Ways of sociotechnical integration of scientists and volunteers in citizen science

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Abstract. The given research is directed on the analysis of the scientist and volunteer’s relations at realization of joint projects of the citizen science, which have recently been developed increasingly due to information-communication technologies introduction in the process. The authors conducted a substantial analysis of more than 200 projects; thus, special attention is paid to the projects presented on Zooniverse site. The site serves as the main base for the paper’s authors since it is the world’s largest and most popular platform for constructing communication of scientists and volunteers. The continuous research covers the period from May 24, 2019 to September 24, 2019, showing what changes occurred to the projects, specifying in speed of their ending, progress of the volunteers’ involving, the most popular themes of research, etc. The authors generate the cloud of citizen science’s objectives from scientists and volunteers, generalizing motivation and objectives of the given interaction. The perspective opportunities of the citizen science are noted, allowing solving not only research problems, but also the contemporary global problems.

1. Introduction
Information-communication technologies cardinaly change the human life in various aspects [1-3]: from pregnancy [4,5] to education [6-10]. The wide expansion of information-communication technologies has enormously expanded opportunities of associating people around the world with various objectives.

The opportunity of mutual sharing can concern both physical objects, and opportunities and abilities. One of rather new interesting applications of opportunities of information-communication association of people is citizen science. The scopes of citizen science are very diverse: astronomy [11,12], archaeology [13], geography [14], geology [15], microbiology [16,17], ecology [18,19], oceanography [20], etc. The number of the people involved in the projects totals millions; about two million people participate only in biodiversity projects every year [21]; by means of the appendix eBird (Cornell's Lab of Ornithology), on average more than 7.5 million bird observations are reported to the website every month [22]. The projects can vary from purely virtual ones, demanding only computer work, to the ones, which demand gathering material off-line. The problems’ complexity degree can be various for virtual projects from the collected data classification/processing/recognition (as in Zooniverse) to constructing models, e.g., gravitational lens [23, 24], and in hands-on - from the supervision data gathering to the analysis of samples (e.g., air or water quality, as in “extreme citizen science” or monitoring a stream and benthic community [25-27]).
The objective of the given research is the analysis of ways of sociotechnical integration of scientists and volunteers in citizen science. The research priorities include considering different aspects of citizen science in special literature, and also more detailed study of the practical application by monitoring specialized platforms which allow constructing communication on the scientist-volunteer level, also it is important to identify their main common ground and motivation.

2. Methods
The research methods are presented by a set of various approaches of the theoretical-applied scientific knowledge providing realization of analytical toolkit. Among them, there are methods of the complex and process comparative analysis and synthesis, grouping the factual data. In the research, the interdisciplinary approach, which allows considering the scientists and volunteers’ interaction within the limits of citizen science as a difficult social process in the aspect of communication sociology and science sociology is used. The scientific novelty is characteristic for continuous research of Zooniverse site with processing the information of all the projects presented on the given platform on May 24, 2019, and, also, the repeated research of September 24, 2019, assessing the changes occurred to the projects for this time period. The analysis of more than a hundred projects allows defining the speed of research performance involving the volunteers, the most attractive areas of citizen science, and, also, to construct a cloud of citizen science objectives from scientists’ and nonprofessionals’ viewpoint, opening the peculiarities of the scientists’ and volunteers’ motivation and benchmarking framework. Also, we apply such techniques of research as designing of logic schemes, graphic interpretation of theoretical information and empirical data.

3. Results and Discussion
In the very name of “citizen science” two parties giving life to this phenomenon are presented as scientists and inhabitants of the Internet. The researches, devoted to citizen science, most often occupy one of the given positions, considering the project efficiency from the scientific viewpoint or from that of nonprofessional participants’ involvement. In the traditional scheme, the scientists initiate the project, and the Internet inhabitants respond, actively joining the offered activity. Though in some cases the scientists use the activity already available if, e.g., the scientists use the data, laid out in the Internet by the users, e.g., defining the water level change in historical perspective with Youtube videos [28,29] or Twitter posts [30].

From the science’s viewpoint in citizen science the major thing is what objectives are put and how much they are realized. More than ten years ago, a lot of attention was paid to the educational objectives of citizen science projects [31-35]. Thus, understanding degree may range from purely scientific information to environmental issues and regulations [31] and even lead to positive, cumulative, and measurable impacts on biodiversity [34] and developing local actions to reduce air pollution exposures and improve public health [36].

The discussion on how possible it is to trust such data, received that way [19, 37, 38], led to understanding that the process, properly organized, allows obtaining relevant data. Technically, it can be achieved with purely virtual projects, e.g., with aggregation algorithms which can even give more weight for those who are more accurate, and/or who contribute more [39]. However, in hands-on projects mobile technologies can help avoid some errors, e.g., by automatically logging some data (e.g., date, time, location, limited environmental data, and photographic evidence) [40]. Special mobile appendices, e.g., ground verification of precipitation mobile Precipitation Identification Near the Ground (mPING) [41] or smart sensors enabled by devices utilizing information and communication technologies [42, 43] can give even more effect. However, during data gathering there remain problems connected, in particular at biodiversity research, with species bias, spatial bias, variation in effort, and variation in observer skill [44]. In order to overcome the given problems, there are two basic approaches: imposing a more structured protocol onto the dataset after collection via data filtering [45]; and including covariates in a model to account for the variation [44].
Despite a considerable number of projects and volunteers involved and the idea that the objective of most projects of citizen science is advancing scientific understanding [21], it appears not so simple to consider the scientific results received. Theobald et al. specify that only 12% of the projects considered (in the field of biodiversity) have papers in peer-reviewed journals [21], however, according to Cooper, Shirk, and Zuckerberg’s research, more than a half of central claims about the impacts of climate change on avian migration were based on the data from citizen scientists [46]. Follett and Strezov note that a number of projects prefer other forms of the results’ presentation, such as reports or websites [47].

Other researches consider citizen science from the viewpoint of volunteers’ motivation. Reed et al. allocate, among main motivating factors, Social Engagement (communicate awareness of and interaction with others), Interaction with website (a sense of awareness, facility, and enjoyment) and Helping (positive feelings from helping or volunteering) [48]. In some researches, on the foreground there is a desire to “contribute to original scientific research” [49]. Rotman et al. specify that the motivation changes during participation in the project, and name the personal interests, attribution and acknowledgment as the main ones [50]. It is clear, that some scientific projects a priori appear more fascinating and causing interest by their nature than others. A lot of people like bird-watching or observing distant galaxies. The other reason may be social and political significance of the project. Wanting to solve the problem is one of important motives, especially in case of researching environmental issues [51]. E.g., in citizen science projects, aimed at plastics, a lot of participants specify the significance of the fact that data can influence policies [52]. In the project surveying turtle nests, the main motive was a desire to protect the turtles [53].

At the same time, the system of the data gathering organization may be appealing. A way of increasing attraction is gamification. A widely known example is Foldit game (University of Washington), which allowed achieving a big success in protein folding research. Solve puzzles by nonprofessionals help map retinal neurons from the microscope databank generated by the Max Planck Institute for Medical Research in Eyewire game (Princeton University), and map genetic codes in Phylo (McGill University).

![Figure 1](image)

**Figure 1.** Cloud of objectives of citizen science pursued by scientists and nonprofessionals
It is impossible to disregard a question on possible reward for participants of citizen science projects. Despite the sceptic attitude to the fact that similar practice may affect data quality [54], recent researches confirm that reward mechanisms can promote people’s attraction [55].

Figure 1 demonstrates a number of objectives, which are pursued by scientists-organizers (right side) and participants of citizen science projects. It is obvious that they can be compared, and there are reciprocal motives for basic inquiries.

Let us analyze the volunteers’ involvement in citizen science projects using the example of Zooniverse site. Zooniverse is the world’s largest and most popular platform for people-powered research. Zooniverse research gives people of all ages and background the chance to participate in real research with over 100 active online citizen science projects. Work with 1.7 million registered users around the world to contribute to research projects led by hundreds of researchers. [56]. Nowadays 104 active projects are collected on the platform, there is also information about 87 temporarily suspended projects. All of them are divided, by the site founders, into 11 areas: arts, biology, climate, history, language, literature, medicine, nature, physics, social science, space. Scientists and volunteers, referring to the resource, can choose only the given sections. But, thus, one project can have some research areas, that frequently leads to substantial duplication of some sections of the site, e.g., such as biology and nature. Defining this assumption, we will pass to considering the most popular areas, from the viewpoint of the projects presented by scientists for involving volunteers. First of all, they are nature (65 projects), biology (63 projects), history (23 projects) and space (19 projects). Least interest of scientists in volunteers’ help can be observed in physics and climate (11 projects each), social science (10 projects), arts and medicine (7 projects each), language, literature (4 projects each). The authors’ hypothesis is an assumption that both scientists and volunteers are interested in the same subjects of research. We studied the total number of volunteers who joined the work with active projects in each of 11 areas, presented on the site. The data are rounded to thousands, which, from the authors’ viewpoint, is quite comprehensible. Greatest involvement of volunteers is seen in nature (192 thousand), biology (179 thousand), i.e., the leaders in the number of projects presented by scientists, but space (178 thousand) demonstrates almost the same results. It is necessary to notice, that at practically equal quantity of volunteers – there are three times fewer projects in the given area. According to the authors, it is connected with a special appeal of the space theme for volunteers. In the research of motivating Galaxy Zoo project volunteers we can see the specific motives which are appreciable only for this theme; the second most popular motivation factor was the interest in astronomy, furthermore, among popular motives there was also beauty, and the vast scale of the universe, opportunity to see galaxies that few people have ever seen [49]. Also, the number of volunteers in physics area is high, that, first of all, is connected with duplication of projects in this space area. As a whole, the authors’ hypothesis finds the acknowledgement and specifies practical proportionality of both scientists’ and volunteers’ interests in certain research problems (Figure 2).
Figure 2. Numbers of projects and volunteers in 11 areas of Zooniverse

Also, on the basis of data of Zooniverse site the authors researched the speed of project performance and volunteers’ increase in the time interval from May 24, 2019 to September 24, 2019. Thus, in each of 87 active projects, presented on the site on May 24, 2019, there are data of the project performance percentage, number of research objects and number of the volunteers participating in the project. The following research phase was on September 24, 2019, when new projects were not considered, i.e., started after May 24, 2019, and also the projects which loaded additional objects were removed from the consideration; 49 projects were researched in total. Of these 49 projects, during four months, twenty were completed (and five, at the moment of the research beginning, had 0% of the executed work, and ten did not exceed 50%). All completed projects are large enough, and each one involved the support of 1,000 to 19,000 volunteers, though frequently started work with only 100 volunteers, basically projects in nature and biology areas. The most illustrative example is “Will You Help Us Save Burrowing Owls can serve?” project, where volunteers were offered to watch the behaviour and holes of the western burrowing owl with cameras. A little more than one thousand volunteers were able to help scientists complete the given research in such a short period of four months. One more research of birds’ behaviour of an impressive character is “Notes from nature” project, which asks volunteers to help with a look at footage from the Cornell Lab of Ornithology's Sapsucker Woods FeederWatch Cam to help answer the research question: How does the diversity of species and abundance of individuals affect behavioral interactions at a feeder? During four months the project advanced by 80 %, increased the number of volunteers from 85 to 5,080 who were able to classify 75,600 birds’ actions. Only 6 projects did not obtain the increase of more than 20 % during this period. Therefore, as a whole, it is possible to note the high speed of projects’ performance which more frequently depends on the complexity of work performed by volunteers than on the number of volunteers and the knowledge field. More detailed information is presented in Figure 3 and Figure 4.

The author considers that it is interesting enough to continue the given research in the future with the possibility of studying other similar platforms, keeping the former intervals for measuring, it would help compose a full picture of citizen science projects’ performance time and confirm the hypothesis of project performance speed high enough on similar sites.
Figure 3. Progress (percentage) in Zooverse projects’ performance degree from May 24, 2019 to September 24, 2019

Figure 4. Increase of the number of Zooverse projects’ volunteers from May 24, 2019 to September 24, 2019
4. Conclusion
Citizen science and cooperation, which is its basis, are favourable for both parties: both volunteers, who have no scientific qualification, but wish to be engaged in research and involved in scientific community, and also, thus, to benefit the society, and scientist, who, in case of correct process organization receive the additional resource, first of all, from the viewpoint of data gathering and analyzing, which allows to considerably accelerate the project performance time and to expand its opportunities. The contemporary citizen science agenda is various enough, and includes dozens of areas, but, thus, the supply and demand practically coincide in this intellectual market; in the authors’ research conducted, there is accurately traced the proportionality of both scientists’ and volunteers’ interests in certain research problems. The most popular themes are nature and space, they involve a considerable number of volunteers. But, frequently, one thousand scientists-amateurs is enough to conduct an applied research in short terms. The scale of information-communication technologies’ application opportunities in this sphere is considerable, as, with similar mechanisms, not only separate scientific problems, but also more global public or environmental ones can be solved.

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