Master in Comunicazione della Scienza "Franco Prattico"

Scuola Internazionale Superiore di Studi Avanzati

Empowering citizen scientists: a hidden dance between the ivory tower of science and lay people

Candidate: **Marco Quaglia**

Supervisor: **Mariachiara Tallacchini**

2020 - 2021

"*In a world forcing us to excellence,*

sucking is a revolutionary act"

Anonymous

Table of contents

Introduction

This work revolves around the relation between scientists and lay people in the domain of Citizen Science (CS).

In the first part, 'Context and research question', it presents a logical collection of relevant key concepts: origin of the term CS; clarification of the meaning of 'citizen' and 'scientist' used in the text; PUS and PES interpretations of public participation in Science; government interests and efforts in developing CS; risk of presence of the deficit model; some classifications of CS projects and epistemic practices; post-normal science approach to society and empowerment of citizens. The last section of this part is dedicated to pose the research question: '*How is Citizen Science perceived by scientists of the scientific community?*'.

In the second part, 'Conclusions', some concepts are presented and developed as results: existence of a polarization between scientists inside and outside the ivory tower of science; perception of data quality, objectivity of CS research and peer judgement; authorship and pay of citizen scientists; inevitable growth of CS both for scientific projects and for the bottom-up empowerment of citizens. The work also presents the 'affiliation principle' and suggests how a definition of scientist, detached from this principle, could apply to lay people, that is to a broader group of individuals than that of the ivory tower of science.

Methodology of investigation

The main approach to the topic is the review of existing literature.

Also, the scientist Annibale Biggeri, involved in Citizen Science initiatives, is heard in various meetings to discuss the topics of this work.

Context and research question

Citizens' participation: an ever morphing process

Citizens' participation in scientific activities has always existed in the past, such as in the form of a patient-doctor relation. Participation in science has since grown in order to account for an ever more dominant presence of technology in people's lives, a raise in complexity of society and for a consequent need of scientific literacy to improve community lifestyles. On the contrary, Citizen Science (CS) is rather new term, added to the Oxford English Dictionary in 2014, and has been utilized with different meanings, thus creating a large comprehensive but blurred universe. Indeed, talking about CS can lead on multiple pathways.

There are two main origins of CS: Irwin's (1995) and Bonney's (1996). Irwin's and Bonney's concepts of citizen science are respectively contained in two statements: 'Science *for* the people' and 'Science *by* the people'. The former points towards a science devoted to the satisfaction of people's needs (citizen science is for citizens what military science is for the military), whereas the latter points towards the contribution of people in the making of scientific knowledge, along with a parallel acquisition of understanding of science.

But terminology matters [Eitzel, 2017] and today there is no real unique interpretation of the term CS. We should question the meaning of the term 'citizen' right from the start. Citizens are often regarded as individuals belonging to some kind of established system like a state or country, or simply an urban city. However, this kind of label does not account for all possibile cases, since for instance a person without a formal citizenship in a country could nonetheless engage in a research project or live outside urban cities. In general, we prefer the term 'lay people', meaning people without a sufficient degree of knowledge to be called experts. However, also in this case we can encounter some contradiction, for an expert of some field of knowledge can easily become a lay person in some other field. Thus, from now on, we will consider lay people, or equivalently citizens, those individuals not belon-

ging to an institution widely recognized to be the knowledge authority on some subject. A cardiologist can be regarded as a citizen if dealing with environmental research with no scientific knowledge of it.

We should also question the term ‘Science’. One way of interpreting the term is by considering the scientific method and its scientific epistemological approach to the discovery of phenomena in the universe. Through this first interpretation, it is easy to separate society into two parts: an ivory tower of science made of institutions in which selected people undisputedly apply the scientific method, and an outside world where lay people live. In this scenario, there is almost no connection a priori between the group of selected people called scientists performing the mystical ritual of the scientific method and asking questions to nature in order to get answers and the lay people who do not apply it. There is a barrier between the two groups and it is penetrable by lay people only through the acquisition of enough knowledge so that they can use the scientific method themselves. CS is a link between the two dimensions, allowing a touch between the two groups.

If, however, we relax the condition of having only the scientific method as a means to investigate nature, we open a door to other kinds of epistemic practices that can change and widen the rules of investigation leading nonetheless to answers. In this second approach, lay people suddenly have the tools to ask valuable questions and obtain answers even the definition of scientist starts to shake; they become empowered citizen scientists. CS a bridge between the ivory tower of science and lay people and when we deal with it definitions and concepts that might at first appear so clear become blurred.

Throughout most of this work we will refer to scientist meaning an individual belonging to the ivory tower of science

With an ever more complex society, science and society have more and more intertwined together. Decision makers, scientists of the ivory tower and lay people all play important roles in the development of society and in the search of solutions to the challenges it faces. Various attempts have been made to try and develop theories and actions in order to achieve these goals.

PUS and PES, also SiS, SaS, SwafS and all that

Public Understanding of Science (PUS) since the mid ‘80s is a theoretical framework which tries to understand the needs arising in our society correlated to science and develop policies to deliver the best solutions. It relies in the belief that people need to understand science in order to let innovation and society grow, thus its main objective is to raise scientific literacy. However in this approach people are kept afar from institutions and can easily fall into a condition of mistrust towards them and science in general. To avoid this, a deeper dialogue is believed to be required and the PUS framework is substituted with the Public Engagement with Science (PES). According to the American Association for the Advancement of Science (AAAS), some goals of PES include civic engagement skills and empowerment, awareness of the cultural relevance of science and recognition of the importance of multiple perspectives and domains of knowledge to scientific endeavors. Empowerment is the final step in which citizens acquire specific skills that allow them to take action and make decisions for their personal good and the collective one. CS is a part of the entire society ecosystem in which all this can happen.

Institutions have tried to develop normative structures to support CS and the multiple visions of how science and citizens should connect. Even dedicated associations have been founded, like the Citizen Science Association (USA), the European Citizen Science Association (ECSA).

Government institutions, as well, have considered CS. In the United States of America, CS has been recognized as a very effective instrument for research, mainly due to the fact that citizens participation is most often voluntary. In 2015 John P. Holdren, assistant to the president for Science and Technology and director of the Office of Science and Technology Policy, wrote a memorandum bearing the subject ‘Addressing Societal and Scientific Challenges through Citizen Science and Crowdsourcing’, directed to all the heads of executive departments and agencies. In this memorandum he reported that researchers at the University of Washington analyzed 338 citizen science biodiversity projects around the world and estimated that contributions of 1.3–2.3 million citizen science volunteers to biodiversity

research would have an economic value of up to $2.5 billion per year. Although this is undoubtedly the first reason why CS is considered in the USA, Holdren also presents other secondary benefits: enhance scientific research; address societal needs; increase science, technology, engineering and mathematics (STEM) literacy. He also adds some specific scientific achievements: solve the structure of an AIDS-related enzyme; map the 3D structure of neurons in the brain; discover a new class of galaxy and map the surface of Mars; collect air quality and other environmental data to improve the health and well-being of their communities; improve predictive models for coastal change and vulnerability to extreme storms; tag millions of archival records.

In Europe, the European Commission has tried over the years to develop programmes that would have as part of the objectives the development of CS throughout the territory in accordance with the PES principles. The latest examples of such programmes are the Science and Society (SaS) programme (2002-2006), the Science in Society programme (2007-2013), the Horizon Europe (2014-2020) and the next Horizon Europe (2021-2027). One key point of all these programmes is public engagement, seen as a means to create participatory multi-actor exchanges and dialogues with the potential to foster mutual understanding, co-create outcomes and provide inputs to policy agendas. Within these programmes, multiple CS projects have been and will be carried out. This is the most common way to picture CS in our society, that is as a group of projects in which people are engaged at different levels. But this vision and approach come from the top of the institutions all the way down to the bottom. The attempts in the name of the PES unconsciously risk to go back to the PUS, thus leading back to mistrust in institutions and science. CS is surely about scientific projects but also something else, a phenomenon emerging from the bottom where citizens are the engine of research and policies.

The shadow of deficit model

Very often, in every conceived way of letting people participate in science stuff, there is a crawling approach behind the scenes which is hard to surpass and to let go: the deficit model. According to this model, people are empty boxes to be filled with experts' intellectual material. Sometimes this point of view can present itself in disguise, even when there is an honest will to connect the ivory tower of science with the rest of the society. It is as if somebody, trying hard to reach a certain light, inevitably brings behind him a shadow, which can cease to exist only after the final moment of stepping inside that light. We always need to ask whether this shadow is with us. The deficit model may impede the thriving of new unexpected ways to do science, because it can lead decision makers and scientists to do the same acquainted actions and not try and explore others. The fight against the deficit model is the key for the future of science and society and can be won when the whole ecosystem steps into the light by truly connecting the ivory tower of science and lay people. CS can be the tool to reach that light, an hidden dance between the ivory tower of science and the lay people that needs to be further unveiled to break the separation:

'*Contemporary discourses on public participation in science, including "citizen science," are challenging a number of founding elements of the modern regime of knowledge production based on the separation between expertise provided by professional scientists working in dedicated research institutions and the lay public understood as a consumer of scientific knowledge and technologies.'* [Strasser, 2018]

To better understand how to picture CS engagement or participation, we will present some structured and organized models that help to classify and order CS initiatives. These models are inevitably limited, since CS is too large of a universe to be condensed in some enclosed representation.

A simple first representation for the level of engagement of lay people is provided by the Arnsteins Ladder, which graphically gives at a glance the sense of an ever growing presence in the decision making process as we go 'up' the ladder. The process of citizens

climbing ‘up’ the ladder depends mostly on two categories of stakeholders: decisione makers and scientists, who can delegate their power and provide citizens with decision making and scientific expertise:

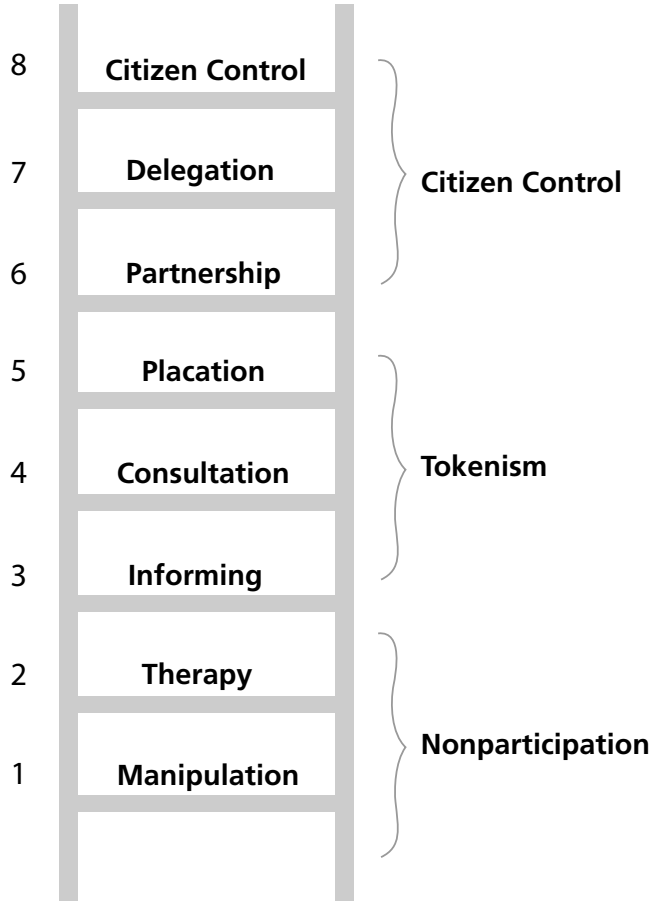

Fig. 1 - Arnstein’s ladder of citizen participation
Reference: https://www.citizenshandbook.org/arnsteinsladder.html

In this fashion, any citizen science activity or project can be assigned to a certain degree of citizen participation. For instance, in the case of citizens participating in the creation of the research question of a project they can be regarded as partners (degree 6), whereas if citizens only download a certain software to allow scientists to make use of their local device to analyze data, citizens are taking a negligible part into the lead of the project.

Further refinement of certain structured models can be done. An example is the participatory cube, which utilizes three axes to quantify certain aspects of participation:

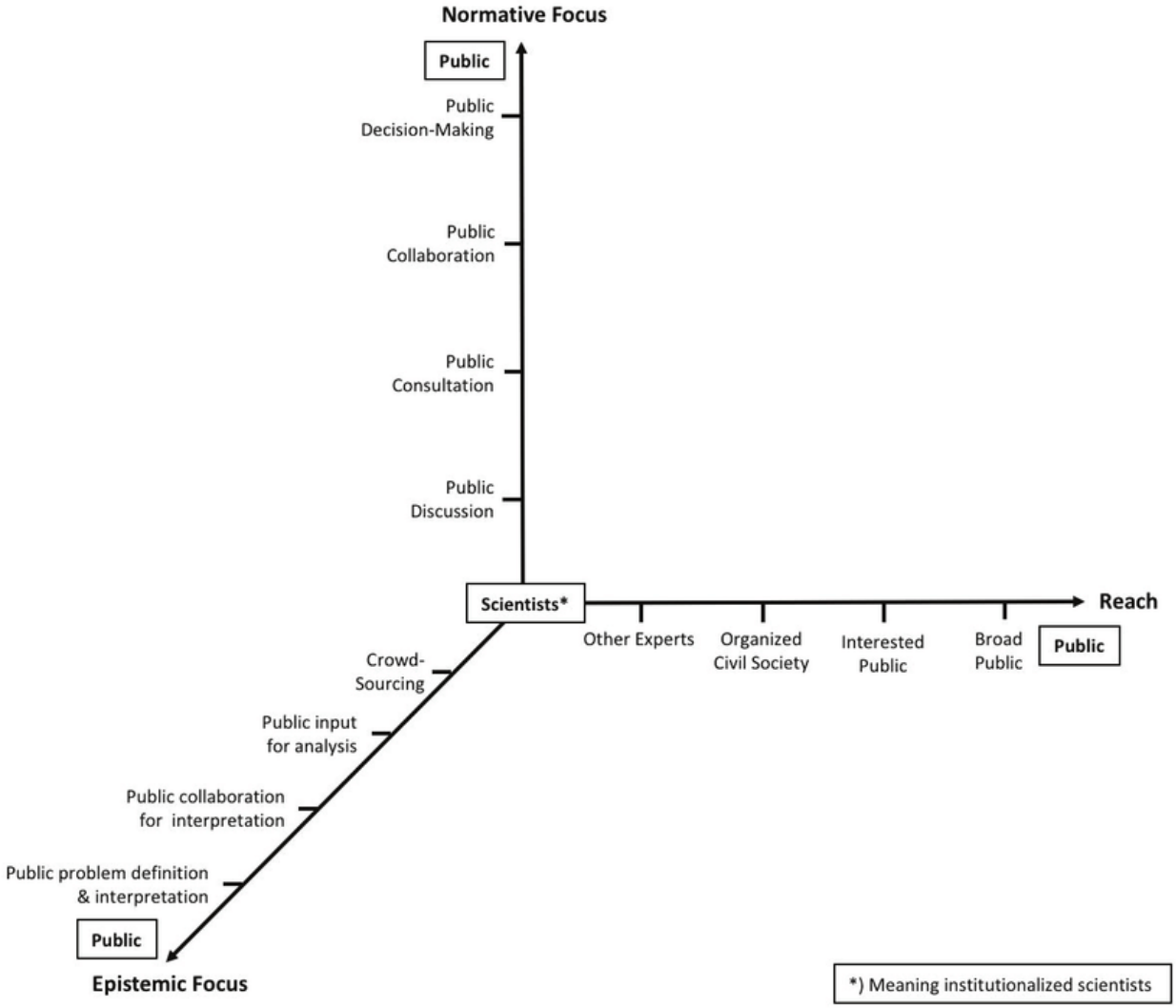

fig. 2 - participatory science cube
Reference: https://www.researchgate.net/figure/The-participatory-science-cube_fig2_333107804

The ‘epistemic focus’ axis, taken alone, becomes a simple classification relying on the type of contribution that citizens give to the research:

- *Contributory*: provide data and analyze it
- *Collaborative*: analyze and interpret data, design study
- *Co-created*: create the research question

These classifications have a political agenda: projects should fulfill citizen empowerment, in the sense that citizens take action on which scientific problems to work on, rather than exploitation, while ensuring that they contribute to science.

The preceding classifications do not account for the type of research that is carried out, which can be a way of labeling CS initiatives. Wiggins and Crowston have focused on the typologies of projects based on the goals of the study and so they stress the difference between the physical and the virtual world in which citizens can work:

- Action projects initiated by citizens to encourage intervention in local issues
- Conservation projects about natural resource management
- Investigation projects focus on scientific research goals
- Virtual projects with all volunteer interaction occurring online
- Education projects that are often performed in the classroom or school

The participation in the construction of knowledge by actors coming from outside the ivory tower of science can enrich the investigation with new epistemological procedures. Rather than classify citizen science projects based on the level of participation or subject, one can instead point out various epistemic practices that can coexist simultaneously in the same project: sensing, computing, analyzing, self-reporting, making.

These different classifications all refer to CS as a group of scientific projects strictly stimulating the connection between the ivory tower of science and lay people in the domain of use of the scientific method. CS can change facet and acquire a new meaning when the monolithic and powerful ivory tower of science fails to deliver solutions to the immediate and relevant needs of society? This happens when uncertainty prevails.

Living in a Post-Normal Science society

There are theories about uncertainty as an ontologically embedded principle in the construction of knowledge, including the scientific one. Such an interesting approach is called Post-normal Science (PNS), coined by Funtowicz and Ravetz in 1993, which particularly applies in those domains where science has no time to settle and decant to unleash its powerful scientific method, where facts are uncertain, values in dispute, stakes high and decisions urgent, in which new characteristics regarding science emerge: as opposed to the typical properties attributed to science, namely certainty and value neutrality, new features such as uncertainty and decision stakes are relevant. These new attributes strike at the heart of calm scientific work when there is immediate need of action and consequences for each and every choice. A representation of such model is the following:

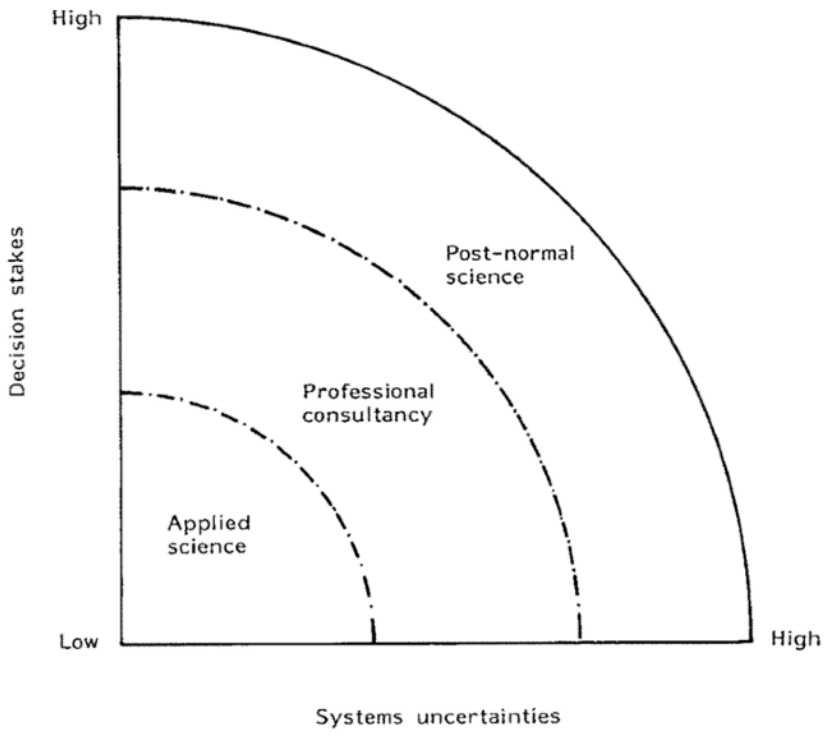

Fig. 3 - representation of Post-normal Science model
Reference: “Science for the Post-Normal Age”, Funtowicz, Ravetz

A perfect stage for PNS is the ongoing planetary pandemic due to the SARS-CoV-2 virus. Actions must be taken quickly and there are major consequences even for small decisions. This does not mean that science fails, but rather that it has only a part in the game. It cannot provide an exact and complete answer, instead it can give suggestions based on the bits of informations it produces while events change abruptly. In a way, science regains a leading and fundamental role in a time in which uncertainty puts it to the test. Decision makers have bowed again to science and its advise, although it remains up to them to decide in which directions to lead society to. For example, tan historic moment was when he prime minister of UK Boris Johnson and the President of the USA Donald Trump decided to pursue the lockdown option instead of awaiting for the herd immunity after consulting a scientific report by the Imperial College on possible casualties in case of no lockdown.

It is here in this environment that the concept of scientific citizen empowerment most comes to life. The top-down approach of imposing certain behaviors to citizens does not work, because institutions have not the resources to supervise every individual action taken by the people. Also, dialogue and indications are not enough because of the almost infinite possible scenarios to take into account. People must not merely obey some unknown rule, they ought to understand it and furthermore learn when to apply it more or less stringently. Thus, it is ultimately up to the citizens to have the responsibility to acquire the scientific competences to act properly for their own good and the collective one.

PNS is an opportunity for both science as an institution and for citizens as empowered individuals.

Another case is self-care. When normal science has no answer, something else does have it. The engineer Anne Wright told her personal story to present the practice of health self-tracking through the BodyTrack system and how this practice could empower individuals, so that they would explore and address issues in their lives. Citizens within this CS project learnt how to use scientific instruments and how to read their body responses, like the neural activity during the sleep, and were able to find solutions for themselves. It should be stressed that as of now these people would join such a project in case that hospitals and doctors fail to deliver solutions to them. Thus, such a practice, deeply correlated to the empowerment of citizens, would be an ideal candidate for the mixing of the ivory

tower of institutions like hospitals and doctors with empowered citizens practices to develop a better and more effective health ecosystem.

In this other view, CS is something different scientific projects and degree of participation. It is a conception of society in which citizens are totally empowered as they have acquired scientific competences necessary to take meaningful actions without the help of some institution.

Research question

We want to focus on the perception of CS by scientists of the ivory tower of science, here interchangeable with scientific community, considering both those scientists who get involved in CS initiatives and those who remain within the tower and away from CS.

The research question is therefore:

How is Citizen Science perceived by scientists of scientific community?

We want to pose this question because we have that since scientists of the ivory tower of science are part of the scientific ecosystem and can very well themselves be citizen scientists when working on fields of research outside their own, they are eligible to strengthen CS as a valid epistemological approach to research. We believe their help, although not strictly needed for the thriving of CS because it can sometimes be a bottom-up process, can be effective. The more visibility CS acquires in society, the more its positive effects on society will manifest.

In the following part, for some of the conclusions, we will refer to the work conducted by Riesch and Potter in 2018, in which a qualitative study of 30 interviews with scientists working on the 'OPAL' (Open Air Laboratories) project in England has been carried out. They also have a similar feeling with respect to the need of pushing CS forward:

'CS not only needs to be beyond reproach in the science that it produces, but it also needs to be visibly seen to be so', [Riesch, Potter, 2018]

What better judge than the scientific community itself to verify whether this vision of CS is indeed true or not?

Conclusions

The heretic scientist

Taking a step outside the ivory tower of science to venture into CS can lead to a solitary journey. This is because there is not an organic and structured procedure to connect the scientific institutions and the outside realities. Often scientists have to act individually to start a project and can find themselves ‘alone’ in this process.

A polarization between scientists inside the ivory tower of science and those stepping outside of it inevitably starts to grow. This polarization is so strong that the latter scientists do not seek in any way the recognition of their colleagues for what they do or for what CS means to them. This process is further accentuated for an individual who has never been part of the academy and who challenges it by claiming to be a scientist.

This polarization can lead to weaker or stronger stigmatization of these outsiders as ‘heretic scientists’. What happens is that any scientific result found by the scientist being in contrast with the academy will probably lead to a stigmatization, even though there is a recognized membership. The scientist is seen by the rest of the scientific community in connection with one or more societal bubbles that are outside the ivory tower of science and are considered far away from the scientific method that they are acquainted with.

Thus, not being recognized by the academy, a scientist can get labeled as heretic:

‘If we overlook the problems faced by scientists with persuading the wider scientific community of the validity of CS work then we fail the scientists who are potentially putting their careers on the line when they sign up to participate in CS’ [Riesch, Potter, 2018]

Data quality, objectivity and peer judgement in CS

Scientists from the ivory tower of science care about data quality and scientific objectivity of a research. They have certain rules and standards which must not be violated. For instance, when comparing instruments that are homemade by citizens and their unique modern high cost instrument, they tend to develop a certain skepticism towards any research developed by those citizens.

On the contrary, scientists who have stepped outside the tower believe that not everything has to be thrown away For instance, when considering homemade receivers there is consciousness of the limits but the instrument per se could provide usable data.

Some scientists worry about the judgement of their peers from the scientific community even though data quality is in order. This shows that there is a prejudice towards CS from inside the ivory tower of science perceived by the scientists who step outside of it.

Also, scientists do not tend to believe that CS can lead to major discoveries:

'Scientists involved in CS do not tend to believe that CS research will lead to revolutionary results' [Riesch, Potter, 2018]

Authorship and the very concept of scientist, salary

Research in CS opens a wide variety of deep and profound questions with respect to authorship, the very definition of scientist and salary that would be due for creating intellectual material.

- What does it take to be an author of a scientific paper?
- Is an author of a scientific paper a scientist?
- Do you need to be part of the ivory tower of science to be a scientist?
- Are lay people scientists?

The first question can be answered by stating that it is sufficient to contribute to the creation of knowledge regarding the research topic of the scientific paper. This statement demands the author to have some kind of expertise in order to be able to create such knowledge, but by no means implies that one has to be a priori a member of the ivory tower of science.

The second question could be easily answered by playing with the words: yes, because the paper contains scientific knowledge and the author has created it.

The third question stimulates an interesting debate on what really portraits a scientist, if it is the way of living, the way of thinking, the way of acting, or rather the fact that the scientist belongs to a recognized institution. This last assumption is what we call the ‘principle of affiliation’ or ‘affiliation principle’. At this point we are free to choose whether to relax or not this condition by rejecting or accepting the principle as a prerequisite to be a scientist. It is notorious that scientists present their names in conjunction with an institute of affiliation, but we claim that, if they are asked this question, the same scientists would at least hesitate in answering it and would present examples of scientists not belonging to any institution.

The latter question seems a contradiction, but only if we keep the strict definition of scientist as given above, that is an individual belonging to an institution widely recognized to be the knowledge authority on some subject. By relaxing the condition of affiliation and

for what concerns this reasoning, if lay people, equivalently citizen scientists, contribute to the construction of knowledge by publishing a scientific paper then they are effectively scientists.

The topic of authorship in CS research is still new and debated. Scientists do not clearly know how to handle it when they need to think whether and how to include citizen scientists within the paper's list of authors:

'*obviously when the papers are written ... they'll receive it as 'this is what you've done'. Authorship's puzzling me on this, because we can't put twenty people on authorship. So I'm struggling with that one. I might try it and see what happens.'* [Riesch, Potter, 2019]

There are numerous attempts in including citizen scientists as authors, using individual and collective names, but there is not a systematic and widely accepted procedure.

The case of the Foldit project is a remarkable example surpassing the affiliation principle. The lay people of the project appear as authors in a publication on the Nature journal and they are labeled as 'Unaffiliated'. [Koepnick, 2019]

There is another ethical problem correlated to knowledge production and that is the role of pay of citizen scientists for their efforts in CS:

'*The real remuneration for professional scientists' work is not just authorship but of course their pay. If public participation and expertise is to be thought of as equal in status to the professional contribution then it is legitimate to ask how we can justify that one part of a project is being done by people who are getting paid for it, and another is being done by people doing it for free.'* [Riesch, Potter, 2018]

We know that for instance John P. Holdren highly encouraged CS remarking that a contribution of 1.3–2.3 million citizen science volunteers to biodiversity research would equal an economic value of up to $2.5 billion per year. We argue against the free use of citizen scientists primarily because they should be payed for their intellectual work, in case they want to. This huge free work, however, can have consequences on the scientific community itself, especially on junior scientists participating in those same projects as the citizen scientists and striving to get paid for their job. What do they feel about that?

‘*I suppose another way of looking at it [...] as about to be unemployed scientists, there’s people who are doing it for free [laughs]. They’re taking my job away from me [laughs]. I’ve got all this training [laughs]. But […] citizen science is brilliant or it’s not very good…’* [Riesch, Potter, 2018]

This ethical issue should not be underestimated and could easily lead to an irreparable contrast between the future scientific community composed by these junior scientists and the citizen scientists themselves, even to the point of disrupting the connection between the two groups and vanishing all efforts made to achieve the opposite goal:

‘If we overlook the ethical problems that CS raises we may end up unintentionally strengthening the lay–expert boundaries that CS was thought to overcome, through potentially fostering a sense of resentment by junior scientists who might feel their jobs are being outsourced, or by leaving us open to accusations of unintentionally exploiting free labour.’ [Riesch, Potter, 2018]

Citizens' participation: an unstoppable process

The lack of pay to citizen scientists is one of the reason why CS projects spread so much. CS will also spread as a bottom-up approach of citizens taking action and empowering themselves. CS is an unstoppable process and will be more and more a core asset for the scientific research and for the empowerment of citizens.

There is a precious hidden dance between the ivory tower of science and lay people that brings a scent of great changes within. Society, with its decision makers, scientists of the ivory tower and lay people themselves, needs to act and improve on intertwined aspects:

- effectively step into the light and dissolve the shadow of deficit model
- discuss and address ethical issues related to CS research, like the affiliate principle and authorship or pay, to naturally include CS in the scientific research ecosystem or to avoid a back firing negative process on the relation between future ivory tower scientists and citizen scientists themselves
- dare to debate the very same concept of scientist to include whoever has a meaningful part in the creation of scientific knowledge

Bibliography

- Aristeidou et al., “Profiles of engagement in online communities of citizen science participation”, 2017
- Arnstein “A Ladder of Citizen Participation”, 1969
- Auerbach, “The problem with delineating narrow criteria for citizen science”, 2019
- Averett, “New Blood: The Promise of Environmental Health Citizen Science Projects”, 2017
- Bedessem, “Citizen Science and Scientific Objectivity: Mapping Out Epistemic Risks and Benefits”, 2020
- Biggeri, “Epidemiologia partecipata per recuperare credibilità e fiducia”, 2018
- Bonney et al., “Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy”, 2009
- Broeder, “Citizen science for health in all policies”, 2017
- Broeder, “Citizen Science for public health”, 2016
- Burgess, “From ‘trust us’ to participatory governance: Deliberative publics and science policy”, 2014
- Callon et al., “Taking European Knowledge Society Seriously”, 2007
- Ceccaroni, Piera, “Analyzing the Role of Citizen Science in Modern Research”, 2017
- Cooper et al., project FoldIt papers 2010-2019
- Curtis, “Online citizen science projects: an exploration of motivation, contribution and participation (PhD thesis)”, 2015
- Eitzel et al, “Citizen Science Terminology Matters: Exploring Key Terms” 2017
- European Commission, “Green Paper” 2014
- European Commission, “Citizen Science and Citizen Engagement” 2020
- European Commission, “White paper”, 2017
- Follett, Strezov “An Analysis of Citizen Science Based Research: Usage and Publication Patterns“ 2015
- Fritz et al., “Citizen science and the United Nations Sustainable Development Goals”, 2019
- Funtowicz, Ravetz, “Science for the post-normal age”, 1993
- Gadermaier, “Peer-reviewed publishing of results from Citizen Science projects” 2018
- Garbarino, “The Power of Engaging Citizen Scientists for Scientific Progress”, 2016
- Gianicolo, Vigotti, “Indagine conoscitiva sulla stato di salute della popolazione e dell’ambiente nella Città di Manfredonia”, 2016

- Heigl et al., “Toward an international definition of citizen science”, 2019
- Holdren, memorandum “Addressing Societal and Scientific Challenges through Citizen Science and Crowdsourcing”, 30 September 2015
- Holdren, memorandum “Multi-Agency Science and Technology Priorities for the FY 2017 Budget”, 9 July 2015
- Irwin, “Constructing the scientific citizen: science and democracy in the biosciences”, 2001
- Irwin, “From deficit to democracy (re-visited)”, 2014
- Jasanoff, “A mirror for science”, 2014
- Jones, “Reflecting on public engagement and science policy”, 2014
- Koepnick, “De novo protein design by citizen scientists”, 2019
- Landler, Castle, “Behind the Virus Report That Jarred the U.S. and the U.K. to Action”, NYT, 2020
- Lutyanenko, “Emerging problems of data quality in citizen science”, 2016
- Rasmussen, Cooper, “Citizen Science Ethics”, 2019
- Resnik, “A framework for addressing ethical issues in citizen science”, 2015
- Resnik, “Citizen Scientists as Human Subjects: Ethical Issues”, 2019
- Riesch, Potter, “Citizen Science as Seen by Scientists: Methodological, Epistemological and ethical dimensions”, 2013
- Rommetveit et al., “What can history teach us about the prospects of a European Research Area?”, 2013
- Schrogel, “The Many Faces of Participation in Science”, 2018
- Stilgoe et al., “Why should we promote public engagement with science?”, 2014
- Strasser et al., “Citizen Science”? Rethinking Science and Public Participation”, 2018
- Tallacchini, Biggeri, “La Vigilanza dei Cittadini sulla Salute Ambientale tra Tecnologie Digitali e Genomica”, 2014
- Woolley et al., “Citizen science or scientific citizenship? Disentangling the uses of public engagement rhetoric in national research initiatives”, 2016
- Wynne, “Further disorientation in the hall of mirrors”, 2014

Acknowledgements

I thank Mariachiara Tallacchini for the patience and the support

I thank Annibale Biggeri for the interesting confrontations