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Essay

Can Citizens Do Science? Science in Common and Social Responsibility

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Abstract: Citizen science is an effective tool that unites ordinary citizens and scientists for a common cause. In particular, this tool enables ordinary citizens to participate in research and increases the likelihood of generating new knowledge. It is seen as the democratization of science. It is mainly applied in developed countries, and citizens usually help obtain environmental data with emerging technologies. However, training citizens to obtain good-quality data is one of the most significant challenges. It is also important to involve citizens in other phases, such as data analysis, discussion, and knowledge generation. Citizen science can be a tool for integrating different groups in science to promote social inclusion, including environmental, agricultural, earth, and life sciences. Thus, citizen science can contribute to education, sustainability, and climate change mitigation.

Keywords: data acquisition; earth sciences; education; social integration

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1. Introduction: Concept of Citizen Science

Scientific research is a time-consuming task that requires, among other things, financial effort and great dedication on the part of scientists. Research usually focuses on a field of knowledge in a discipline, addressing a problem, solving it, and providing new knowledge or new perspectives about the issue investigated. This implies the existence of prior scientific knowledge and training to undertake research. However, science is more than research, and the purpose of science is linked dynamically to society [1]. It is a tool that can be used to discover our environment and the way that things happen, and it can help drive humankind forward. Citizens can contribute to science by providing a large workforce to solve research problems, promoting participation, and increasing their ability to engage citizens in democratic debates about scientific and technical issues [2].

Basic research and applied research are the foundations that support the progress of society and improvements in the quality of life. Nowadays, under the challenges provoked by climate change, research has been converted into one of the most powerful tools to mitigate the negative effects and translate innovation to society to combat the problems we face, building on multiple analytical frameworks, including those from the physical and social sciences, and identifying opportunities for transformative action that are effective [3]. Moreover, educational and informational programs using the arts, participatory modeling, and citizen science can facilitate awareness, heighten risk perception, and influence behaviors [3]. Even more, learning from fieldwork experiences creates new understandings of existing social challenges and new commitments to making change happen [4].

Following the "White Paper on Citizen Science for Europe" [5], science should not leave aside the people it serves in the society for which scientists work. The integration of people into science is the foundation of citizen science [5]. However, the major issues are how to integrate people and how they can develop valid scientific work.

In citizen science, a broad network of people collaborates [6]. Participants provide experimental data and facilities for researchers, raise new questions, and co-create a new

scientific culture. In theory, the role of people is more than a passive one because they can ask questions and provide theories, hypotheses, and discussion. While they add value, volunteers acquire new learning and skills and gain a deeper understanding of scientific work in positive ways. However, discussion about the level of participants in research projects is still undertaken, from lay to expert citizens, but surely this depends on the type of project, and it is important to determine in what ways an expert might enhance or limit the citizen science study of a particular environmental issue [7]. An expert citizen can be a double-edged sword, depending on whether researchers are looking for advice or to collect the feelings and expectations of the non-expert citizen.

The definition of citizen science is not static, as it is an evolving concept; new forms of participation continually appear along with new and diverse definitions. One of the definitions given, as commented previously, is that presented in the "White Paper on Citizen Science for Europe" [5]: citizen science refers to general public participation in scientific research activities in which citizens actively contribute, either with their intellectual effort, with knowledge of their environment, or by contributing their tools and resources. The concept seems new, and obviously, the application of this concept is recent under this given definition. Although the participation of citizens in science is not new, examples can be found in the past century or even before, associated to the emergence of professional scientists in the mid 19th century [8]. However, the term citizen science was introduced in the social and natural sciences during the middle of the 1990s [9,10].

Citizen science is considered a part of citizen expertise, although there are some discrepancies because citizen expertise is a term that entails a conflict of values: the person participating as a citizen expert is expected to be, at the same time, a citizen and an expert on a specific concept or issue [11]. Krick [12] focused her work on three types of citizen expertise: local knowledge, service user involvement, and citizen science. These are all located in different societal sectors and research fields and are characterized in terms of their epistemological and political status. But, considering the last one, the definition given indicated that citizen science is used to define the collaborative research practices that involve non-scientists in scholarly knowledge production [13]. Citizen science initiatives and publications proliferate, especially in the life and environmental sciences and in projects that gather and typify large amounts of observation.

Beyond an exact definition, the main characteristics that describe citizen science, considering the previous definitions, are as follows: the participation of non-scientists, the collaboration of non-scientists with scientists, the acquisition of data by non-scientists, the enrolment of non-scientists in the generation of knowledge, and, finally, scholarly knowledge production.

The interest in citizen science is obvious, as it includes the field of public participation in scientific research, and it has drawn the attention of environmental researchers and the public alike [7]. However, an additional characteristic is being added to citizen science, related to the accessibility of the new technologies. For today's quality of life to be considered a prospect for people in the future, participatory democracy must be interwoven with accessibility [13].

The participation of citizens should be recognized in some way. Can scientists give recognition to citizens for their work? If yes, how can they do it? This is a difficult question to answer because citizen science is commonly conducted with volunteers or with people enrolled in regulated teaching at different levels, from schoolchildren to university students [14,15]. Even more, if the number of participants is too high, although it depends on the project, establishing a method for giving recognition is not easy. However, a good example is the campaign "Sponsor a Rock", proposed by the IGME (Geological and Mining Institute of Spain, Madrid, Spain) [16], involving citizens in the selection and monitoring of the state of geological elements, recognizing citizens as sponsors of places and elements of geological interest (LIG, in Spanish: Lugares de Interés Geológico) and, to a large extent, guarantors of their surveillance, status, and the information transmitted to the IGME. This program facilitates a diploma in recognition of the dedication and commitment to it. People

feel the geological element as something of its own, as a real geological heritage with inherited value [17]. Another way to recognize the work is belonging to a citizen science observatory, in which people are integrated and feel inside a group of research, feeling this group as their own place and as real participants of research; for example, platforms like the citizen observatories (COs), for instance, https://eu-citizen.science (accessed on 28 February 2024), created in EU member states [18].

As a result of this open, networked, and transdisciplinary scenario, science–society–policy interactions are improved, leading, in turn, to more democratic research based on evidence and informed decision-making [5]. This is, in part, a result of the relationship between science policy and public opinion, considered to be a lively topic [19]. The democratization of science, being quite a complex concept, basically means opening the doors of science to society and to the active participation of citizens.

Emerging technologies expand the frontiers of ecological research and public engagement [20]. Based on new technologies and the spread of mobile personal communication devices and other tools to be connected online and in real-time (camera, microphone, GPS, and data storage devices), citizen observatories have been created in many countries. Internet access coverage in the territory is another very relevant factor. Moreover, citizen observatories are community-based environmental monitoring and information systems that invite individuals to share observations, typically via mobile phone or the web [21]. In this sense, observations are mostly related to the close environment of the observer. These observatories serve as a platform to spread citizen science and projects that reclaim the participation of the people.

One of these observatories is located in Spain, the "Observatorio de la Ciencia Ciudadana en España" (Observatory of Citizen Science in Spain) [22]. The main objective of this observatory is to compile citizen science projects carried out in Spain with the aim of disseminating them and creating a network of collaboration and participation between the different agents involved: professional scientists, citizen scientists, managers, promoters, politicians, science disseminators, and communicators. Most of the projects shown in the observatory are based on the request for data from observations made by citizens in their environment, although there are other projects that involve more active participation of citizens, and some of them could be classified as demonstration projects.

After the previous considerations regarding the definition and characteristics of citizen science, the aim of this paper is to show the variability in the projects in which it is presented, even when this concept was introduced in the recent literature during the last twenty-five years. In addition, the countries where citizen science is implemented and the most common themes are shown through a brief review of scientific publications on the topic, how data are obtained by citizens, and finally, the use of citizen science is proposed for education and the integration of different groups, including those who have different abilities or are close to social marginalization. All of this is analyzed from a critical perspective, in which the evolution of citizen participation strategies has been changing over time.

2. Citizen Science in the World

Globalization is a phenomenon that is present in all human activities. This is the case for citizen science, but the number of related projects and the intensity and number of participants differ between countries [23]. The field of citizen science is becoming more widely represented worldwide, including in well-established regional networks [24], such as the European Citizen Science Association [25], the Citizen Science Association in the USA [26], the Australian Citizen Science Association [27], and globally via the Citizen Science Global Partnership [28].

After searching in any database (Scopus was the one selected in this article), an idea about the development of citizen science and in which countries it is presented has been elucidated. In this case, seeking the number of publications between 1977 and 2023 related to citizen science, there were 24,395 documents and 15,606 articles, but only 4539 were used as keywords for citizen science. Most of them were associated with social sci-

ences, environmental sciences, and agricultural and biological sciences as subject areas (Figure 1). Both are the areas in which the greatest number of publications are made in relation to citizen participation in science, mainly in life, environmental, and ecological sciences. This is surely because they are the most related subjects to our surrounding environment, to what we perceive immediately, and from where we can obtain a greater number of observations.

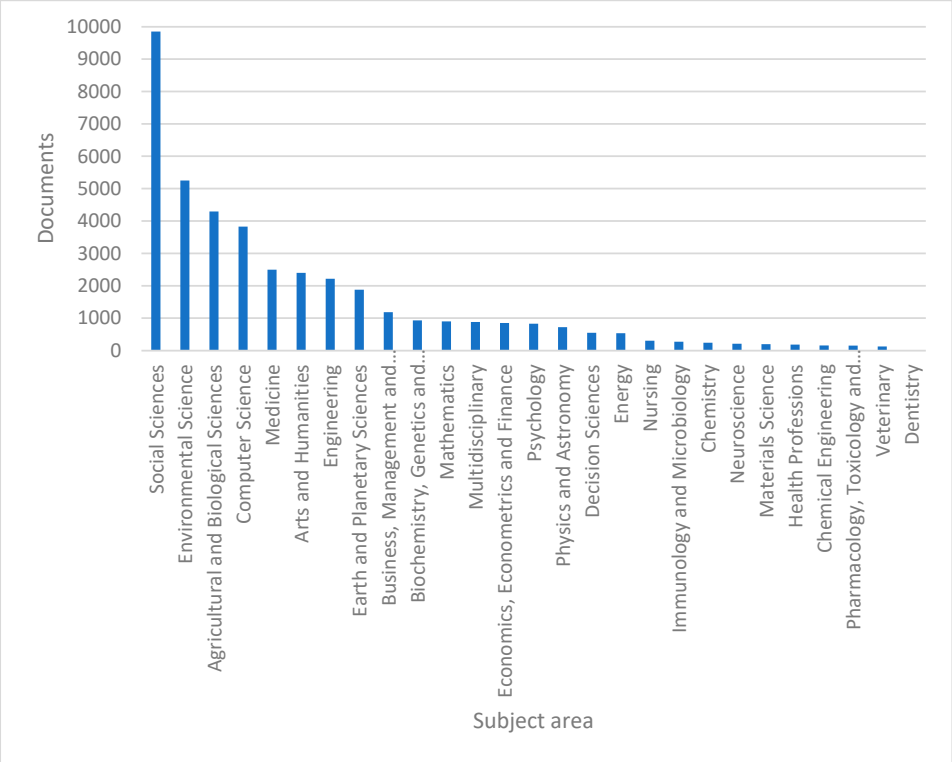


Figure 1. Number of publications related to citizen science per subject area of Scopus (1977–2023).

The number of publications increased from 1977 to 2023, achieving the highest values in the last three years (2020–2022) (Figure 2).

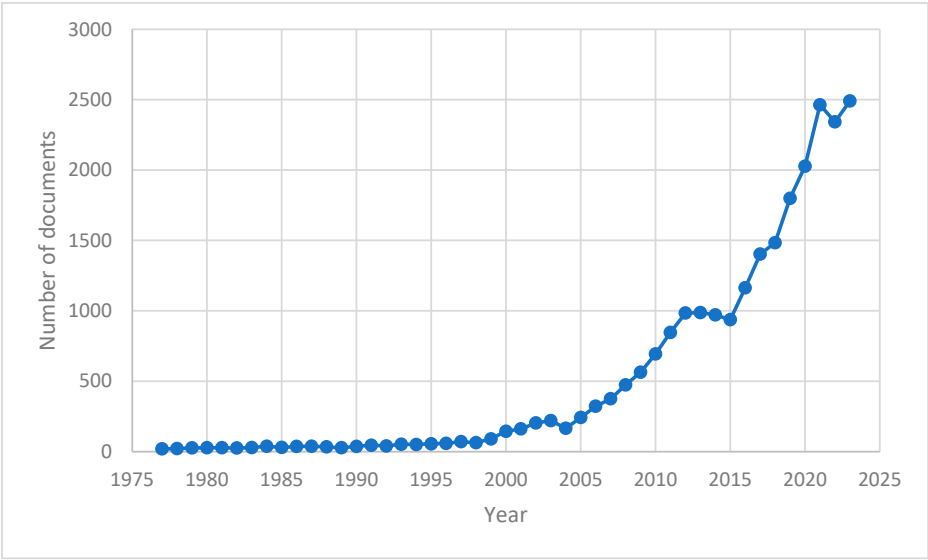


Figure 2. Number of publications per year about citizen science based on the Scopus database (1977–2023) and the tendency line during this period.

Considering the origin of publications, the countries with a greater number of studies are situated in North America, Australia, and Europe, as Figure 3 shows. The United States of America stands out among all countries, followed by the United Kingdom, Germany, Italy, Australia, Spain, Canada, France, the Netherlands, and Brazil.

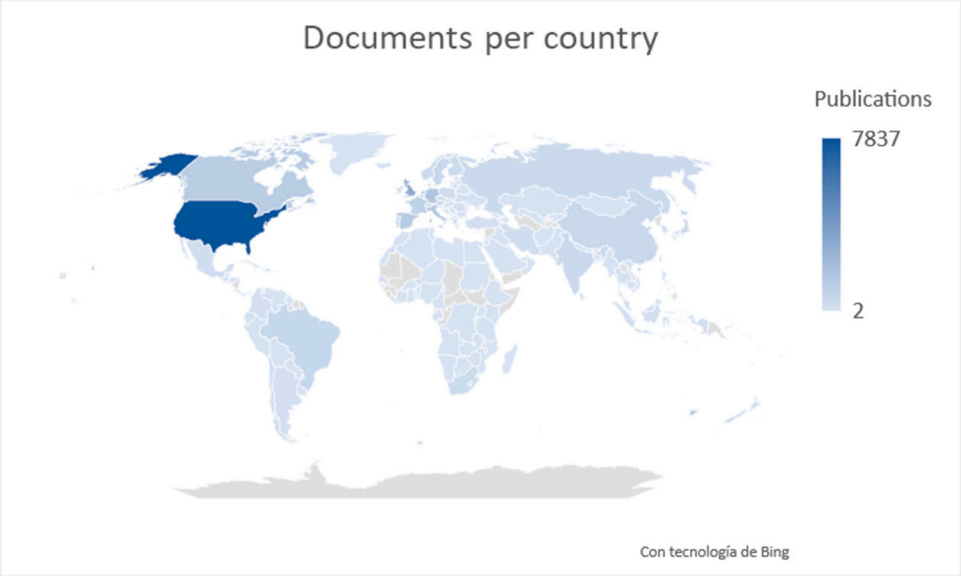


Figure 3. Number of publications about citizen science per country, source Scopus database (1977–2023).

The number of documents published per author confirms the results shown per country, as Figure 4 shows.

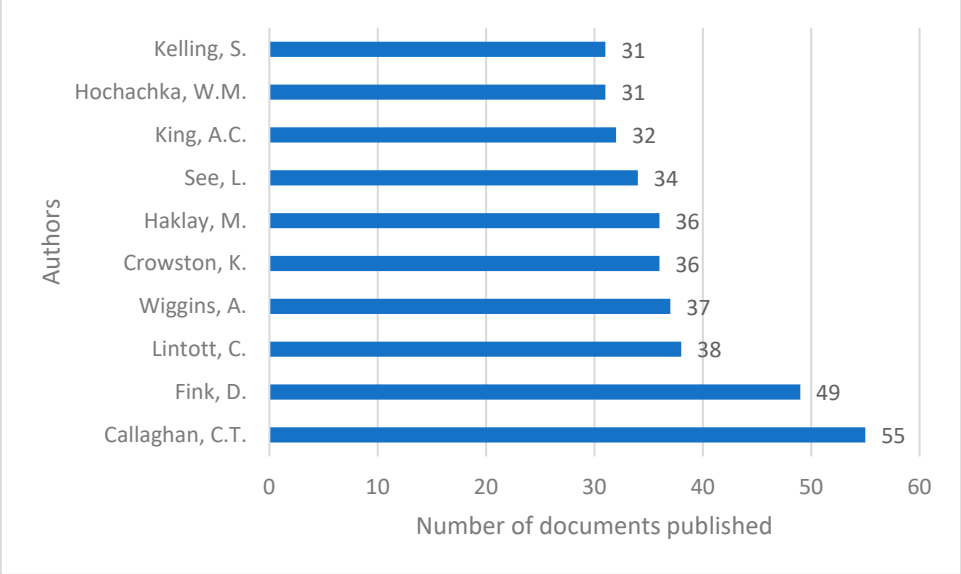


Figure 4. Number of publications per author (first ten authors, source Scopus database from 1977–2023).

This probably means that the major concern about citizen science is within developed countries, as confirmed by the presence of relevant organizations, as mentioned in the first section. It is important to note that most of the projects and initiatives about the participation of citizens in scientific research are centered on the environmental, agricultural, and biological sciences. In fact, based on Tweddle et al. [29], the term citizen science is restricted to studies of biodiversity and the environment. However, this has been overcome.

Citizen observatories (COs) are directly engaged in environmental observation, as the European Commission indicates, talking about COs: "innovative earth observation tech-

nologies (in particular those based on the use of mobile telephony) . . . [and] community-based environmental monitoring, data collection, interpretation, and information delivery systems; empower communities with the capability to monitor and report on their environment; and enable communities to access the information they need to make decisions in an understandable and readily usable form" [21]. Technological facilities are becoming the most important tool for citizen science and are responsible for increasing the participation of citizens (both laymen and experts). The use of new technologies is widespread in developed countries, as is the number of research facilities, and it is precisely this dissemination of technology that arouses the interest of researchers, promoting the greatest number of projects associated with citizen science. Access to technology seems to be one of the factors influencing citizen participation and its facilitation.

The citizens of developed countries, most of them accustomed to participation in political decisions, could be more motivated to participate in research projects than others. However, motivations for participating in citizen science projects vary between individuals. In order to attract participants and keep them engaged in a project, it is important to understand what drives them to participate and why they stick with a project or leave it [30].

In general, there are two factors that motivate participation. One of them is altruism, and the second one is principlism, which is the framework of four universal and basic ethical principles: respect for autonomy, nonmaleficence, beneficence, and justice [31]. However, the order of both depends on the type of project and the individual [32].

The conditions, based on the studies mentioned previously, needed to develop citizen science can be summarized as follows: the number of researchers and projects, the awareness of scientists to facilitate the participation of citizens, the existence of people motivated to get involved in science, and the facilities provided by technology. It should be considered that the projects have to be well designed, and regular feedback to citizens motivates them and helps them avoid leaving.

3. Citizen Science: People and Projects

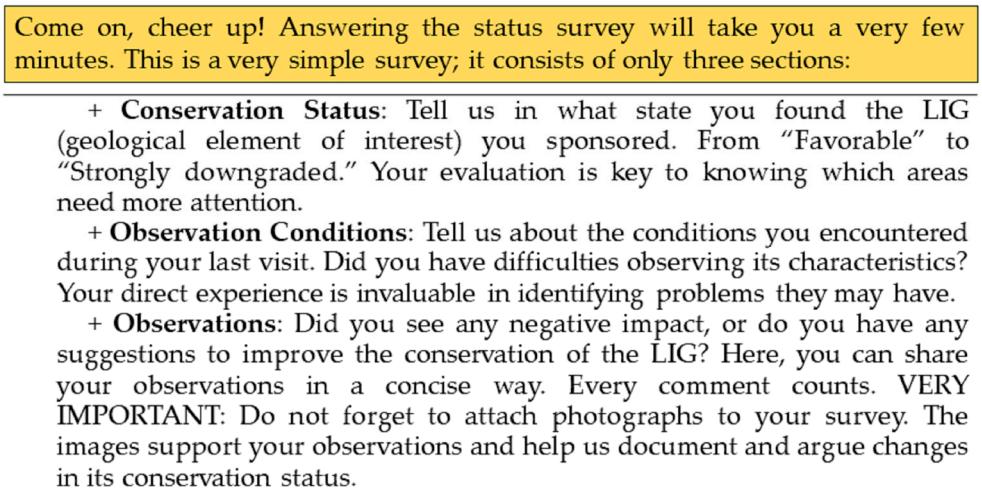
Scientific and technological issues present particular challenges and opportunities for participation: on the one hand, they are associated with claims to highly specialized, professionalized knowledge and expertise that may serve to exclude, yet on the other hand, recent scientific controversies have also created new demands and opportunities for concerted citizen engagement in decision-making [23]. Projects involving citizens provide a new dimension concerning scientific issues and policymakers.

Citizen science has no barriers regarding the age of participants in these projects. This is one of the characteristics that makes this methodology attractive to most people. There are hundreds of project examples in the literature where people of any age participate with scientists to produce new knowledge or even preserve knowledge to avoid loss. The last one is the case in several social projects that maintain the memory of society, such as the Puçol School Museum (Elche, Spain), where a school project started in the 1960s has managed to preserve, value, study, and value the life, materials, and customs of their ancestors [33]. This project has been recognized by UNESCO.

As an example of citizen science projects in the USA, National Geography [34] published a list of them for grades 3–12+ belonging to the most popular subjects (Biology, Ecology, and Earth Science): Bird Census, Celebrate Urban Birds, Monitor Bird Nests, The Horseshoe Count, Butterfly Census, Search Space, World Monitoring Day, Frog and Toad Populations, Count Birds, Observe Appalachian Flowers, Survey Monarch Populations, Learn About Local Plants, Observe Plant Life Cycles, Take Mountain-Top Photographs, Collect Weather Data, Classify Galaxies, Bird Feeder Stakeout, Bird Watch, Participate in a Field Survey, Observe Coral Bleaching, Measure Night-Sky Brightness, Chesapeake Bay Foundation, Observe Wildlife Anywhere, Document How Landscapes Change, Exoplanet Watch. Most of them have observations of the environment in common.

Those tasks need perseverance to obtain good results. For this reason, it is necessary to maintain the interest of participants and incorporate new observers. Altruism and principlism are not the only things that attract citizens. People take part in citizen science for many reasons. West et al. [35] indicated that "citizen science does not just help scientists; it can also be an opportunity to learn, to get exercise, and to meet new people. As project designers, we really should try to be as inclusive as possible." Scientists should motivate people and engage them in science.

Following the example given in a previous section, "Sponsor a Rock" [16], it is important to keep the project alive because, in Earth Science, it is necessary to follow and know what is happening because human actions quickly affect the land surface and the crust of the Earth is changing naturally. In this sense, the project aims to keep people engaged in the long term. The last email campaign to the participants is presented in Figure 5. This message is a good reminder and motivation for participants to remain vigilant and continue with the project.



Come on, cheer up! Answering the status survey will take you a very few minutes. This is a very simple survey; it consists of only three sections:

+ **Conservation Status**: Tell us in what state you found the LIG (geological element of interest) you sponsored. From "Favorable" to "Strongly downgraded." Your evaluation is key to knowing which areas need more attention.

+ **Observation Conditions**: Tell us about the conditions you encountered during your last visit. Did you have difficulties observing its characteristics? Your direct experience is invaluable in identifying problems they may have.

+ **Observations**: Did you see any negative impact, or do you have any suggestions to improve the conservation of the LIG? Here, you can share your observations in a concise way. Every comment counts. VERY IMPORTANT: Do not forget to attach photographs to your survey. The images support your observations and help us document and argue changes in its conservation status.

Figure 5. Message sent to citizen participants in the project "Save a Rock" (IGME) [13].

Although there are a lot of projects, the participation of people in scientific observations is more than three centuries old. Highfield [36] pointed out that "Even though the term 'citizen science' only entered the Oxford English Dictionary in the last year (2014)", there is evidence from several centuries ago, found when, in 1715, Edmund Halley used Philosophical Transactions to ask colleagues to help him observe a total solar eclipse, prompting observers from all over the country to respond to Halley (1715) [37]. More references can be found in the post by Highfield [36], in which the participation of citizens and experts was mostly utilized to collect observations. It is worthy to mention initiatives like this of a teacher named Wells Woodbridge Cooke, who, while living in the Mississippi Valley, began noting the arrival dates of migratory birds in 1880 [38]. Following birdwatching initiatives, it is remarkable to consider the citizen science project Audubon's Christmas Bird Count. Every year since 1900, Audubon has asked citizens to observe and collect information about local birds between December 14 and January 5 [39].

Trying to summarize a citizen science project implies observations, data analysis, discussion, and the generation of knowledge. This is a basic approach that can be useful in understanding the common role of researchers and citizens in the same project. This is close to that mentioned by Spasiano et al. [40], who talked about the most common definitions distinguishing three typologies (or levels) of citizen science: (1) contributory, (2) collaborated, and (3) co-created, close to observations and data, data analysis, and the generation of knowledge, respectively. Figure 6 is a schematic representation of the participation of both, based on our own observations in our own and nearby projects, where people's support for observations is close to 100%, and this drastically reduces when considering data analysis and the generation of new knowledge.

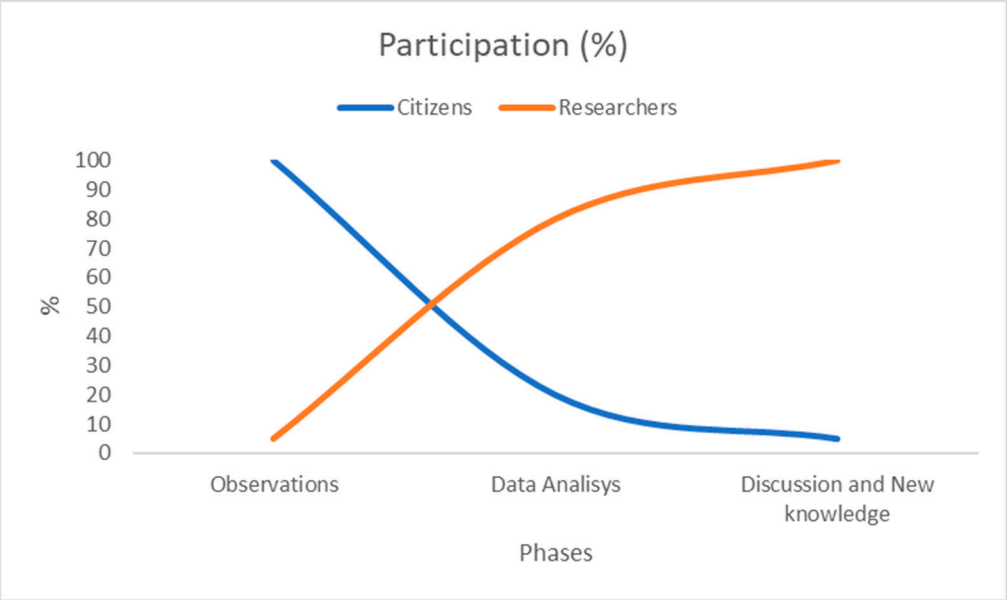


Figure 6. Estimation in percentage of participation in the three main phases of a citizen science project (based on our own observations).

Considering that data come from citizens, we should consider their reliability because the most important things in all research are the data, their validity, and the trust generated by their use.

4. Reliability of the Data Coming from Citizens

The feature that most distinguishes citizen science from other forms of science is the involvement of non-professional scientists in the scientific process. These non-scientists, the "citizens" in citizen science, can collaborate with scientists in all stages and aspects of the scientific process, but in most projects, they only contribute to data collection and analysis [30].

Are citizens ready to obtain good scientific data? Although data can be complex, simple, direct, or prepared and derived from previous studies, citizens have the ability to observe their environment and make these observations in such a way that a scientist can use them to understand what is happening and properly analyze the data. As Van Eupen et al. [41] showed for species distribution models, data are expected to be cleansed, including the removal of spatial and temporal outliers, duplicates, and records with low precision. Data, in general, should be filtered based on record attributes that hold information on the observation process or post-entry data validation [42]. As an example, the eBird platform, one of the largest citizen science projects in the world, launched by the Cornell Lab of Ornithology in 2002, using the message long employed by the lab's citizen science staff: "Help scientists track the birds" [43], has data curation processes carried out by humans and machines [44].

Irwin [8] emphasizes that lay people possess valuable insights and can produce reliable knowledge, which is opposite to the view of Bonney (1996) [9], where the expertise of citizens is necessary, attributing a more limited role to citizens. This is the dilemma that exists when it comes to participating in these projects: the participation of laymen or experts or of everyone together. Common conceptualizations of participation assume that high-level participation is good and low-level participation is bad. However, examining participation in terms of high and low levels of knowledge and engagement reveals different types of value in each case [14]. The solution lies in the type of data and the methods that should be used to acquire them and, even more so, in the prior training that participants in the project can receive. It is the researcher's responsibility to ensure that citizens have help and support to be able to correctly carry out their observations. The research design

should be used to minimize the mistakes that can occur during the acquisition of data. It is interesting to mention that in the citizen science games area, several projects train their citizens before they can contribute to the project. For example, Stall Catchers from Cornell University (https://stallcatchers.com/main, accessed on 28 February 2024) or MalariaSpot was developed by the Polytechnic University of Madrid as a mobile app. Foldit is a successful example [45]. This game is a one-of-a-kind protein folding computer game developed by several university scientists: the Center for Game Science (University of Washington, Seattle, WA, USA), the Institute for Protein Design (University of Washington), the Cooper Lab (Northeastern University, Boston, MA, USA), the Khatib Lab (University of Massachusetts Dartmouth, Dartmouth, MA, USA), the Siegel Lab (University of California, Davis, CA, USA), the Meiler Lab (Vanderbilt University, Nashville, TN, USA), and the Horowitz Lab (University of Denver, Denver, CO, USA), where citizens can contribute to advanced research on human health, cutting-edge bioengineering, and the inner workings of biology.

However, errors can always occur in observations and in data collection, which can harm the project as a whole or partially. A review of the data is necessary. But what happens when there are lots of data? How can we separate the errors? In these cases, we can resort to computational statistics and artificial intelligence (AI). Notwithstanding, it is important to ensure the veracity of the data that will later be used in the analysis. AI supports the collection of big data and favors the opportunities and challenges of using citizen science and AI techniques for ecological monitoring under six key categories: efficiency (opportunities only), accuracy, discovery, engagement, resources, and ethics (challenges only) [46]. AI is frequently used in environmental citizen science, and it is of great concern to develop AI solutions for reducing errors and biases in volunteers' contributions to support the validity of citizen science outcomes and data quality validation. Overall, the integration of citizen science and AI technology can be used to help maximize the amount of data that can be collected and processed efficiently through the use of machine learning trend models in the eBird project [47] while simultaneously engaging and informing people about professional research activities and their value for society and decision-making processes that affect socio-economic and environmental systems [48].

Although, as reported in many works, the participation of citizens is limited to data acquisition, there are some responsible tasks they can participate in, such as co-designing research and contributing to the interpretation of data, and the impetus of this tradition is empowering, bottom–up, and cooperative [49]. Opening the participation to a more specialized task requires a more complex research design but paves the way to open up science and science policy to the public, raise the responsiveness of science to society's needs, and approximate 'scientific citizenship' [8].

5. Citizen Science as an Educational Tool

Education is immersed in continuous processes of transformation and innovation. For instance, augmented reality and computer sciences are becoming important tools in education and can be useful to increase the participation and involvement of people in science, improving the educational process and future research [50,51]. Although these tools are not specific to citizen science, they can positively contribute. Surely, without the development of computer science, it would have been very difficult to engage citizens and encourage their participation as well as the improvement of education. In both cases, technology has played a fundamental role, in particular computer science.

The participation of the scientific community is necessary to develop citizen science projects [29]. Moreover, it is the best way to integrate citizens, especially the youngest, into the importance of science in its democratization and to promote the capacity for criticism and decision-making. The practice, therefore, provides significant opportunities for youth science education, particularly in the realm of inquiry, in both formal and informal learning environments [52]. Citizen science is used as a tool to teach 'scientific understanding' and skills to the public. Citizen science projects in the natural science tradition are usually top-

down projects initiated by professional researchers [53]. However, those related to climate change impacts and sustainability are becoming more important, and the participation of people can contribute directly to the implementation of sustainable development goals [54].

Although some of the projects are centered on school and university groups, volunteers are one of the main supporters. However, citizen science is not well known because this tool acts as a catalyst that changes the perspective and knowledge of the environment of marginal groups in society. Social inclusion is one of the targets that can be achieved by using citizen science [55].

Citizen science can be used as a tool for the integration of different groups, both marginal from a social point of view and those who have different sensory, physical, or cognitive abilities. Moreover, it will be a perfect space for interaction between different groups and people pursuing common goals. The potentiality of citizen science can be exploited in this sense, but the responsibility of researchers will be increased because the design of the research, the activities, data acquisition, observations, and the later phases of the whole project should be well designed considering the target of integration.

Here are some examples developed in Spain. One of the most interesting examples found in the literature is The Inclusive Circular Lab of the "Fundación Juan XXIII" [56]. This is an educational program based on circular economy and citizen science through research projects and composting of organic waste in schools, led by people with intellectual disabilities. The leadership and capabilities of people with intellectual disabilities have been revealed, creating environments of integration and learning experiences. Similar experiences and examples can be found in other countries, exploring the capacity to engage people with learning disabilities [57,58]. Moreover, Carr [57] gives important tips about the design of research for citizen science and people with disabilities ('Nothing about us without us': Inclusive Research Design). Carr [57] pointed out that research within learning disability studies shows that when people with learning disabilities are given help and an opportunity to be involved in the process, they demonstrate their capabilities. Moreover, this tool can be an inclusive approach to capacity building within citizen science.

Earth sciences are one of the most important subjects in which citizens can participate [59]. Following this line, in the Paleontological Museum of Elche (MUPE, Elche, Spain), the project promoted by the National Organization of the Blind of Spain (ONCE, Spain) called "The hands that see" facilitates the recognition of fossils by touching, and this is a first step in training people so that they will be able to identify them. This is an experience that brings blind people closer to the world of paleontology [60]. Moreover, through a volunteer project (VOLCAM, Spain), environmental monitoring of outcrops and prospecting for new geological deposits were carried out with a team of volunteers (citizens) [61]. Since then, there have been numerous projects that the MUPE is developing in this sense and, importantly, adapting them to society, increasing accessibility and inclusion.

6. Citizen Science vs. Community Science

Citizen science should consider ethical considerations when conceptualizing projects by embracing (1) inclusivity (finding ways to include those who have traditionally been excluded), (2) adaptation (modifying projects to provide greater opportunities for varied participation), (3) sensitivity (ensuring projects take into account and respect cultural traditions and beliefs), (4) safety (protocols that protect the physical, psychological, and cultural safety of citizen scientists and society at large), and (5) reciprocity (benefits for citizen scientists) [62].

The concept and participation of citizens in science have changed, especially in the past two decades. That is why the term "citizen science" has been complemented or superseded by others as "neighborhood science" or "community science" to describe citizen science activities [63]. In fact, as Cooper et al. indicated, for citizen science to live up to its democratizing potential, important issues such as equality and cultures of inclusivity need to be considered [64].

The changes have been positive; they open new perspectives and, moreover, new opportunities for all kinds of people. However, gender imbalance is presented in citizen science, as Ibrahim et al. indicated [65], and the fewer projects/publications from poorly developed countries are barriers that must be overcome.

As a result of these opportunities associated with citizen science and the participation of people in science, in the European framework, a lot of projects have been developing, and even the EU Commission has great concern about the possibilities of citizen science and its essential role in enriching research and reinforcing societies' trust in science and innovation in the battle against climate change. Opening up science to society is essential to enriching research and reinforcing societies' trust in science and innovation in the battle against climate change [66]. Under Science with and for Society (SwafS), part of Horizon 2020, the European Commission seeks to promote citizen science projects in research methodologies by changing a predominantly scientist-led process to a more participatory, inclusive, and citizen-involved one [64]. Citizen science is becoming an important part of the EU Green Deal and a way to achieve sustainability, making people understand the need for lifestyle changes.

This task is a work of shared social responsibility, in which citizens and their contributions, as well as their data, are fundamental to generating new knowledge.

7. Conclusions

Citizen science is one of the most important tools with which to join citizens and scientists on a common task. It is a collaborative project designed and supervised by researchers. This is a democratic and participative task. However, most of the time, the role of citizens is limited to support for observations and data. This role is, in some way, a passive one. It is important to improve the participation of citizens in all phases of a research project, favoring the generation of ideas and discussion and enriching the research. Projects related to citizen science are not only demonstration projects or show projects because the goals, although not comprehensive, should be the generation of knowledge. The role of citizens must be less passive and even participate in the following phases of data analysis and the discussion of the new knowledge generated, although this requires greater attention and involvement from scientists.

Most citizen science is carried out in developed countries with research traditions mainly centered on environmental, agricultural, and life sciences. Along with this fact, the use of new technologies, internet coverage, and ease of access to mobile devices favor the implementation of citizen science observatories.

The major concern, from a research point of view, is to obtain good data with high quality and reliability taken by citizens. However, this can be achieved with an adequate research design and the use of advanced tools, such as AI, to discern which data are appropriate and which contain errors and biases.

Citizen science is a powerful tool for improving education, whether it is regulated or not. There has been an increase in the possibilities of generating new knowledge from citizens. Moreover, it can be a tool for integrating different collectives in science, favoring social inclusion.

Finally, it is important to note that the strategies adopted by scientists to integrate citizens, as well as the dissemination of the results and science in society, are key factors for improving future actions and involving citizens in decision-making and better-achieving goals and quality of life. Furthermore, citizen science can be a basic tool to understand and mitigate climate change, promote sustainability, and be part of social responsibility.

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