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Citizens, amateurs, volunteers: Conceptual struggles in studies of citizen science

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Biographical notes

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Abstract

The goal of this literature review is to bring together the different concepts, respective definitions and perspectives that have been used to study the participation of non-professionals in scientific activities. We start by presenting a short definition of citizen science and the perceived benefits of such approaches to the production of scientific knowledge. We then clarify the difference between today's citizen science projects and their ancestors in the field sciences by highlighting technological and social changes. This is followed by a short discussion on typologies of citizen science projects and a description of "contributors," considering the different terms used to identify them as well as the meaning assigned to these different semantic choices. The issues of expertise and the role of different forms of knowledge are then addressed, leading to a discussion on the quality of the contributions. Finally, we have a look at what has been written on the motivations of contributors.

Contents

1. Introduction

The public – whether we call them citizens, volunteers or amateurs – has long participated in science in different ways: more frequently, as an object of study, for example in psychology or in social sciences; as a stakeholder, especially in consultations linked to decision-making in public policy; but also as a contributor to the production of scientific knowledge. In recent years, we have in fact witnessed a surge in scientific projects that include the participation of the public in the research process. We have also seen a corresponding increase in studies on this form of public participation, often centred on case studies and with the intent to identify best practices. As a result, theorization efforts are still at an early stage and classifications may be context-specific.

The goal of this literature review was to bring together the different concepts, their definitions and perspectives that have been used to study the participation of non-professionals in scientific activities. As a result, our review draws from a variety of domains. Our list of references includes publications from the social sciences, such as sociology and education, from science and technology studies and information sciences, as well as field sciences. This is not a comprehensive review, however. Despite the diversity of sources, we focus mainly on work linked to biodiversity and conservation studies, particularly its development in areas such as biology, ecology, oceanography, geography, environment studies or hydrology.

2. Public participation in the production of scientific knowledge

Projects which invite members of the public to participate in producing scientific knowledge are often classed under the rubric of citizen science. For some scholars (Irwin, 1995; Feynman, 1998; Piron, Duranceau, & Pion, 2009; Piron, 2010), citizen science also includes activities as varied as scientific popularisation and public participation in debates on issues such as nuclear power, environmental issues or biotechnologies. Even when citizen science is considered as knowledge generation, it is very diverse both theoretically and empirically. In fact, citizen science "encompasses very different degrees of agency with regards to the research process, very different relationships with the professional scientists and very different degrees of influence on policy relevant scientific projects where citizens contribute to as ‘citizen scientists’” (Nascimento, Pereira, & Ghezzi, 2014, p. 5). It has been designated by a variety of terms and the use of “citizen science” itself is not without controversy (Suomela, 2014).[1] To avoid misinterpretation, Heaton, Millerand, Liu and Crespel (2014) prefer the term “participatory science” to describe the engagement of non-professionals in scientific investigation, whether by contributing resources, asking questions, collecting data, or interpreting results.

The added value of these contributions can be approached from two different perspectives (Haywood, 2014): 1) the public understanding of science and technology tradition that is oriented towards scientific research in which the *external value* of projects is more salient; 2) the public engagement in science tradition that emphasizes an opening up of research and policy, and can be perceived as more focused on the *internal value* of such projects, namely for their participants. Haywood identifies four main goals associated with these traditions while reviewing public participation in scientific research projects: expanding the scope and scale of scientific research, enhancing science knowledge and understanding via interactive learning experiences for “non-scientists,” increasing environmental stewardship and developing more democratic and inclusive science research and policy processes (Haywood, 2014, p. 65). Widening the scale of research is all the more important in the context of biodiversity and conservation, given the nature and complexity of the issues (Tulloch, Possingham, Joseph, Szabo, & Martin, 2013). These authors identify eight objectives for making use of volunteer-collected data: management (in ecology), awareness (including influence on policy makers), education (increasing knowledge and engaging the public), serendipity (uncover unexpected events), recreation (bonding the community), social and economic research (studying human behaviour),

[1] In a European Commission report, Nascimento et al. (2014) map the study of citizen science and list the concepts used in the definition of citizen science and respective authors, reviews on the topic, goals of citizen science projects as well as terms used to designate the participants.

ecological knowledge (for its own sake), and, finally, improving methods (a meta-objective) (Tulloch et al., 2013, pp. 129–30).[2]

Other authors note that participation in science promotes a better relationship between volunteers and scientists, with positive impacts such as raising environmental engagement and awareness (Johnson et al., 2014), especially in conservation projects (Thiel et al., 2014). From the point of view of scientists and funding agencies, cost-effectiveness is often cited as a benefit of citizen science given limited financial and human resources in biodiversity conservation initiatives (Darwall & Dulvy, 1996; Miyazaki et al., 2014). Nonetheless, it is generally recognised that these projects continue to require at least some financial support (Thiel et al., 2014), and other costs – such as time and effort in managing people and technological support – need to be considered (Gura, 2013). As a result, analyses of the return on investment of these projects have to acknowledge that coordination, communication with volunteers, and data checking and compilation involve costs that can be very high in the long run (Tulloch et al., 2013). Still, in many cases citizen science is synonymous with large projects crowdsourcing information at a very low cost, which is seen by some as an exploitative form of big science (Kinchy, Jalbert, & Lyons, 2014).

The participation of non-professionals in producing scientific knowledge is not a new phenomenon, particularly in the field sciences (Charvolin, Micoud, & Nyhart, 2007; Miller-Rushing, Primack, & Bonney, 2012), where collections (of data or specimens) play an important role. In botany, as in astronomy, regular amateur contribution has been well established since the 19th century (Goodchild, 2007; Secord, 1994). What is new, however, is how the development of information technologies (in particular advances in sensing technologies, data processing and analysis, and knowledge communication), as well as the ubiquity of digital tools and media make the involvement of amateurs and the general public in scientific research a viable research strategy (Buytaert et al., 2014; Lievrouw,

[2] Tulloch et al. (Table 1, 2013, p. 130) identify the publications discussing each goal. Haywood et al. (Table 1, 2014, p. 67) present a similar list of scientific literature but in regard to the benefits for the participants, rather than to the organisers of citizen science projects.

2010; Nascimento et al., 2014; Rotman et al., 2012). Databases and digital devices have been praised for their ability to enable global access to the "commons," improve human knowledge and even allow a reconnection with the natural world (Ellis, Waterton, & Wynne, 2010). The formation of virtual communities, gaming as a tool for engaging non-traditional audiences and an increased role for cyberinfrastructure have all been evoked as part of the future of citizen science (G. Newman et al., 2012).[3] In this sense, as amateurs gain access to collaborative tools and feed databases that aggregate their contributions, scientific knowledge production is enriched, and participants become more knowledgeable, appreciative of and engaged with science (Heaton et al., 2014). Nevertheless, social trends, namely higher levels of education as well as increased leisure time, also play a role in the recent growth in participation in citizen science projects (Haklay, 2013).[4] Funding bodies may also encourage this growth, since they have started requiring grantholders to include outreach activities in their scientific projects (Silvertown, 2009).

3. What is "citizen science"?

The literature contains a variety of vocabularies to describe the people, activities and different types of projects that make up "citizen science." The latter can be divided into categories according to the functions performed by citizens, the issue of concern, geographical and temporal scales, whether it is initiated by scientists as well as their impact for science and for the community (Nascimento et al., 2014). According to these researchers, despite many differences, citizen projects have one thing in common: they are all institutionally led. However, the existence of this common trait can also be contested. On the one hand, such a statement is contingent on how we define "institution." For instance, grassroots non-profit associations may also initiate participatory science projects (Heaton et al., 2014). On the other, authors like Couvet and Teyssèdre (2013) consider that participatory science in the field of biodiversity can follow either an "exploration" model,

[3] For a diagram of key research process steps and aspects of citizen science projects in the past, present and future, see G. Newman et al. (2012, p. 303).

[4] Haklay (2013) claims these social trends are linked to a bias in the socio-economic profile of the participants, as they more likely to live in advanced economies, be male, well-educated and at least middle-class.

in which case it is usually led and defined by a scientific research lab, or a "transformation" model, in which civil society drives the process, contacting researchers to help define research protocols and analyse results.

Several models propose classifying projects according to the level of engagement of non-scientists and the benefit they may obtain, usually along a continuum (Buytaert et al., 2014).[5] For instance, Bonney et al. (2009) analyze a series of projects according to the involvement and control these participants have, namely whether they are "Contributory" (designed by scientists), "Collaborative" (non-scientists not only contribute, but can also play a role in steps like design, analysis and dissemination), or "Co-created" (designed together and with a strong and continuous involvement of the public). Haklay's cumulative model (2013) names the lowest level "Crowdsourcing," in which citizens are only "sensors;" followed by "Distributed intelligence," where they do some interpretive work; then "Participatory science," in which citizens participate in problem definition and data collection. Finally, in the most engaged level, "Extreme citizen science," citizens are also involved in analysis and therefore their role as producers of knowledge becomes akin to that of scientists.

In an attempt to provide a perspective different from task-based models, Wiggins and Crowston (2011) propose an empirically grounded typology anchored on organizational characteristics, goal orientation and the inclusion of information technologies. They created five categories: Action (similar to community-science), Conservation (managing natural resources), Investigation (scientific research), Education (education and outreach) and Virtual. The latter diverges from Investigation mainly by integrating technological mediation into the projects' operations. Although the underlying assumption of these different typologies is that a given citizen science project should correspond to a particular category, it is often difficult to make concrete cases fit into abstract outlines (for instance,

[5] These authors present a list of models according to the levels of engagement (Buytaert et al., 2014, pp. 3–4). Their analysis of citizen science projects in hydrology and water resources management follows Haklay's (2013) model, while also including Bonney et al.'s (2009) "collaborative" category.

Heaton et al., 2014). The same obstacle arises when discussing participants' profiles: who they are, their level of expertise, what they do and what motivates them.

4. Who are the "citizens"?

The "citizens" in citizen science are typically described as passionate about a scientific domain or activity: a fondness for nature means they will be more inclined to volunteer (Clark & Illman, 2001; Cohn, 2008). An *American Scientist* editorial notes that projects of this sort "take advantage of activities that people like to do already, such as birding, gardening, or taking nature walks" (Havens & Henderson, 2013, Lessons for Scientists section). By taking part in these hobby-like activities, people can acquire a high level of specialization and build a reputation for expertise that may even be recognised by scientists (Thiel et al., 2014), particularly if they are practised as "serious leisure" (Stebbins, 1982, 2007). [6] In the pursuit of durable benefits and by steering away from play, preprofessional amateurs follow a path paved with "necessity, seriousness, commitment, and agreeable obligation, as expressed by regimentation (e.g., rehearsals and practice) and systematization (e.g., schedules and organization)" (Stebbins, 2012, p. 35). As leisure becomes more professionalized and oriented towards performance, it also becomes more like work (Godbout, 1986).

Clark and Illman (2001) distinguish between *citizen scientists* (who take into their own hands their understanding of science), *citizen volunteers* (members of the public who follow the indications of scientists, of which the Audubon Society remains a key example), and *citizen activists* (who are able to hold a conversation with experts, and are usually proud of the knowledge they have gained). Citizen science can in fact be placed "at the interface of political activism and volunteering" (Buytaert et al., 2014, p. 3), enabling the

[6] Stebbins defines serious leisure as "the systematic pursuit of an amateur, hobbyist, or volunteer activity that is sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of its special skills and knowledge" (Stebbins, 1992, p. 3). For this author, although this type of activity is unpaid in monetary terms, participants gain in experience, personal growth and ultimately self-fulfillment. The word "serious" stems from the descriptions made by amateurs, hobbyists and volunteers themselves, highlighting the importance of these activities in their lives.

emergence of "environmental citizenship" with an impact – even if hard to precisely identify – on biodiversity policy (Ellis & Waterton, 2004). Participant involvement includes data recording and promoting public awareness of nature (Thiel et al., 2014). Nascimento et al. (2014) note that citizen scientists have been described in the scientific literature as researchers, data collectors, observers, data processors, sensors, a conservation army, communicators and disseminators as well as amateurs and enthusiasts. In addition to labels such as non-professional, non-scientist, lay person and public, the concepts of citizen, volunteer and amateur are often used interchangeably, even if some differences can be drawn between them: "volunteerism" is associated with an undertaking of free will, "citizenship" with a sense of belonging, whereas "amateurism" is connected with emotional attachment (Edwards, 2014, p. 388). All are used to describe contributors to scientific projects who are not scientists and who are not paid.

Still, drawing lines between participants in citizen science projects is not always clear-cut. For Haklay (2013), all active participants are scientists, with the difference that "professional scientists" receive a salary for contributing to science, whereas the other participants are considered to be "unpaid scientists." Other studies note that participants can also be scientists, science teachers and students, and that all contributors have at least some awareness of the scientific process (Cohn, 2008). Furthermore, as in the case of citizen science, these categories are fluid since professionals often assume the role of volunteer naturalists outside their working hours (Ellis & Waterton, 2004), and volunteers may become members of paid staff (Bell et al., 2008) or vice-versa. The question of whether participants are paid or not also depends on the context: in developed countries volunteering is usually unpaid, however, in developing countries such participation may be a source of income for local inhabitants (Buytaert et al., 2014). Even if they are not paid directly, particularly in the context of "marginal volunteering" (when there is a sense of obligation in the activities), volunteers can be profiting from time-money schemes (e.g., tuition reduction programs) or searching to improve their chances at a work career (Stebbins, 2001).

5. Citizen expertise and volunteer knowledge

Different definitions of citizen science imply different perspectives on the hierarchy of knowledge held by scientists and citizens (Nascimento et al., 2014). On one side we find positions close to a "deficit model," in which the participation of citizens allows them to acquire scientific knowledge and, therefore, leads to a decrease in negative attitudes towards science and technology. Other approaches argue that citizens possess other, "non-scientific," but relevant forms of knowledge that they bring to bear on their understanding of issues such as biodiversity. Suomela (2014) argues that the deficit model cannot be sustained given the wide involvement of the public in the co-production of knowledge and policy. Moreover, he underlines the potential of studying citizen science to better understand the distinction between "professional" and "expert," since it is possible to be an expert outside the realm of profession.

In terms of the level of expertise of contributors, the words "citizen" and "volunteer" are said to be neutral in tone; whereas amateur may have a negative connotation, suggesting a lack of accountability, preparation and reliability of that person's actions. Yet, it makes little sense to disdain the amateurs' passion, as though it would taint their contribution to science, if we consider that professional researchers themselves feel passionate about their work (Charvolin, 2009). Amateurism can also be described in a positive light as a serious enterprise (Stebbins, 2007, 2012), and be "associated with personal commitment to practice and learning, openness to possibilities and freedom from personal financial interest" (Edwards, 2014, p. 387) as well as tied to feelings of vocation and a love of learning.

For Bonney et al. (2009), public participation in scientific research includes citizen science, volunteer monitoring and participatory action research. In fact, the designation "volunteer" is used as an equivalent to "citizen scientist," particularly while discussing environmental monitoring projects, and refers to contributors whose knowledge on a particular topic is acquired outside a formal education setting and is distinct from scientific knowledge (Rotman et al., 2012; Thiel et al., 2014). Such "traditional ecological knowledge" (TEK) or local ecological knowledge (LEK) "has been gained through lifetime observations and experience, often related to some professional activity" (Thiel et al., 2014, p. 259). Contributors hence provide science with "a better representation of local experiences and priorities" (Buytaert et al., 2014, p. 2; see also Wynne, 1992). For Buytaert et al. (2014), the term "citizen" is not neutral due to its political dimension and citizen science brings about "knowledge encounters" or "battlefields of knowledge," in which different forms of knowledge interact, hopefully enriching each other.

6. The importance of data quality

The question of the level of expertise of non-professional contributors is tied to a topic with a strong presence in articles on citizen science: ensuring and improving data quality (Darch, 2014; Wiggins, Newman, Stevenson, & Crowston, 2011).[7] Data quality is an important issue since the trustworthiness of a dataset is tied to its credibility and, subsequently, to its scientific value (Darch, 2014). The most common method of validation seems to be expert review, which can be performed by professionals, experienced contributors or multiple parties (Wiggins et al., 2011).[8] In addition to the knowledge they may or may not possess, the number of participants is said to have an influence on data quality (Haklay, 2013). Care in the preparation of protocols (Cohn, 2008; Hochachka et al., 2012; G. Newman et al., 2012, 2012; Wiggins et al., 2011) and appropriate training can allow for the collection of data as reliable as that of "professional" collectors (Fore, Paulsen, & O'Laughlin, 2001; C. Newman, Buesching, & Macdonald, 2003). Disparities between data gathered by professionals and volunteers are not merely due to observer error; rather, they can also be caused by procedural differences and study design issues (Gillett et al., 2011). In monitoring projects, even unframed contributions – like public-sourced photos – can lead to results similar to input generated from a formal call (Davies, Stevens,

[7] Haywood (2014, p. 65) notes the pervasiveness of the topic in said literature, citing as examples Dickinson et al., 2010; Lee et al., 2006; Lepczyk, 2005; Schmeller et al., 2008; Wintle, Runge, & Bekessey, 2010.

[8] Other methods include: paper data sheets submitted along with online entry; replication or rating, by multiple participants; QA/QC training program; automatic filtering of unusual reports; uniform equipment; validation planned but not yet implemented; replication or rating, by the same participant; and rating of established control items (Wiggins, Newman, Stevenson, & Crowston, 2011, p. 3). For a more comprehensive list of data quality and research validation mechanisms, see Table IV (2011, p. 5).

Meekan, Struve, & Rowcliffe, 2012). Nevertheless, detailed surveys require more expertise and a higher level of interest from volunteers (Darwall & Dulvy, 1996), and accuracy drops when there is a high level of difficulty (Crall et al., 2011).[9]

Quality seems to become less of a problem with prolonged participation in a project. Therefore, retaining volunteers over time needs to be a concern. This "is facilitated when volunteers perceive that their efforts lead to something of practical use, such as publications, conservation initiatives, management decisions, or policy actions" (Thiel et al., 2014, p. 258). Receiving credit for one's contributions is not only motivating, it is equally conducive of higher data quality; nevertheless, how you attribute credit is also important, as promoting competition based on volume of contributions may steer participants away from quality concerns (Darch, 2014). In large-scale citizen projects that value data volume, the question becomes one of finding the proper balance with quality (Hochachka et al., 2012). In these types of projects, the implementation of data validation tools, namely automated filters that produced flagging warnings, is an emerging method for controlling data quality (Bonter & Cooper, 2012). Advances in instrumentation and the fact that volunteers are motivated, dedicated and attentive to detail compensates for their lesser skills (as compared to professional scientists) that could jeopardize the validity of citizen science projects (Haklay, 2013).

7. Participant motivation in citizen science projects

Stebbins (2001) identifies both altruism and self-interestedness as leading motives for volunteering. The latter may mean wanting to work for a cause important to the participant or to experience a number of social and personal rewards attached to it. Altruism is recognised as playing a role in large-scale citizen science projects, but it also has its limitations. Therefore, these projects often integrate different types of rewards,

[9] To overcome this problem, Crall et al. (2011) suggest leaving the difficult identification to taxonomists or pairing volunteers with professionals.

particularly when they demand large quantities of data (Hochachka et al., 2012).[10] These include adapting digital tools to make contributions more visible, and making contributions easy to search, share and visualise (Hochachka et al., 2012). Along with personal satisfaction and public recognition, learning is an important factor in keeping volunteers motivated. Knowledge exchange or mutual learning seem indeed to play a key role in why volunteers become and remain engaged in these projects, “specifically, through systems of informal mentoring, where the most experienced teach the less experienced” (Bell et al., 2008, p. 3450). The ability to learn, to make discoveries and to teach have all been identified in the study of motivations in citizen science (Raddick et al., 2010). Other motivations include the desire to contribute to science and to help, a sense of being part of a community, having fun and enjoying beauty as well as being interested in the project, in the field and in science in general (Raddick et al., 2010).

In the specific case of projects with environmental concerns, the desire to acquire knowledge is tied to a love of nature. Ellis, Grove-White, Vogel, & Waterton (2005, p. 17) note that “[i]nvariably, autobiographical descriptions of an introduction to natural history and the development of expertise begin with a passionate, detailed and deep involvement in the natural world.” Bell et al. (2008) conclude that the participants’ love for nature results in a strong commitment to acquiring new knowledge, which in turn is favoured by mutual learning and like-minded companionship. Another study revealed volunteers’ main motivation to be a concern for the environment and wildlife conservation, followed by the opportunity to spend time in nature and the opportunity to see wildlife (Johnson et al., 2014). In addition the quality of exchanges between volunteers and researchers as well as the latter’s awareness of what motivates participants help contribute to ongoing participation (Couvet & Teyssèdre, 2013), while lack of such understanding and issues of mutual apprehension and mistrust constitute demotivating factors (Rotman et al., 2012). Whatever motivations volunteers may have, they tend to be dynamic throughout the participation cycle and form a complex framework of both internal and external factors

[10] In addition to altruism, Stebbins (2001) identifies the other principal motive of volunteering as self-interestedness, which may mean wanting to work for a cause important to the participant or to experience a number of social and personal rewards attached to it.

(Rotman et al., 2012, 2014).[11] Studies of volunteering not restricted to citizen science have already emphasized the multimotivational nature of this involvement: different goals are pursued and more than one goal can be pursued at the same time (Clary & Snyder, 1999).[12]

This literature review aimed to present the main concepts used to describe current forms of citizen science or participatory science, the activities they entail and their participants. This work shows that scientific publications mobilize diverse concepts that correspond to differences in definition, and that are closely related to the specifics of each study. The result is a nuanced and complex portrait of citizen science, activities and participants. Although typologies and classifications may be helpful as abstracts frameworks, they may be too constraining while analysing actual cases. Therefore, we suggest that the adoption of any theoretical model and its associated vocabulary should be made explicit and guided by the particular context and characteristics of the empirical research.

[11] They propose a framework inspired by the model of four types of motivation enunciated by Batson, Ahmad and Tsang (2002): egoism, altruism, collectivism and principlism.
[12] Clary and Snyder identity six personal and social functions of volunteering: values (to express or act on them), understanding (to learn), enhancement (for growth and development), career (to gain experience), social (to strengthen relationships) and protective to reduce negative feelings or to solve personal problems (see Table 1, 1999, p. 157).

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