

Achieving Sustainable Outcomes Through Citizen Science: Recommendations for an Effective Citizen Participation



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Abstract Citizen Science refers to a scientific project, managed by researchers, where volunteers are involved in studying and acquiring data related to a natural phenomenon. To this end, researchers design a platform to support this process. A successful Citizen Science project delivers important sustainable outcomes because it contributes to understanding and addressing environmental issues. For an effective Citizen Science project, researchers manage crucial actions: the management of volunteers' motivation and engagement and the development of a Citizen Science platform. With this study, I contribute to the literature discussing these three topics proposing recommendations to address these actions, based on a literature review. The study has certain implications for practitioners and researchers.

Keywords Citizen science · Literature review · Participation of volunteers · Citizen Science project design

1 Introduction

There is an increasing interest of scholars and practitioners in studying how advanced information and communication technologies (ICT) contribute to the development of a more sustainable society [1]. To this end, ICT support the development of a sustainable society because they help “meet the needs of the present without compromising the ability of future generations to meet their own needs” [2 pg. 43]. ICT allows novel forms of interactions [3] and novel opportunities to exploit them in order to alleviate the impact of society on the environment [4]. Within this landscape, various studies investigated how these ICTs deliver sustainable value in the organizational setting and smart city [5–7], while others started exploring the role of Citizen Science for a sustainable society [8]. Citizen Science refers to a scientific project which is led by researchers and where citizens participate in the collection of

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data [9]. To this end, researchers make use of a platform which is used to collect data by citizens regarding various phenomena in natural contexts, such as bird watching [10, 11].

Citizen Science project delivers sustainable outcomes. It contributes to creating awareness over an environmental issue related to the disappearing of species, pollution and on social issues like diseases [12]. Also, citizen science help mitigating these issues by means of the collection of data which are then analyzed by experts in order to develop a solution [11]. Moreover, citizen science platform can help develop a community over a distinct issue that can community it to people who are not aware by word of mouth. In this way, the sustainable value of citizen science project can be amplified. In order that citizen science is successful, researchers should manage the motivation and the engagement of volunteers, as well as the development of a suitable platform. With this study, I want to contribute to the literature illustrating these three topics deeply. I conduct a review of studies [13] in order to provide a recommendation for successful citizens science projects.

In the next section, I present the theoretical framing of citizen science. In Sect. 3, I illustrate the research method which I conducted. In Sect. 4, I portray the results of the literature review. The study concludes in Sect. 5.

2 Citizen Science

In literature, there are various definitions regarding citizen science: “*Citizen science enlists the public in collecting large quantities of data across an array of habitats and locations over long spans of time*” [9]; “*Engaging non-scientists to survey ecosystems, a process known as citizen science has been adopted worldwide*” [14].

Summarizing, citizen science is a scientific project, in which researchers or scientists engage citizens or “non-scientists” to collect data regarding a precise phenomenon through an online platform (or mobile application) [9]. The project purposes are twofold to study a phenomenon and increase citizen knowledge about it [11].

It is important to clarify which Citizen Science is not new. Scientists and citizens have already collaborated: “*Charles Darwin (1809–1888) sailed on the Beagle as an unpaid companion to Captain Robert FitzRoy, not as a professional naturalist* [12, pg 1]”. What is new is the employment of information and communication technologies. Indeed, afterwards, the choice of the scientific question, new socio-technical actors intervene in the projects: the volunteers and the platform. Scientists (or researchers), the managers of the projects, should handle these two actors because the success of the project depends on them, as well [11, 15]. The volunteer should be found, and they should be involved in the project. Thus, scientists should motivate these people in entering in the citizen science projects and maintaining a high level of engagement [16]. Also, the platform should be managed in order to make it easy to use and ready to acquire data [16].

Table 1 Model for the development of a citizen science project

Model for developing a citizen science project	Subjects	Critical actions for
1. Choose a scientific question	Scientists	
2. Form a scientific an evaluator team	Scientists, platform	Platform
3. Develop, test, and refine protocols, data forms, and educational support materials	Platform	Platform, volunteers engagement
4. Recruit participants	Volunteers	Volunteers engagement, volunteers motivation
5. Train participants	Volunteers	Volunteers motivation, volunteers platform
6. Accept, edit, and display data	Platform, scientists	Volunteers motivation, volunteers platform
7. Analyze and interpret data	Scientists	Platform
8. Disseminate results	Scientists	Platform
9. Measure outcomes	Scientists, volunteers	Platform

In Table 1, I summarized the phases to develop a citizen science project, based on the work by Bonney et al., which are enriched by the actors involved in the phase and the actions that researchers manage for each phase. The project is designed and tested in the first three phases, together with the platform. In phase 4 and 5, volunteers are recruited and trained to use the platform. Data are then collected. In the last three phases, data are analyzed and interpreted. Results are disseminated, and the project is eventually evaluated [11].

The extant literature revealed several application fields of Citizen Science projects. Mainly, citizen science project aims at investigating phenomena involved in the natural context where particular species of animals are the main subject. Bird-watching was the first “hobby” which is transformed into a citizen science project (ebird) [11, 16]. Still, I found other topics of citizen science project having as the main aim the understanding of illness (malaria) or “soft” theme like the implication on traffic after a drive-ability law reform in Finland and the meteorology [17].

3 Research Method

I conducted a literature review [13] over Scopus in January 2019 with the following query searches: Citizen Science AND Motivation; Citizen Science AND “Engag*” OR “Engaging”; Citizen Science AND “Platform” OR “Proces*”. In order to increase the validity and reliability of the research [18], I refined the search by choosing articles in English and only from journals. I merged all the articles which are extracted from the query searches in a single database. The database contains 450 articles. I read

all the title and abstracts, and I selected the most pertinent papers for the purpose of the research. Afterwards, I read the entire papers and I select the more relevant to my research. I was guided by investigating the topic of the motivation and the engagement of volunteers and the development of a citizen science platform. The final database contains 17 papers.

4 Findings and Discussion

In this section, I present and illustrate the findings for the topic of motivation and engagement of volunteers as well as the platform of citizen science projects.

4.1 *The Motivation of Volunteers for a Citizen Science Project*

The motivation of volunteers refers to the reasons for which volunteers undertake and pursue a citizen science project.

A citizen science project is often well-defined and aims at studying a particular phenomenon. This means that volunteers undertake the citizen science project because they already know something regarding the phenomenon, and they are enthusiastic in knowing more. Accordingly, the project design should plan actions to maintain alive this enthusiasm and interest.

From the proposed model for the development of a citizen science project in Table 1, an important task, in phase 3 (the design part), is to create educational materials, because these materials can be offered to support participant understanding and satisfactory completion of project protocols [9]. Still, according to Dem et al. volunteers are keen on taking part in a scientific project and interested in knowing about the results [19]. Indeed, according to Landzandra volunteers wanted and reported a gain in knowledge about citizen science and the topics of the project [20].

The training phase is a further important action to manage. Indeed, in this phase, volunteers, previously engaged, are motivated to undertake the project, and they have to learn how to use the application. If the application is not clear and easy to use motivation tends to decrease, producing a negative impact on the project.

Motivating volunteers also include the development of reward actions for them. Being the participation free, volunteers do not aim at a monetary reward but a recognition [21]. Studies posited that volunteers want a recognition which has social and environmental value. Environmental reward refers to taking part in the scientific process and acquiring knowledge (or educational learning) through the data collections and interactions with scientists and the fulfilment of the project. The social reward refers to the knowledge that can be put into practice in the real-life and useful for the community [22].

These rewards should be designed prior to the beginning of the project: “*The majority of the citizen science programs focused on scientific outcomes, whereas the educational and social benefits of program participation, variables that are consistently ranked as important for volunteer engagement and retention, were incidental. Evaluators indicated usability, across most of the citizen science program sites, was higher and less variable than the ratings for participant engagement and retention [20, p. 568]*”. Accordingly, scientists should design phase 8 – dissemination results both to present the results to other scientists (conferences, papers) both to the citizen in order to make the results tangible for the community.

In conclusion, to maintain the motivation of volunteers, managers should organize events to facilitate face-to-face interaction of volunteers along the process. Thus, it is important to provide users with tools to communicate in order to support social learning, community building and sharing [24]. This has implications for the design and management of online citizen science projects. Furthermore according to Cappa, beyond the enrichment of the task is to provide supports to the citizen through face-to-face interaction between scientists and volunteers, since information technologies (App or website) can isolate volunteers from the rest of the project [25].

4.2 *The Engagement of Volunteers for a Citizen Science Project*

The term *engagement* refers to the actions to communicate project and recruit volunteers. Despite, the query produced several results, very few papers focus on this topic, which is represented by *Phase 4 - Recruit participants* of our main schema. I proposed some extracts:

“During February 2006, 2007, and 2008, we recruited 58,35, and 26 volunteers respectively from the New York-New Jersey Trail Conference (NYNJTC); a recreational hiking association with a membership of about 10,000 individuals and about 100 clubs. These volunteers were recruited via an email flyer sent to the entire membership. We offered no material incentives. If volunteers were able to undertake the hiking and could attend the training sessions, they were accepted [18, pg. 427].”

“Potential participants were informed about the project through (a) the website of the project; (b) an information desk in the Cretaquarium; (c) posters and leaflets which were distributed in the participating diving clubs and the tourist information offices. Often, divers were approached directly before their dives in the diving centres and usually expressed interest in participation¹”.

“Aided by a social media campaign that raised awareness of the project in the two jurisdictions, citizen scientists were recruited in-person from community centers located in different areas in each city and the universities of Regina and Saskatchewan to ensure recruitment of a representative sample²”.

¹<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5893892/>

²<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5893892/>

From these examples, I can state that to engage volunteers, the management of citizen science project should create a communication plan through different types of media. Indeed, Bonney et al. said. that participants can be recruited by a various techniques like press releases, listservs, direct mailings, advertisements, public service announcements, magazine and newspaper articles, brochures, flyers, and presentations, including posters and workshops at conferences of potential participants or their leaders [9].

Moreover, Pandya proposed a framework to engage diverse communities in citizen science in the U.S. starting to reflect on the reasons for the lack of participation (family resources: lack of transportation, access to natural areas as well as and scientific education) and concluding with a well-articulated framework [27]:

- Align research and education with community priorities. Here, Pandya et al. said that the research question is driven by a need of the studied community. In that way, it will be easier to find volunteers.
- Plan for co-management of the project. The citizen science management should propose a training course to make easier the data collection since inevitable conflict should happen during the project.
- Engage the community at every step.
- Incorporate multiple kinds of knowledge. Successful participatory projects seek expertise from all participants and build processes and procedures (such as regular community meetings) to facilitate and validate that expertise.
- Disseminate results widely.

Concluding, these studies show that volunteers are challenging step without a strategy. There is a commitment to finding these volunteers. Firstly, the recommendation is to find volunteers within the community which is interested in the topic - the beauty of citizen science is that very specific and it is not difficult to find the main topic and their audience. Afterwards, the management of the project should encourage these volunteers to “convince” friend to help the project (word of mouth).

4.3 The Platform for a Citizen Science Project

Platform refers to the information technology (web site or mobile app) which is employed for two main tasks: to acquire, collect and analyze the information as well as allowing the volunteers to create a community and get their recognition (*in terms of scientific results*) [12]. Data are often stored in the cloud in order to reduce costs [28].

The platform is an actor intervening in several phases of the main framework. Indeed, the platform is designed in Phase 2 - Form a scientist/educator/technologist/evaluator team through a commitment of scientists and IT technicians. Thus, in Phase 3 - Develop, test, and refine protocols, data forms, and educational support materials, the platform is tested and evaluated. Here, the main goal is to make suitable the platform to collect the data in a scientific way and ensure

data quality [9]. The data quality issue is crucial for citizen science since reliable data is not often accomplished. To address this issue, citizen science projects employ accurate technologies [10] or stringent protocol. Bear in mind that the employment of stringent protocol shall be presented with a user-friendly way. Otherwise, it causes reduction of volunteers [16]. Moreover, this protocol improves the reliability of data through the automation of location (GPS) and the species (or subjects of analysis) recognition as well as validation tools in the data gathering (If the volunteers fulfil the form entirely). Still, some works said that further development to improve the data quality is the creation of a data centre within different citizen science projects, where the data can be integrated [29, 30].

In phase 5 – Train participants, volunteers try and test the platform. Studies assert that the application should be user-friendly and presented as a means to engage the volunteers [9]. Phase 6 and 7 are the most important and crucial part of the project because all the data are gathered, analyzed and interpreted. These two phases are effective, whether the application has been well-designed [9].

Along with the entire project, the application should have “social skills”. Indeed, the creation of a community is useful both to maintain high the moral/motivation of the volunteers both to have a trained public for future citizen science projects. Thus, the application should have functionalities for the communications among volunteers and scientists (a sort of social network of the project). Still, the application should contain functionalities to disseminate the results among the volunteers allowing to get their “recognitions”.

Whether you are seeking practical advice to design a platform, Newman et al. reviewed how to develop a citizen science platform studying volunteer perceptions, and how to solve problems and improve the platform performance [16]. The framework highlights that a platform needs customizable data entry forms and allows to communicate volunteers among and other and with scientists.

5 Conclusion

The study illustrates three main actions that the developer of a citizen science project should manage: the motivation and the engagement of volunteers and the development of a platform. Based on a literature review, I summarize and propose discuss recommendations to address these actions. The study has certain implications for practitioners. I pinpoint various aspect that managers should consider during the design phase of the project and along with the project. I also highlight a model for the development of citizen science and actions to manage the volunteers and the development of the platform.

The study also has implication for researchers. The study illustrates a participative approach for citizen science, where the role of volunteers is crucial. The platform has two features, both related the data acquisition but also to maintain alive the commitment of volunteers. Further studies investigate this participative approach exploring further critical factors for an effective citizen science project, and what are the features

to make easy-to-use a citizen science platform. Moreover, researchers should advance the knowledge related to the sustainable outcome of citizen science projects and when such project can be integrated into a Smart City architecture. The study has a limitation because I used the Scopus database for the literature review. Thus, I encourages researches to conduct a similar literature review employing different a database, such as Google Scholar and Web or Science.

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