators were seen in the UK:

The mission brief included the following statement:

> *"We designed this mission to help you learn more about insect pollinators and the benefits they bring; benefits that are largely taken for granted. Whilst observing current Government guidance on restricted movement, social distancing and washing your hands as soon as you get home, we*

> *would like you to spend some time in your outdoor spaces looking for insect pollinators. Anyone can take part whether you have a small window-box, balcony, or garden.*
>
> *We are asking you to share your observations or upload photographs of the insect pollinators you see and answer some questions. In doing so, you will help us understand which pollinators are commonly observed and where, as well as how much we know about these important species. This mission will help you learn about different types of pollinating insects, why they are important and why they need our help*."

This mission attracted contributions from 7,824 participants and the summary of findings reported that observations of pollinators were submitted from all across the UK, from 123 of the 124 postcode areas. Bumblebees were the most common. In terms of participants, it was interesting that there was a high level of engagement amongst dedicated wildlife watchers. However, researchers found that 19.2% of participants wouldn't normally observe or identify pollinators and 10.9% were not previously aware of the threats they faced.

(https://nquire.org.uk/mission/oupollinatorwatch/findings)

4 DISCUSSION

4.1 Case Studies

There is much activity around citizen science as is indicated above and much is written about extending the model of participation beyond merely data collection. The two examples we have chosen to illustrate above provide the opportunity to consider what is meant by participation and what the benefits of these activities are. In each case, there is a benefit to the scientists of specific data on interesting topics, in the case of Forest 404 an investigation into the impact of sound leading to a publication. In the case of OU Pollinator watch, good quality information on insect pollinators in the UK with representation of the whole country, but even more is the intent of the scientists to develop an activity that engaged the volunteers, providing opportunities to develop skills in observation but also to learn about what makes a difference to the societal problem of decrease in insect pollinators and what behaviours might have significant impact. This is in the nature of a call to action around environmental issues. Both these examples therefore give a purpose to the activity beyond data collection opportunities for scientists presented by public engagement events in the media combined with citizens science activity.

4.2 The Different Models of Participation

The notion of a ladder of participation was first introduced by Arnstein (1969) and in recent years has been elaborated on by Haklay et al. (2021). However, there are other issues to be unpacked about the nature of participation in citizen science. A stated aim of our nQuire development has been to extend the possibilities for democracy in research (Herodotou, Kenny& Scanlon, 2024) and this is predicated on the support that our platform can give for citizens to own their investigations and perhaps even set them up.

Yet, participation as creation of research is, at least at the moment, rather uncommon and challenging for participants even to consider (Herodotou et al., 2022). Yet, some participants would be interested in being supported to do so, should there is support and time availability (ibid). There are interesting examples of how such hurdles can be overcome. For example, Sharma et al. (2022) specifically discusses online citizen science issues of species identification through consensus building identified ways of improving accuracy and consensus building on identification tasks among volunteers.

The European Commission (EC 2020) points out that citizen science *"has the potential to improve research and its outcomes and reinforce societal trust in science"* and increase *"science literacy and confidence of the public in research"*.

There are voices in citizen science echoing this desire and some bold attempts to operationalize the support. But there are also additional considerations. The democracy movement in citizen science has not won over all scientists involved in citizen science projects who query whether members of the general public should be encouraged or allowed to participate in different ways from the traditional role of data collector.

Resnik (2019) (p.1) gives an interesting commentary on this expansion of types of participation discussing the ethical implications of the mixture of roles:

> "*Citizen involvement in research raises novel ethical issues for human studies, because individuals have traditionally occupied the role of researcher or subject,*

but not at the same time. The confluence of these two different roles in the same person poses challenges for investigators and oversight committees because legal rules and ethical guidelines focus on protecting the rights and welfare of human subjects and do not address issues that fall outside this domain, such as study design, data quality and integrity, reporting misconduct, authorship, or publication."

It is also not appropriate to assume that ideas of co-design or co-construction or participation are limited only to the world of citizen science, or any other type of citizen inquiry.

Heiss et al. (2017) (p.21) describes how:

"the discussion has moved away from a classical "public understanding of science" approach, aiming at transferring knowledge about scientific processes to the public, to a "science in society" approach (Felt et al. 2013)"

This links to discussions around knowledge production as a mode two activity which means that:

"... that knowledge is no longer produced exclusively in scientific institutions, but in transdisciplinary collaborations, which aim to solve existing practical problems. Such transdisciplinary collab orations may not only involve interactions between scientific disciplines, but also between scientific and non-scientific actors (Hurni and Wiesmann 2014). The concept of "transformative science" builds on these observations and argues that such transdisciplinary collaborations become more important in modern societies, which are characterized by the increasing penetration of scientific results and processes within society. In order to ensure the external legitimacy of institutionalized scientific research, scientific actors have to open up to societal actors and actively involve them." (p. 21)

Outside of the specific research practices of citizen science, there are paradigm shifts in research design in the social science more generally. In medicine, in social research and in the practices of design-based research there are also ways of working aligned with more co-production of research.

Palmer and colleagues (2019, p.247) writing about medical research capture this shift in the zeitgeist as follows:

"Participatory methods increasingly used in healthcare improvement coalesce around the concept of coproduction, and related practices of co-creation, co-design and co-innovation. These participatory methods have become the new Zeitgeist—the spirit of our times in quality improvement. The rationale for this new spirit of participation relates to voice and engagement (those with lived experience should be engaged in processes of development, redesign and improvements), empowerment (engagement in codesign and coproduction has positive individual and societal benefits) and advancement (quality of life and other health outcomes and experiences of services for everyone involved should improve as a result."

Roche et al, in a 2020 review of citizen science progress in this area has a clear prescription of what needs to be done in terms of practices and that is:

"to align educational learning outcomes with citizen science project goals at the planning stage of the project using co-creation approaches to ensure issues of accessibility and inclusivity are paramount throughout the design and implementation of every project. Only then can citizen science realise its true potential to empower citizens to take ownership of their own science education and learning." (p.1)

Jenkins (2011) points out the increased possibilities in citizen science for making students see science as relevant to their own lives, and with Archer et al. (2015) sees the possibility of increasing the science capital, an important potential pathway to change. However, Hall (2024) points out the paradox between scientists aiming for science discovery and aiming for publishing relatively little from citizen science studies.

"Citizen science yields increased scientific capacity in exchange for science literacy and promises of a more responsive science to society's needs. Yet, citizen science projects are criticized for producing few scientific outputs and having exploitative relationships with the citizens who participate" [p.1527]

They propose a model of engagement for citizen science to result in benefits for citizens and scientists alike relating to a case study of citizen involvement on a hydrology project. Heywood (2016) like others

considers that there is a need for better cooperation between scientists and the public.

While participation in citizen science activities can bring benefits to involved stakeholders, it should be noted that the type and magnitude of these benefits depends on the design of projects and in particular how volunteers are allowed to engage with them. Distinct learning benefits were recorded for youth volunteers depending on whether they were asked to record biodiversity - which was associated with enhanced observation skills or identifying species - which was related to enhanced sharing of knowledge and a desire to become a scientist (Herodotou et al., 2024). In addition, certain types of participation may be less or more accessible to volunteers than others, promoting inequalities in access and participation (DeWitt, & Archer, 2017). Widening participation has been an issue of concern with strategies such as the design of projects relevant to volunteers, improvements in the accessibility of a project and effective support by others been proposed as mitigation strategies (Vogt et al., 2016). For example, online citizen science platforms such as iNaturalist are viewed as "opening the door to science" as they enable diverse participation of youth including those with no prior science experience and interest (Herodotou et al., 2024).

5 CONCLUSIONS

The endeavour in which we are engaged is to explore ways in which our tools can contribute to improving the public's understanding of science and how scientific knowledge develops.

Part of this endeavour is how best to engage individuals and communities with limited or no research expertise and interest in scientific investigations with the process of designing and implementing a scientific investigation. With our research work's origins in personal inquiry learning in schools, bringing together approaches to developing understanding of science concepts and processes, this continuing research work on citizen science was started with a recognition of the possibilities of combining inquiry learning with citizen science and collaboration. Harnessing these components could provide more opportunities for participants' learning from engaging with citizen science.

With many nQuire 'missions' completed (69 to date), we have developed a useable tool, and we have developed the possibility of making progress on the democratisation of the research process by enabling enhanced levels of participation and by turning volunteers into co-researchers.

Like others we have begun to experiment with using AI tools, to speed up and improve the potential data analysis of missions with many participants as reflected in the recent systematic reviews of the potential of Generative AI in learning settings e.g., Bond et al. (2024). We are also working on versions of the tool that would support projects exploring design thinking, youth mental health, eco-anxiety, and policy prioritization in funded research e.g. (https://learn.nquire.org.uk/signin.)

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