Chapter 8
Social Context of Citizen Science Projects

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ABSTRACT

This chapter provides a brief history of citizen science in our societies, identifies the main stakeholders involved in projects of this topic, and analyzes the main points to take into consideration, from a social perspective, when designing a citizen-science project: communicating; recruiting and motivating participants; fostering innovation, interdisciplinarity and group dynamics; promoting cultural changes, healthy habits, inclusion, awareness and education; and guiding policy goals and decisions. Different governance structures, and a coexistence of different approaches, are analyzed together with how they suit different communities and scientific studies.

INTRODUCTION

Citizen science engages the general public with scientific research activities, and while not new, is becoming a mainstream approach to collect data on a variety of scientific disciplines (Miller-Rushing, Primack, & Bonney, 2012). The consolidation of citizen science can be perceived from the adoption of a formal name, increased research about the field and formalization of international associations. Citizen science maturity has advanced with technology innovations of recent years.

Societies are facing rapid changes in values, interests and expectations. The growth of social networks and collaborative web projects has implications for the relations between scientists, decision makers and different societal groups. Citizen science is growing to be a mechanism that allows citizens to have an active role in science development and in dealing with important environmental and scientific questions.

Scientists who support the rise in citizen science recognize the benefit of volunteer contribution to science in terms of increased scale, data collection and analysis, outreach capacity, while dealing with budget constraints. Consequently, an increasing number of studies have started to work with volunteer citizens, helped by easily accessible technological tools. Awareness among scientists for these social

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changes has increased, generally in a gradual way, but faster in countries with a higher tradition of public participation, especially scientific participation (Hess, 2010).

Citizen science can also have a positive impact on society and support sustainable development, by fostering connections between environment, society and economy and overcoming barriers between disciplines (Giddings, Hopwood, & O'Brien, 2002).

Given its collaborative nature, citizen science is characterized by a wide range of stakeholders, whose motivations and interactions can be determinant for the success of a citizen science project and thus should be carefully taken into account on project design.

This chapter provides a brief history of citizen science and identifies the main stakeholders involved in these projects. The chapter then analyzes the main points to take into consideration, from the perspectives of these different stakeholders, when designing a citizen science project.

THE HISTORY OF CITIZEN SCIENCE IN OUR SOCIETIES

For centuries, scientific research was conducted by amateurs (people that were not paid to do science) (Vetter, 2011). Professionalization of science, in the late 19th century, drew those amateurs away from the scientific world and created a big gap between "real scientists" (people that are paid to do science) and citizens interested in those subjects (Vetter, 2011).

John Ray, Alfred Russell Wallace, Gregor Mendel are prime examples of amateurs who produced incredible scientific advances. John Ray published important works on botany, zoology, and natural theology and his classification of plants in *Historia Plantarum*, was an important step towards modern taxonomy (Raven, 1942). Alfred Russel Wallace was a British naturalist, explorer, geographer, anthropologist, and biologist. His best known work was on the theory of evolution through natural selection and his paper on the subject was jointly published with some of Charles Darwin's writings in 1858 (Raby, 2001). Gregor Mendel was a friar who gained posthumous fame as the founder of the modern science of genetics. His pea plant experiments established many of the rules of heredity, now referred to as the laws of Mendelian inheritance (Weiling, 1991). These individuals were largely pursuing research because of an innate interest in particular topics or questions (Vetter, 2011) and were recognized experts in their field, conducting research indistinguishable from today's professional scientists.

On a different level of participation, though not yet called citizen scientists, general people have also been involved in scientific activities on a volunteer basis for centuries, documenting observations of nature. Farmers, hunters and amateur naturalists were some of the activities involved in collecting natural world data (Miller-Rushing et al., 2012). In the 18th century, Carl Linnaeus, collected, with the help of many volunteers, animal, plant, rock and fossils specimens and artifacts from around the world. For 1200 years court diarists in Kyoto, have been recording dates of the traditional cherry blossom festival (Primack, Higuchi, & Miller-Rushing, 2009) and in China citizens and officials have been tracking outbreaks of locust for at least 350 years (Tian et al., 2011).

In some specific science issues, such as weather, astronomy and birds surveys, there is a long history of citizen science, particularly in Anglo-Saxon countries and center and northern European countries such as England, United States of America, Australia, Netherlands or Finland.

The project National Weather Service - Cooperative Observer Program (NWS-COOP) has been collecting basic weather data across United States since 1890 with results supporting much of what we know about variability and directional changes in climate (Miller-Rushing et al., 2012). With a twofold mission of providing observational meteorological data and helping to measure long-term climate changes, the project has more than 8,700 volunteers taking observations in farms, in urban and suburban areas, National Parks, seashores, and mountaintops (NOAA, National Weather Service, 2014).

In the astronomy area, the British government funded, in1874, the Transit of Venus project to measure the Earth's distance to the Sun. This project engaged the admiralty to support data collection all over the globe and recruited the services of amateur astronomers (Ratcliff, 2008).

Ornithology has a long linking history with citizen science. Bird monitoring in Europe goes back to 1749, when amateurs, in Finland, collected data on timing of migration (Greenwood, 2007). Wells Cooke, a member of the American Ornithologists' Union, developed one of the earliest known formal citizen science programs in the United States, in the late 18^{th} century. This project, overtime, transformed into today's North American Bird Phenology Program. Citizens involved collect, on cards, information about migratory bird patterns and population figures. Those cards are being scanned and recorded into a public database for historical analysis (Dickinson, Zuckerberg, & Bonter, 2010). Another example of one of the oldest citizen science programs in the United States, which is still active, is the Christmas Bird Count, sponsored by the National Audubon Society. Since 1900, the organization has sponsored a bird count that runs from December 14 through January 5 each year. An experienced birder leads a group of volunteers as they collect information about local populations of birds. More than 2,000 groups operate across the United States and Canada (Dickinson et al., 2010).

Nowadays the focus of citizen science is changing from the traditional "scientists using citizens as data collectors" to citizens as scientists (Lakshminarayanan, 2007). In this new era of citizen science projects, citizens can participate at the diverse stages of the scientific process from co-creating a project with a scientist, following up all the steps of the project, raising new questions, collecting or analyzing data, producing reports and disseminating findings (Tweddle, Robinson, Pocock, & Roy, 2012). Depending on the desired level of engagement in science, different models of action can be adopted, such as pooling of resources, collective intelligence, grassroots activities, data collection, analysis tasks, serious games or participatory experiment (Socientize, 2014).

Citizen Science has already a long history and has recently begun to evolve into a broad research methodology with new applications and different stakeholders' approaches. Several historical case studies and personalities, involved with this subject, may help us analyze what can be the future direction of citizen science.

WHO ARE THE DIFFERENT STAKEHOLDERS INVOLVED IN CITIZEN SCIENCE PROJECTS?

Citizen science, although in its basic form was viewed as a partnership between volunteers and scientists to answer real world questions (Cohn, 2008), was expanded to a multiplicity of stakeholders, ranging from research scientists, teachers, students, managers, environmental organizations, and politicians (Bonney et al., 2009), due to its potential for educational purposes, raising awareness and driving policy changes, among other reasons. These stakeholders have many different interests in citizen science, and face particular constraints in their involvement.

Despite the considerable amount of stakeholders involved, clustering them into four groups: citizen scientists, scientists, other societal groups and policy makers, allows us to analyze the project design from these four different perspectives. Citizen scientists and scientists are directly involved in the scientific process, while other societal groups and policy makers are more indirectly involved, e.g. using data, promoting education, guiding policy goals and decisions or giving answers to social concerns.

Assuring a good and stable relationship between the interests of these groups is important for the project's success (Figure 1).

Thinking specifically in the citizen scientists, depending on the project aims and activities, target people are diverse and may include hobby and professional groups such as schools, students, scouts, naturalists, tourists, sports enthusiasts, farmers, fishermen, or multiplicity of actors. Engaging these different stakeholders into a shared framework with some common and some specific means of communication are good ways to achieve results. Projects like eBird, iSpot and iNaturalis have in their objectives and strategies specific ways of involving and engaging different groups (Sullivan et al., 2009; Clow & Makriyannis, 2011; Bowser, Wiggins, Shanley, Preece, & Henderson, 2014).

Points to Take into Consideration IN Project Design

Project design is a crucial step in ensuring the effectiveness of the project and the capacity to achieve its goals (Raddick et al., 2009). When designing a project, this will inevitably involve trade-offs, e.g. gathering comprehensive, high quality data according to rigorous scientific protocols, and the ease of data collection (Hochachka et al., 2012). If the data collection is too complex or too time consuming, volunteers may lose their desire to participate and thus, understanding and adapting the program to the skills, expectations and interests of the volunteers is critical (Shirk, Bonney, & Krasny, 2012).

Figure 1. Groups of stakeholders involved in citizen science projects

When designing a citizen science project, it is thus important to take into account a social perspective meaning the interactions generated between the different stakeholders, their collective co-existence, regardless of whether they are aware of it or not, and of whether the interaction is voluntary or involuntary.

Although citizen science is nowadays a broad methodology used in many different scientific areas, there are several cross-cutting issues, common to all of them. Highlighting the importance of taking a stakeholder view when designing a citizen science project, table 1 summarizes issues to take into consideration, which will be analyzed in detail below. Some, such as motivation or awareness, are important for several stakeholders, but in very different ways and assuming varying degrees of importance.

Communicating and Recruiting Participants

When designing the project, and after deciding that citizen science is the best methodology to achieve the project's goals (Tweddle et al., 2012), one must identify the groups that might want to be involved, understand the reasons and motivations they have to participate, recruit them and maintain their participation over time. In recent years much has been written on communication and recruiting (Van Den Berg, Dann, & Dirk, 2009; Dickinson et al., 2012; Roy et al., 2012; Pandya, 2012; Tweddle et al., 2012; Silvertown, Buesching, Jacobson, & Rebelo, 2013).

The starting point for recruitment is to determine who the target audience is, which can be from a specific group like students, amateur astronomers, bird watchers, divers or from a broad group like inhabitants of a certain area (Bonney et al., 2009). Knowing who will be the projects' participants is important to decide how to reach them, what will be said, how it will be said, when it will be said, where it will be said and who will say it (Kotler, Wong, Saunders, & Armstrong, 2005). Successful citizen science projects like eBird, Galaxy Zoo, OPAL, attached great importance to the communication approach with the targeted volunteers (Sullivan et al., 2009; Raddick et al., 2010; Tweddle et al., 2012).

Then it is necessary that people who might want to participate get to know that the project exists, to whom it is directed and what are its main objectives (Cohn, 2008).

Table 1. Points to take into consideration for different stakeholder groups, in a citizen science project design

Project design			
Citizen Scientists	**Scientists**	**Other Societal Groups**	**Policy Makers**
• Communicating and recruiting participants • Motivating participants • Promoting education • Giving feedback • Enabling personal recognition and reward • Taking into account work scale preference	• Enabling outputs for scientific studies • Assuring data quality • Sharing open source results • Fostering innovation, interdisciplinarity and group dynamics • Motivating participants • Overcoming reluctance	• Giving answers to social concerns • Promoting healthy habits • Promoting inclusion • Promoting awareness and education • Taking into consideration cultural differences • Overcoming reluctance • Sharing open source results	• Guiding policy goals and decisions • Giving answers to social concerns • Promoting awareness • Overcoming reluctance
Project Evaluation and Governance			

These recruitment efforts may vary, depending on the previous existence – or not - of a community (Robson, Hearst, Kau, & Pierce, 2013). Nowadays there are websites dedicated to host citizen science projects where people can obtain information and enlist as volunteers (Dickinson et al., 2012; Newman et al., 2012). Platforms like Zooniverse, one of the world's largest and most popular platform for people-powered research, covers many disciplines and topics across the sciences and humanities (Reed, Raddick, Lardner, & Carney, 2013). With specific high motivated groups, or in countries with a higher tradition on citizen science, e-mails and newsletters can be sufficient ways of promoting the project (Dickinson et al., 2012). Social networks like Facebook or Twitter provide, nowadays, good opportunities to reach a high range of participants (Pickard et al., 2011; Robson et al., 2013).

In countries facing barriers to public participation, due to lack of tradition in these areas, the actions to promote the project and then to engage people to participate, need to be much more active.

For a more effective recruitment process the use of different types of media is important. Sometimes it is the scale of the project that determines the capacity of the project manager to reach several media channels: print media (newspapers, magazines, direct mail, and specialist publications), broadcast media (radio, television), display media (signs, posters, billboards spread in a country, city, school – depending on the scale of the project), and online and electronic media (websites, social networks) (Kotler et al., 2005).

Organizing a launch event or an event at an existing festival or fair that allows face-to-face contact, can be an important social measure to promote the project (Wiggins & Crowston, 2011), allow citizens to interact directly with the scientists involved and establish a relationship (Tweddle et al., 2012).

Also allowing time for participants to socialize during activities is important for recruitment and retention for longer-time (Silvertown et al., 2013). Word-of-mouth recruitment between peers is one of the most powerful ways of growing a network of contacts. Identifying "influencers" can bring other persons along, increase visibility, credibility and create bandwagon effects (Kotler et al., 2005).

Motivating Participants

Motivations of volunteers and scientists to participate or conduct a citizen science project, have already been the subject of several studies from different authors (Bruyere & Rappe, 2007; Van den Berg et al., 2009; Bramston, Pretty, & Zammit, 2011; Jordan, Ballard, & Phillips, 2011; Silvertown et al., 2013).

Understanding citizen scientists' motivations to contribute may improve the results obtained. These motivations may be different from country to country and for different societal groups or age groups (Dierkes & von Grote,2000; Forte & Lampe, 2013). Cultural differences also influence the reasons to collaborate (Rotman et al., 2014). Some of the main participant motivations highlighted in many of the existing studies include:

- The desire expressed by participants to learn new skills and about the scientific issues behind the project (Bell et al., 2008; Van den Berg et al., 2009; Raddick et al., 2010);
- The desire to see the impact of their work (being able to see and share the efforts undertaken and its further use within a scientific or policy community) (Van den Berg et al., 2009);
- The sense of making a discovery, e.g. finding a new galaxy in Galaxy Zoo project (Raddick et al., 2010);
- The desire to feel as active participants and co-owners of the project (Dickinson et al., 2012; Rotman et al., 2014);

- Gaining recognition for their input, e.g. through feedback and interaction with scientists and peers, and through gaining achievements (Rotman et al., 2014);
- The desire to feel competent in doing a task (Rotman et al., 2014), e.g. progression to expert status or from simple to more complex tasks requiring additional responsibility (Nov, Arazy, & Anderson, 2014);
- The sense of participating in a project that might be relevant to their community (Van den Berg et al., 2009);
- The feeling that they are helping the environment and taking an active conservation action (Van den Berg et al., 2009);
- The enjoyment of developing activities in nature (Bell, et al., 2008; Van den Berg et al., 2009);
- Getting to know other people with similar interests and making new friends (Van den Berg et al., 2009);
- Allowing to explore different career options (Van den Berg et al., 2009);
- The enjoyment of developing team activities that put scientists and citizen scientists working together with a sense of camaraderie, making scientific exploration and discoveries enjoyable (Nov et al., 2011; Newman et al., 2012);
- Competing with other participants. Some projects appeal to the competitiveness of the participants by providing tools for determining the relative status of volunteers (e.g. numbers of species seen) and geographical regions (e.g. checklists per area) (Hochachka et al., 2012).

While most people committed with citizen science projects are likely to belong to an already environmentally aware subsector of the population (Coghlan, 2005), a surprisingly large number of people are motivated by curiosity, tourism motives or because they want to make a new start in life (e.g. after divorce, job redundancy, etc.) (Silvertown et al., 2013), although these motivations may hardly sustain, by themselves, long-term participation.

Studies on motivations, from the perspective of scientists, to participate in citizen science projects are scarce. Some identified motivations for scientists include: professional reasons like further their own professional career, promoting their scientific work in society, the outreach obtained with those projects, advance science, and become more aware of local knowledge and expertise (Carolan, 2006; Rotman et al., 2012).

Providing Education

Some studies show that many skills needed to do research can be obtained by non-experts when they are properly trained (Janzen, 2004; Cohn, 2008). Citizen science projects can benefit greatly from the educational materials provided by scientists, despite some scientists still framing this training and supervising as time wasted away from professional research, rather than a beneficial investment of time (Silvertown et al., 2013).

Most citizen science projects provide volunteers with educational material like training workshops, field lessons (e.g. on species identification, field guides, volunteer manuals or web-based educational tools; Crall et al., 2010). In some cases participants also need to learn how to use maps, technological devices and applications, such as GPS units (Crall et al., 2010).

Protocols used for citizen science should be easy to perform, explainable in a clear and straightforward manner, and engaging for volunteer participants (Bonney et al., 2009). Pilot-testing protocols with naive audiences is important when directed at a wide swath of potential participants. For example, Cornell Lab of Ornithology project designers have tested draft protocols with local bird clubs, school groups, and youth leaders by accompanying participants in the field and observing them as they collect and submit data and tested protocols at distant locations by collecting online feedback. When protocols prove to be confusing or overly complicated, they can be simplified, clarified, or otherwise modified until the participants can follow them with ease (Bonney et al., 2009).

The higher the interaction between scientists and citizen scientists, the higher is the engagement of participants (Dickinson et al., 2012). People tend to participate more when they feel supported by the appropriate expertise while doing the activity. Participants should have all the information about the project and should feel helped by the project team.

Some projects develop learning elements that align with relevant school curriculum standards (Zoellick, Nelson, & Schauffler, 2012). Partnerships between schools and these citizen science projects are likely to become much more important in the future with substantial gains for the projects' multiple goals.

Giving Feedback

Giving participants a rapid feedback and providing regular communication about their contribution and the outcomes of the project, is a powerful way of motivating them and maintaining their participation, since people like to know to what they are collaborating and how is being used the information they are collecting (Devictor, Whittaker, & Beltrame, 2010). Giving feedback is also an important way for people to increase perceived competence and usefulness of their participation.

This feedback can be included by design of the project (e.g. real-time publication and/or validation of the information collected in the project website), or can also be accomplished in many different ways, such as through field events, email, phone, newsletters, blogs, discussion forums and various forms of social media. Organizing a closing event can also be a good way to share results and thank the participants (Tweddle et al, 2012).

Enabling Personal Recognition and Reward

Rewarding citizen scientists, in a number of ways, provides a sense of achievement (Tweddle et al, 2012) and is thus an effective way to encourage and support participation. Volunteers like the idea of knowing that their work is important and that their contributions can help scientists make better and more comprehensive analyses (Musick & Wilson, 2007).

A reward system can be implemented in several different ways such as highlighting the identity of contributors with observations to acknowledge their contributions explicitly (e.g. in Observado, iSpot and iNaturalist; (Clow & Makriyannis, 2011; Bowser et al., 2014), providing participants with certificates of recognition, thanking participants and acknowledging their role (e.g. through organization of a closing event, which can also be used to solicit further inputs and give feedback of project's results) (Tweddle et al, 2012), providing open access to all records in the database, or at least the non-sensitive (Newman et al., 2012), holding a competition (Newman et al., 2012), recognizing the degree of volunteer expertise (e.g. progressing from amateur to expert levels in iSpot; Clow & Makriyannis, 2011), fellowships and sponsorship, symbolic rewards such as badges (Cooper, Dickinson, Phillips, & Bonney, 2010; Clery, 2010).

The eBird website was modified to provide direct rewards to participants and with these modifications participation rapidly increased and eBird has gathered more information in 1 month (almost 3 million observations) than it did during the entire first 2 years of the project (2 million observations) (Hochachka et al., 2012).

Project managers should make an effort to provide easy access to scientific, institutional, managerial and/or legislative information packages produced from project data, in ways of interest to stakeholders. Apart from their immediate value to the target stakeholders, this helps participants understand the value of their contribution. For example, it may not be readily apparent that a few species observations might contribute collectively to e.g. reveal the arrival of invasive / pest species, and eventually promote a policy measure.

Taking into Account Work Scale Preference

Different citizen science projects have different goals and, depending on those, work at different scales such as local, regional, national, continental, global or virtual. Not all citizen scientists like to work at the same scale, preferring to be engage with local questions, helping to give answers to a community problem, while others like broad scale issues like climate change questions or species invasions problems (Cooper et al., 2007; Dickinson et al., 2010; Wiggins et al., 2011; Hochachka et al., 2012).

Enabling Outputs for Scientific Studies

For research scientists, citizen science projects can offer many benefits for their work but usually require a balance between data quality and quantity. The amount of data that can be collected and the geographic scale of these data can give a completely different dimension to a scientific study (Bonney et al., 2009). Funding constrains often limit the amount and scope of these studies and citizen science projects allow them to become a reality (Darwall & Dulvy, 1996; Danielsen, Burgess, & Balmford, 2005). The incorporation of these new sources of data with scientific projects enable them to fill existing gaps e.g. on species distributions (Danielsen et al., 2005).

Some citizen science projects do not produce scientific peer reviewed publications (Theobald et al., 2015) but more awareness publications, in many cases due to a lack of data quality assurance.

To optimize the data quality and quantity provided by participants, researchers must understand which factors affect most their performance (Bueshing & Newman, 2005; Bueshing & Slade, 2012) and then find ways to optimize and mitigate these factors, for instance allocating tasks to the best suited individuals (Mackney & Spring, 2000), which can represent an increase on the quality of data collected.

Another issue to take into account is that some projects, that have specific goals, can have outputs that might be useful for different purposes, not always foreseeable. Flexibility and data open access can increase the projects scientific value.

Assuring Data Quality

Assuring data quality is important in attracting more scientists to use and engage with citizen science projects and become this methodology widely accepted (Dickinson et al., 2010, Bonter & Cooper, 2012). In order to achieve the scientific goals of the projects data collected by citizens should be validated, e.g. checked for errors and entered reliably into databases suitable for further analysis and sharing (Crall et al., 2010).

Statistical approaches should be robust and adapted in order to achieve better data quality (Bird et al., 2014). Protocols need to be developed and later adjusted to any limitation identified (Bonney et al., 2009). Networking among scientists and citizen scientists is an important tool to improve protocols. In this regard a lot can be learnt with computer programmers open source systems (Bonney et al., 2009).

In citizen science projects concerning biology and ecology, the main problems identified in data quality include under or over estimation in species abundance measures (Bray & Schramm, 2001), species misidentification (Brandon, Spyreas, Molano-Flores, Carrol, & Ellis, 2003; Genet & Sargent, 2003; Fitzpatrick, Preisser, Elison, & Elkinton, 2009), protocols too simple that did not produce useful data (Engel and Voshell, 2002). Even though taxonomic identification is a skill that requires years of training the rates of misidentification depend on species rarity or conspicuity (Genet and Sargent, 2003). Many citizen science projects ask people to add information on presence of species (ignoring absences), introducing in those projects problems of bias relating to presence-only data. However, the growing number of participants in citizen science projects can help to reduce uncertainty. A place where large numbers of volunteers submitted presence data for some species, but no data on presence of other species, confidence can be increased that the lack of data on the absent species is due to the true absence of the species, rather than from a lack of sampling effort (Stafford et al, 2010).

Sharing Open Source Results

Nowadays, in citizen science projects the most accepted culture is openness and free data access which is shifting some science paradigms (Newman et al., 2012; Socientize, 2014). However it should still take in consideration the intellectual property rights, fundamental personal data protection rights, ethical standards, legal requirement and scientific data quality (Newman et al., 2012; Socientize, 2014). Information and communication technologies foster open, efficient and agile systems, turning ideas into the actions required to mobilize citizens individual and collective.

There are still some concerns over sharing data due to data sensitivity like species cultural or biological significance (Jarnevich, Graham, Newman, Crall, & Stohlgren, 2007), or private property. To avoid this, many citizen science websites use features that protect those species like year filters (data can be hidden for a certain period) or data will be added with low resolution (Jarnevich et al, 2007).

Fostering Innovation, Interdisciplinarity, and Group Dynamics

When different people with different backgrounds are working together there is all an unpredictable group dynamic that achieve interesting results. Research on collective intelligence indicates that diversity matters and that new leaps of logic, innovation, and invention are more likely to arise when people of different backgrounds and abilities work together toward a common goal (Wooley, Chabris, Pentland, Hashmi, & Malone, 2010).

Comparing to more traditional scientific projects, a citizen science project aims to be more interdisciplinary involving both scientists and citizens with different backgrounds. Apart from the scientific thematic the study is about, a good project design should include people with different skills dealing with technologies available, social and communication aspects (Wiggins et al., 2011; Sullivan et al., 2014).

Creating opportunities for interaction between participants and scientists may also foster innovation and reach useful results (Newman et al., 2012).

Overcoming Reluctance

There is still high reluctance in people from different societal groups (scientists, politicians, decision makers, teachers, students), concerning citizen science projects. Some of them put in question data quality, some do not understand the aims of citizen science projects, the reasons to participate and to use data from these projects (Bonney et al., 2009; Catlin-Groves, 2012).

Project team should be as available as possible to answer questions, to provide any clarification required and to change communication strategies when they are not being effective (Bonney et al., 2009) in order to increase the perceived credibility of the project.

Giving Answer to Social Concerns

Several societal groups take an interest in citizen science due to its ability to give citizens the opportunity to address social concerns and priorities.

In the citizen science process, concerned citizens, government agencies, industry, academia, community groups, and local institutions collaborate to monitor, track and respond to issues of common community concern (Whitelaw, Vaughan, Craig, & Atkinson, 2003). Areas like pollution, public health or species monitoring invasions are sensitive to society in general and thus frequently are subjects for citizen science projects (Cohn, 2008; Bonney et al., 2009; Crall et al., 2011).

Public support for conservation can be increased by building social capital (Schwartz 2006) and this has been measured by increased levels of trust, harmony, and cooperation in communities with scientific engagement (Sultana & Abeyasekera, 2008). This can lead to a more educated community (Pollock & Whitelaw, 2005; Cooper et al., 2007) and a creation of a stewardship ethic (Whitelaw et al., 2003; Cooper et al., 2007).

At the same time, there is evidence that long-term economic and environmental success arrives when people's ideas and knowledge are valued, and power is given to them to make decisions independently of external agencies (Pretty et al., 1995).Citizen science projects also seemed to promote more sustainable communities (Whitelaw et al., 2003).

Communities where citizen science is prevalent tend to be more engaged in local issues, participate more in community development, and have more influence on policy-makers (Whitelaw et al., 2003; Pollock & Whitelaw 2005; Lynam, Jong, Sheil, Kusumanto, & Evans 2007).

Highlighting the social concerns addressed by citizen science may thus be a strong argument when communicating with different society groups, in particular policy makers.

Promoting Healthy Habits

Many citizen science projects promote nature observations in the field. Getting more people into nature is, by itself, an excellent value that may be drawn from citizen science projects (Cohn, 2008). Projects like OPAL have a strong connection with young children and schools promoting a proper childhood development and physical and emotional health once it stimulates interactions with nature which can be quite important (Louv, 2005). The increasing prevalence of childhood obesity has lead policy makers to rank it as a critical public health threat for the 21st century (Koplan, Liverman, & Kraak, 2005). When attending to many citizen science activities, child, young people and adults avoid sedentariness and engage in physical activity. For elder people, participating in citizen science projects is also a way to maintain brain and/or physical activity.

Promoting Inclusion

Citizen science projects aim to be inclusive (Pandaya, 2012). Studies have shown that diversity benefits all participants (Gurin, 1999) and the project itself. Different groups of citizens from different age groups, race, educational level, background, are called directly to take part in some projects, so, it is possible to find projects with specific actions for universities of the third age, minority groups Bushway, Dickinson, Stedman, Wagenet, & Weinstein, 2011) or prisoners (Ulrich & Nadkarni, 2009), with interesting results.

Some communities are frequently excluded from citizen science projects and identifying the barriers to participation is important for finding solutions to widening the community e.g. new technologies may inadvertently create barriers that widen the digital divide between those adopting/having the technology and those avoiding/lacking it (Newman et al., 2012).

Promoting Awareness and Education

Concerns about climate change, species extinctions, land use change, are recurrently discussed in the media but, nevertheless, there is still a widespread scientific illiteracy in society (Miller, 2004). This illiteracy depends on the cultural background of the societies involved (Dierkes & von Grote,2000) and citizen science projects can help promoting citizens' education.

Participating in citizen science projects increases people's awareness in many different areas. Due to its participatory nature, these projects appear well suited to elevating public understanding and support for science, environment and earth stewardship (Shirk, et al., 2012).

The increment of science literacy is a huge benefit of citizen science, giving a personal empowerment to the people involved (Brossard Lewenstein, & Bonney, 2005). Participants that improved their science and technology literacy are better informed to make decisions and can contribute more effectively to society as citizens, workers or consumers (National Science Board, 2008).

Some countries identify the need to put students in an educational environment that instigates them to ask questions, plan and conduct an investigation, use appropriate tools and techniques, think critically and logically about the relationships between evidence and explanations, construct and analyze alternative explanations, and communicate scientific arguments (Natural Research Council, 1996). Citizen science projects can play a role to achieve this objective.

Ideally, citizen scientists will be endowed with knowledge and skills to collect and disseminate this awareness and expertise.

Scientists face nowadays citizen science as a way to connect scientific research to public outreach and education (Lepczyk et al, 2009). It is also true that a public educated on these issues is more likely to fund and support scientific research that seeks to address them (National Science Board, 2008).

Taking into Consideration Cultural Differences

Multiple social and cultural drivers can affect the amount of information available and the efforts required from citizen science projects. To encourage participation in citizen science, project managers should recognize differences across countries, regions, and societal groups.

For example, the number of species observation records per square kilometer is high in countries with high per capita gross domestic product, high proportion of English speakers and high security levels, although those are not necessary countries with higher biodiversity (Amano & Sutherland, 2013). In some countries the value of public participation remains largely unknown to the society so, in these countries, the effort required should be much higher.

Sensitivity to cultural factors will be important to the success of projects that cross boundaries and involve local/traditional ecological knowledge (Dierkes & von Grote,2000; Ballard, Trettevick, & Collins, 2008). Even inside a specific country, significant differences in cultural attitudes towards citizen science may be found between different regions (Rotman, et al., 2014).

The project's strategy should match the target culture, so the two need to be in alignment. Sometimes, focusing on a few critical shifts in behavior may provide best results with the least effort. Measuring and monitoring cultural evolution are also best practices to take into account throughout the project, in order to identify backsliding or correct course (Katzenbach, Steffen, & Kronley., 2012).

Guiding Policy Goals and Decisions

Citizen science projects and their results can guide and influence policy goals and decisions. Community's awareness and literacy attained with these projects may lobby politicians concerning environmental issues.

The data collected by these projects can be used in policy area for management, like natural resource management (Brown, Krasny, & Schoch, 2001) or for environmental regulation (Penrose & Call, 1995). Citizen science projects that focus on biodiversity monitoring, in general, are beneficial to government agencies for several reasons: they offer a cost-effective alternative to government employee monitoring (Whitelaw et al. 2003; Conrad & Daoust 2008), fieldwork can be undertaken over larger areas and during non-office hours (Whitelaw et al. 2003) and they respond to governments' desire to have more stakeholders included in the process (Lawrence & Deagan 2001; Whitelaw et al. 2003). The specific projects of early warning, from pollution to invasive species, enable rapid responses. The inability to avoid invasions and control the existing ones resulted in enormous environmental and economic losses worldwide (Pimentel, 2011) and the costs associated to a false positive identification are much less than the cost of false negatives (Westbrooks, 2004). The need, in this area, of large amounts of data across multiple spatial and temporal scales requires strong collaborations among multiple stakeholders (Lodge et al., 2006). These particular subjects have a good media coverage and projects on these areas attract more participants and have a strong influence in policy decisions.

Conservation of biodiversity has become a major political issue, just like climate change. States are obliged, by international agreements, to implement the Convention on Biological Diversity and several indicators are being developed to achieve the convention's objectives. In France, for instance, the implementation of the indicator "Trends in the abundance and distribution of selected species" is completely dependent on data collected by volunteers, which allows governments to save a significant amount of money (Levrel et al., 2010).

Another example of citizen science projects influencing policy measures comes from the USA. Pond associations from Martha's Vineyard, an island located south of Cape Cod, Massachusetts, had big concerns about water quality, mainly because of local shellfish industry. Numerous dedicated water monitoring initiatives, led by nonprofit organizations, and the partnerships forged with environmental managers in the area, have resulted in policy measures being taken (e.g., pressuring the Board of Health to inspect and replace failed septic systems, address boat related pollution, distributing pamphlets and educating boaters, etc.) and, consequently, in improvements to water quality (Conrad & Hilchey, 2011).

Evaluation

Evaluation of the success of the citizen science initiatives should be taken into consideration to achieve better results in the future (Newman et al., 2012) and contribute to socioecological system resilience (Jordan et al., 2012).

It is quite important to establish evaluation metrics regarding monitoring protocols, to ensure data quality (Engel & Voshell, 2002), to assess the effectiveness of the projects in meeting educational goals (Cohn, 2008; Bonney et al., 2009), to value the scientific outputs that come from the project e.g. scientific publications, and to identify policy goals and decisions influenced by the results.

Evaluating the impacts of citizen science projects on learning can be achieve by selecting appropriate indicators or measures of success, to ensure that the desired outcomes are achieved. Such indicators need to be targeted, feasible, valid, and reliable (Jordan et al., 2012). Though, in some cases there is still lack of effective evaluation mechanisms which can be filled, in educational area, by mechanisms from informal science education (Friedman, 2008).

Governance

The key principles of societal good governance have been categorized by: long-term vision, quality, openness, accountability, effectiveness, and coherence (Socientize, 2014). These principles can be achieved through a strategic commitment of society on citizen science. An urgent need for bottom-up initiatives that address community demands, is important if scientists want a more responsible, proactive and demanding society that uses its rights knowingly. New societies request from the governance area to establish new policies that prioritize science-society-policy interactions, fostering knowledge-based, intelligent and responsible selection choices. So, promoting a democratic governance of science, via public engagement and debate between policy makers, researchers, innovators and the general public in a structured channel for feedback and open criticism is fundamental. All different societal actors should play an important role, adding value to the scientific and social areas of society. Different background knowledge applied to different areas might allow creativity and joint solutions for solving problems.

The way citizens establish their participation commitments was traditionally categorized into top–down and bottom–up governance structures (Conrad & Hilchey, 2011). Lawrence (2006), suggested organizing participation into four forms: consultative (participants contribute with information); functional (participants contribute with information and are also engaged in implementing decisions); collaborative (participants work with governments to decide what is needed and contribute with knowledge) and transformative (participants make and implement decisions with support from experts where needed).

- **Consultative/Functional Governance:** This form of participation is frequently referred as top-down. This case implies that citizen science promoters are asking for help in collecting information or making decisions. The purpose might be to provide early detection of issues of environmental concern, which can then be further investigated by scientific experts. (Whitelaw et al., 2003; Conrad & Daoust, 2008).

An example of the consultative/functional model is the Cornell Lab of Ornithology bird monitoring projects where teams of scientists determine the questions to be answered and decide what segment of the public will be targeted as participants (Ely, 2008a). Most large-scale ecosystem monitoring programs (e.g., bird monitoring programs) tend to be consultative.

- **Collaborative Governance:** In this kind of governance participants might be involved in co-management or adaptive management, if management is part of the goal of the organization (Cooper et al., 2007). In these cases, projects are often governed by a board or group representing as many facets of the community as possible.

An example of a collaborative governance project is the Global Systems Science, which combines advanced information and communications technology with citizen dialogues to understand and shape global systems. This produces evidence, concepts and doubts needed for effective and responsible policies dealing with global systems, engaging citizens into policy processes and process to acquire data. The vision guiding Global Systems Science is to make full use of the progress in information communication technologies to improve the way scientific knowledge can simulate, guide, be used by, and help evaluate policy and societal responses to global challenges like climate change, financial crisis, pandemics, and global growth of cities (http://global-systems-science.eu/).

- **Transformative Governance:** In this case of governance participants make and implement decisions with support from experts where needed. Participants are governed from the "bottom-up", a model often arising out of crisis situations (this may also be called community based, grassroot, or advocacy groups). The group focuses on an issue hoping to initiate government action (Conrad & Daoust, 2008). These type of groups often focus on specific local issues and sometimes have no private sector or government support (Whitelaw et al., 2003). Initiation, organization, leadership, and funding of these groups are provided by the local community (Mullen & Allison, 1999). Emerging alternative funding mechanisms, such as crowdfunding, allow projects to be funded in more direct and democratic way by the public.

The transformative or community-based model has the advantage of involving participants in every stage of the project from defining the problem through communicating the results and taking action. In this case, the role of the scientist is to advise and guide community groups rather than to set their agendas (Ely, 2008b).

Some researchers believe that by transferring authority over decision-making to those most affected by it (the public), better, more sustainable management decisions will be made— thus, making the bottom–up model a desirable type of governance. However, many failures of bottom–up approaches have also been mentioned. These include lack of success due to little organization credibility and capacity (Bradshaw, 2003).

The Global Community Monitor serves as an example of how transformative governance structures can best serve the concerns of a community, although it has evolved into a collaborative framework. It was created to provide community-based tools for citizens to monitor the health of their neighborhoods, with a focus on air quality. One of the organizations in India is the SIPCOT Area Community Environmental Monitors. Villagers have been trained in the science of pollution and have been engaged in environmental monitoring, which over time has led to published scientific reports. This work formed the basis for a Supreme Court order calling for the establishment of national standards for toxic gases in ambient air in State Industries Promotion Corporation of Tamil Nadu (SIPCOT) (Global Community Monitor, 2006).

It is important to take into account that certain governance structures suit different communities and monitoring situations, with collaborative and transformative participation being associated with local scales of participation and consultative and functional participation being more feasible across broader geographic scales (Conrad & Hilchey). Regardless of the fact that different approaches are being held in an exclusive way, some cases of coexistence between different approaches can result in interesting outputs (Lawrence, 2006). Some longer term projects have already changed their typology of governance to better adjust to different scenarios.

RECOMMENDATIONS AND FUTURE RESEARCH DIRECTIONS

Citizen science projects have plenty of social trade-offs that need to be taken in consideration and evaluated when designing. Giving straight information about the goals of the project to stakeholders is fundamental for them not to feel disappointed with the expectations raised. For instance people should know whether the project intends to be rigorous, with a straight scientific approach, or to provide participation from a wide range of volunteers. The outcomes of the project also depend on those trade-offs.

Some of the trade-offs include: deciding the scope and scale of the project, deciding to keep small with local data control, or connect with larger initiatives to benefit data usage, focusing more on guaranteeing data quality and reliability or on the easiness of producing data, with benefits to environmental education and engagement.

Future research should focus on scientists motivations for participating; transdisciplinary relations between stakeholders, from which added benefits may still be further exploited; robustness of data quality and statistical analysis of data; measures of project success, taking into account scientific, policy and social outputs.

CONCLUSION

Citizen science engages the general public with scientific research activities, and while not new, since for centuries scientific research was conducted by amateurs, is becoming a mainstream approach to collect data on a variety of scientific disciplines, much supported by technology advances. Nowadays the focus of citizen science is changing from the traditional "scientists using citizens as data collectors" to citizens as scientists.

Given its collaborative nature, citizen science is characterized by a wide range of stakeholders, ranging from research scientists, teachers, students, managers, environmental organizations, and politicians, whose motivations and interactions can be determinant for the success of a citizen science project and thus should be carefully taken into account on project design.

Despite the considerable amount of stakeholders involved, clustering them into four groups: citizen scientists, scientists, other societal groups and policy makers, allows us to analyze the project design from these four different perspectives, taking a stakeholder view, and identify issues for each group which are common to projects from many different scientific areas.

It is important that the design of a citizen science project takes into consideration issues such as communicating, recruiting and motivating participants, fostering innovation, interdisciplinarity and group dynamics, promoting cultural changes, healthy habits, inclusion, awareness and education, and guiding policy goals, among several others. Analyzing these factors may contribute to the increased success of citizen science initiatives. Some issues, such as motivation or awareness, are important for several stakeholders, but in very different ways and assuming varying degrees of importance.

Around the globe, every day, new citizen science programs are being launched offering:

1. New opportunities for citizen scientists to get involved and increase their scientific literacy
2. New working challenges and opportunities for scientists
3. Chances for rethinking societies and
4. New ways to influence policy makers.

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